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RESEARCH PAPER

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Agronomic viability of arugula, A functional vegetable, under the residual effect of hairy woodrose (*Merremia aegyptia* L.), rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora*) in the semiarid region

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Abstract

Arugula is a nutritionally rich vegetable. Considered a functional food, it can be used to treat diseases and improve clinical conditions. This work was conducted at the Rafael Fernandes Experimental Farm, in the Alagoinha district, rural area of Mossoró-RN, from December 2016 to February 2017, with the objective of evaluating the agronomic viability of arugula, functional vegetable under the residual effect of species of the semi-arid region. The experimental design was the complete randomized blocks with treatments arranged in a 5 x 3 factorial scheme, with three replications. The first factor was constituted by four green fertilizer (0.0, 0.8, 1.6, 2.4, 3.2kg m^{-2} dry basis) and second factor by the types of green fertilizers (*Merremia aegyptia*, *Calotropis procera* and *Senna uniflora*). Initially radish was planted in plots of 1.4 x 1.4m. After the crop was withdrawn, the arugula cultivated Cultivada was planted. The evaluated characteristics were: height and number of leaves per plant, yield; number of sauces and dry matter mass of the aerial part. The best agronomic performance of the arugula was observed in the amount of 2.4kg m^{-2}, with yield of 902.3g m^{-2} and 30 arugula sauces. Among the types of fertilizers, *Merremia aegyptia* presented statistical superiority in relation to *Calotropis procera* and *Senna uniflora* for yield and number of sauces. The incentive for the cultivation of arugula is important because its benefits are directly related to the farmers who produce and also commercialize, and the consumers who acquire this vegetable.

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Introduction

The production of vegetables is in a fairly intense activity in northeastern Brazil region due to the cycle of crops, ranging from 25 to 35 days. Another factor that contributes to this activity is the demand for these olerícolas products, where the producers realize plantations that meet the needs of the market (Linhares, 2009).

Among the olericolas, one finds Arugula (*Eruca sativa*) also known as Persian Mustard, is a Brassicaceae whose leaves are much appreciated in the form of salad, being produced in all regions of Brazil. It is estimated that the cultivated area is 6.000ha/ano (Sala *et al.*, 2004; Purqueiro *et al.*, 2007). Although it develops better under mild temperatures, arugula has been cultivated throughout the year in many regions (Filgueira, 2008).

In the northeastern region of Brazil, there is a large consumption of arugula due to its use in cooking in various recipes, such in pizza, in meat, which has contributed to the increase of the production area. The cultivation is mainly by family farmers in an organic production system, using manure as the main source of input. Thus, the dependence of this input makes the producer vulnerable to scarcity, since you do not always own on your property, increasing the cost of production (Linhares *et al.*, 2014).

In this context, organic fertilization, using spontaneous species from the caatinga biome, contributed as a with resource availability, besides reducing production costs (Linhares, 2013). Spontaneous species of the caatinga occurring in the rainy season, hairy woodrose (*Merremia aegyptia* L.) and kill pasture (*Senna uniflora*) and throughout the year, rooster tree (*Calotropis procera*), has been used as organic fertilizer in the production of vegetables , contributing to the increase in productivity (Linhares, 2009).

Linhares (2013) states that spontaneous species can promote the same benefits as introduced species in cycling and nutrient availability. In this sense, some studies have evidenced the use of spontaneous species of caatinga as organic fertilizer (Linhares *et al.*, 2009a; 2009b; Linhares *et al.*, 2010; Linhares *et al.*, 2011; Linhares *et al.*, 2012; Linhares *et al.*, 2018; Bezerra Neto *et al.*, 2011; Góes *et al.*, 2011; Linhares et a., 2021 and Linhares *et al.*, 2022).

Neves *et al.* (2018) evaluated the production of leafy vegetables, lettuce, found efficiency in the application of mung bean in the presence of bovine manure in agronomic performance, with productivity of 1.5kg m^{-2} in the amount of 2.0kg m^{-2}.

In this sense, an important aspect to be considered when studying the organic production of vegetables, having as source of fertilizer, species of the caatinga biome, is the contribution that residues left in the soil in successive cultivation can promote in the subsequent productivity, since the fertilization of the soil in an activity as intense, as the olericultura, would increase the cost of production whenever a new crop was implanted. Therefore, with the objective of evaluating the agronomic viability of arugula, functional vegetable under the residual effect of species of the semiarid region.

Materials and methods

Study area

The experiment was conducted in the research area of the Rafael Fernandes Experimental Farm of the Federal Rural Semi-Arid University (UFERSA), in soil classified as Eutrophic Red Yellow Argissolo, caatinga hyperxerophilic phase and flat relief (Embrapa, 2006). The area is located in the Alagoinha district, 20 km from the Mossoró, Northeastern Brazil. The farm comprises of some 400 hectares (Rêgo *et al.*, 2016).

According to Kottek *et al.* (2006) and the classification of Köppen, the local climate is BSwh', dry and very hot, the dry season being 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%.

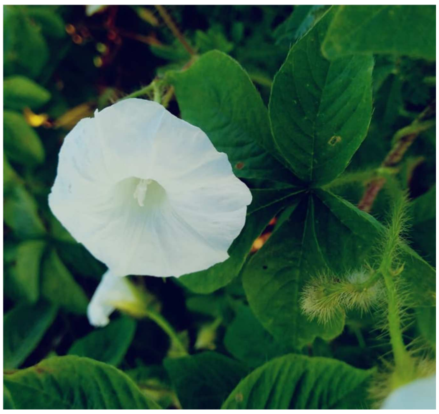
Before the installation of the field experiment, soil samples were collected to a 0-20cm layer and then sent to be processed and analyzed in the UFERSA Water, Soil and Plant Analysis Laboratory, providing the following results: pH (water 1:2,5)=6.80; exchangeable cations Ca=0.60cmol$_c$/dm^3; Mg= 0.85cmol$_c$/dm^3; K = 55.8 mg/dm^3; Na = 7.8 mg/dm^3; P (Mehlich)= 4.2 mg/dm^3; organic matter= 1.3 g/kg; Coarse sand = 630 g/kg; fine sand= 270 g/kg; silte= 20 g/kg; clay = 70 g/kg, soil density= 1.42 g/cm^3.

Statistical delineation and treatments

The experimental design of randomized complete blocks with the treatments arranged in 5 x 3 factorial scheme, with four replicates. The first factor consisted of different amounts of organic fertilizers (0.0; 0.8; 1.6; 2.4 and 3.2kg m^{-2} dry mass). The second factor by the types of green fertilizers: hairy woodrose (*Merremia aegyptia* L.), rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.).

For the arugula crop, the plot was 1.4 m x 1.4 m, with a total area of 1.96 m^2, floor area of 1.0 m^2 with 100 plants of arugula plants in the 0.2 m x 0.1 m spacing, with one plants per pit, being the density plants used in agricultural experimentation (Linhares, 2009). Soil preparation consisted of manual cleaning, removal of natural vegetation present in the experimental area and manual lifting of the beds, using as a tool to hoe.

The spontaneous species were collected from the native vegetation near the campus of UFERSA, at the beginning of the flowering period, when the plant shows the maximum concentration of nutrients. After collecting, the plants were crushed in a conventional forage machine to obtain fragmented particles approximately 2.0 to 3.0cm in size, which were dried in sun to reach a moisture content of 12%; a sample of this material was then subjected to laboratory analyses, which revealed a chemical composition for the hairy woodrose (*Merremia aegyptia* L.*)*: N = 19.8g/kg; P = 8.6g/kg; K = 22.4g/kg; Ca = 9.7g/kg; Mg = 3.0g/kg; S = 1.6g/kg and a C/N ratio of 23/1. For the species rooster tree (*Calotropis procera*): N = 17.5g/kg; P = 10.2g/kg; K = 25.6g/kg; Ca = 10.7g/kg; Mg = 1.9g/kg; S = 1.7g/kg and a C/N ratio of 25/1. For the species kill pasture (*Senna uniflora* L.): N = 18.3g/kg; P = 11.6g/kg; K = 33.2g/kg; Ca = 11.5g/kg; Mg = 2.3g/kg; S = 1.9g/kg and a C/N ratio of 24/1 (Fig. 1).



(A)

(B)

(C)

Fig. 1. Illustration of the scarlet starglory (*Merremia aegyptia* L.) (**A**); kill pasture (*Senna uniflora* L.) (B) and rooster tree(*Calotropis procera*) (C) species from the northeastern semi-arid region, present in the production areas of producers in the region of Mossoró, RN. Photograph: Researcher D.Sc. Paulo César Ferreira Linhares.

Two daily irrigations were carried out using a microsprinkler system at about 8 mm d^{-1} (Lima *et al.*, 2010), in order to promote soil microbial activity during decomposition. At thirty five days after the sowing arugula, the harvest was carried out.

After harvesting, plants were transported to the Post-Harvest of Vegetables Laboratory at the Department of Agronomic and Forestry Sciences at UFERSA where they were analyzed.

For the arugula cultivars the following characteristics were evaluated: plant height (was measured from base to was apex in twenty plant sample batches, using a millimeter ruler and recorded in cm $plant^{-1}$), number of leaf per plant (was determined in twenty plant sample averages), green mass production (was obtained from a cut of the shoot system and weighted with an electronic scale at a precision of 1.0g measured inkg m^{-2}), number of sauces (this was evaluated dividing the green mass by 30g, equivalent to the weight of a arugula bunch, according to information from organic producers in the region of Mossoró-RN, and measured in units m^{-2}), and dry mass (was obtained from a forced-air heating oven at 65°C, until constant mass was attained and measured in g m^{-2}).

Analyses of variance were conducted for the evaluated characteristics using the ESTAT software (Kronka and Banzato, 1995). Tukey's test at ($p < 0.05$) probability was used for comparisons between the types of organic fertilizers. Response curve adjustment for the quantitative factor was performed using the Table Curve software (Jandel scientific, 1991). The response functions were evaluated based on the following criteria: biological rationale, significance of the mean square of the regression (QMRr), high coefficient of determination (R2), significance of the regression parameters, using the t test at $p < 0.01$ probability.

Results and discussion

There was no interaction between the treatment factors for all characteristics evaluated for arugula culture (Table 1). However, it was observed an isolated effect at the level of ($p<0.01$) probability in organic fertilizers quantities for plant height, leaf number, productivity, number of sauces and dry mass of arugula (Table 1). There was a statistically significant difference ($p<0.01$) of probability of plant height, productivity, number of sauces and dry mass of arugula for the factor types of fertilizers: Hairy woodrose (*Merremia aegyptia* L.), rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.) (Table 1).

Table 1. F values for plant height, expressed incm $plant^{-1}$ (PH), leaf number, expressed in units $plant^{-1}$ (LN), green mass, expressed in grams m^{-2} of area (GM), number of sauces, expressed in units m^{-2} of area (NB) and dry mass, expressed in grams m^{-2} of area (DM) of arugula under amounts of types of organic fertilizers { Hairy woodrose (*Merremia aegyptia* L.), rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.)}.

Causes of variation	GL	PH	LN	GM	NB	DM
Amounts (A)	4	12.14^{**}	13.39^{**}	19.12^{**}	17.00^{**}	10.36^{**}
Types of fertilizers (T)	2	10.92^{*}	1.57^{ns}	3.27^{*}	6.05^{*}	4.82^{*}
A x T	8	1.53^{ns}	1.24^{ns}	1.05^{ns}	0.27^{ns}	0.87^{ns}
Treatments	14	24.79^{**}	5.64^{**}	14.96^{**}	20.4^{**}	7.46^{**}
Bloks	2	4.26^{**}	4.84^{*}	6.22^{**}	5.34^{**}	6.57^{**}
Waste	28	------	-------	--------	-------	--------
CV (%)	----	12.7	8.5	11.0	12.2	8.45

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

For height, there was an average increase of 9.0cm $plant^{-1}$ between the lowest amount of fertilizer (0.0kg m^{-2}) and the highest (3.2kg m^{-2}), incorporated into the soil, with an average value of 20.1cm $plant^{-1}$ in the amount of 2.4kg m^{-2} (Fig. 2). Regarding the types of organic fertilizers, the hairy woodrose (*Merremia aegyptia*) was statistically superior to the rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.), with average values of 18.8; 17.5 and 16.8cm $plant^{-1}$, respectively (Table 2). The observed value was higher than that found by Linhares *et al.* (2009) corresponding to 18.40cm $plant^{-1}$, evaluating the period of incorporation of the mata-pasto in the arugula culture.

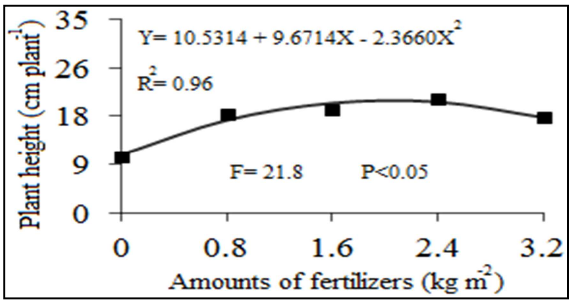


Fig. 2. Plant height of arugula under amounts of fertilizers.

In the number of leaves, there was a maximum point, with an average value of 13.0 leaves plant^{-1} in the amount of 2.4kg m^{-2} (Fig. 3). Among the types of organic fertilizers there were no significant differences, with values of 11.0; 10.0 and 11.0 for the hairy woodrose (*Merremia aegyptia*) was statistically superior to the rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.), respectively (Table 2). These values differed from those found by Harder *et al.* (2005) evaluating the arugula in a system intercropping with almeirão (*Cichorium intybus* L.), with values of 28.6 leaves of arugula. This difference can be related to the successive cultivation, which causes that there are less nutrients available in the soil, to be absorbed by the crop.

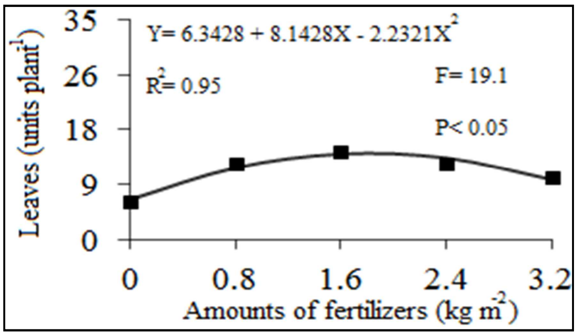


Fig. 3. Number leaves of arugula under amounts of fertilizers.

Table 2. Plant height, express in cm plant^{-1}(PH) and number leaves, express units plant^{-1}(NL) under types of organic fertilizers.

Organics fertilizers	PH	NL
Hairy woodrose (*Merremia aegyptia* L.)	18.8 a	11.0 a
Rooster tree (*Calotropis procera*)	16.8 b	11.0 a
Kill pasture (*Senna uniflora* L.)	17.5 a	11.0 a
CV	15.2	19.2

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

The amounts of organic fertilizers provided a point of maximum yield, in the amount of 2.4kg m^{-2}, with values of 902.3g m^{-2} and 30 units m^{-2}, for green mass production and number sauces, respectively (Figs. 4A and 4B). Regarding the types of organic fertilizers, it was observed that the hairy woodrose (*Merremia aegyptia* L.) was statistically superior to the rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.), with values of 945.5; 825.0 and 743g m^{-2} green mass production and 31.5; 27.5 and 24.8 arugula sauces, respectively (Table 3). The number of sauces is an important feature because it is the form of commercialization in supermarkets in the northeastern region of Brazil.

These values differed from Zarate *et al.* (2006), with arugula yield of 11.4t ha^{-1}, equivalent to 1100g m^{-2} green mass production and 37 units m^{-2} of number of sauces in single crop with application of chicken bed in cover. This superiority found by Zarate *et al.* (2006) is possibly due to the fact that it is evaluating arugula in the first crop, being fertilized with chicken bed, rich in nitrogen and potassium, responsible for the foliar expansion and growth of the crop.

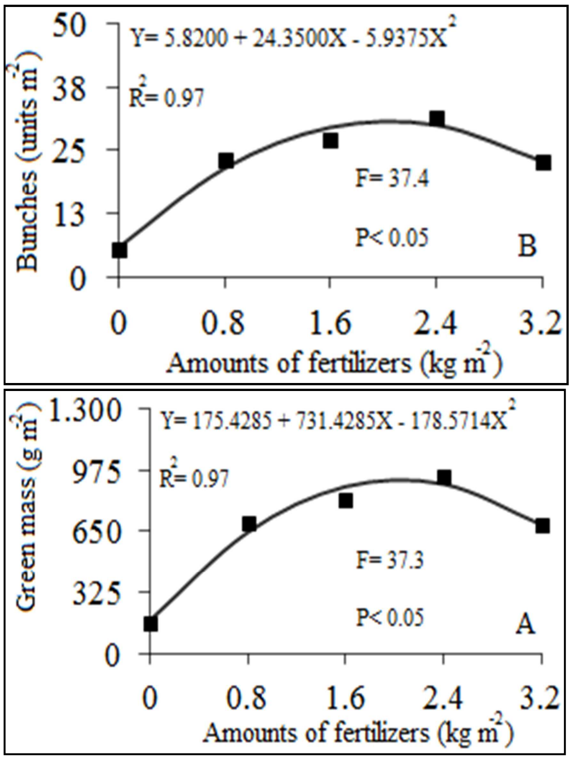


Fig. 4. Green mass (A) and number sauces (B) of arugula under amounts of fertilizers.

Solino *et al.* (2010) cultivating arugula in spacing of 0.3 x 0.1m in no-tillage under different compost doses and cover types, found productivity of 8424kg ha^{-1}, equivalent to 842 g m^{-2} green mass production and 28 units m^{-2} of number of sauces, being less than said research. Linhares (2009) evaluated arugula production in function of different amounts and decomposition times of scarlet starglory, found a yield of 8780kg ha^{-1}, equivalent to 878 g m^{-2} and 29 units m^{-2} of number sauces, being less than said research.

Similar behavior was observed in the dry mass of arugula, with a maximum value of 92g m^{-2} in the amount of 2.4kg m^{-2} of fertilizers of spontaneous species (Fig. 5). Regarding the types of organic fertilizers, it was observed that the hairy woodrose (*Merremia aegyptia* L.) was statistically superior to the rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.), with values of 96.5; 80.2 and 75.6g m^{-2}, respectively (Table 3).

Table 3. Green mass, express in g m^{-2} (GM), number sauces, express in units m^{-2} (NB) and dry mass, express g m^{-2} (DM) under types of organic fertilizers.

Organics fertilizers	GM	NB	DM
Hairy woodrose (*Merremia aegyptia* L.)	945.5 a	31.5 a	96.5 a
Rooster tree (*Calotropis procera*)	825.0 b	27.5 a	80.2 b
Kill pasture (*Senna uniflora* L.)	743.0 a	24.8 a	75.6 b
CV (%)	13.0	11.4	13.4

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

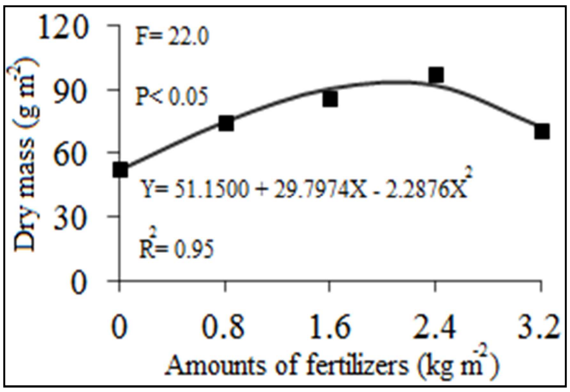


Fig. 5. Dry mass of arugula under amounts of fertilizers.

The dry matter is a characteristic of great importance in the vegetal production, being important in the evaluation of the vegetative growth through the accumulation of dry biomass in the formation of an organ or of the whole plant, without taking into account the water content (Teiz and Zeiger, 2017). In addition, the dry mass is what guarantees the nutritional index of a food, concentrating the most varied amounts of nutrients, some of them indispensable to human health.

Conclusions

Considering the result of the research, the best agronomic performance of the arugula was observed in the amount of 2.4kg m^{-2}, with yield of 902.3 g m^{-2} and 30 arugula sauces. Among the types of fertilizers, hairy woodrose (*Merremia aegyptia* L.) presented statistical superiority in relation to rooster tree (*Calotropis procera*) and kill pasture (*Senna uniflora* L.) for yield and number of sauces. The incentive for the cultivation of arugula is important because its benefits are directly related to the farmers who produce and also commercialize, and the consumers who acquire this vegetable.

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References

Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA. 2006. Sistema brasileiro de classificação de solos. 2.ed. Rio de Janeiro: Embrapa p. 306.

Bezerra Neto F, Góes SB, Sá JR, Linhares PCF, Góes GB, Moreira JN. 2011. Desempenho agronômico da alface em diferentes quantidades e tempos de decomposição de jitirana verde. Revista Brasileira de Ciências Agrárias **6(1),** 236-242.

Filgueira FAR. 2008. Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças. Viçosa: UFV 421p.

Góes SB, Bezerra Neto F, Góes GB, Moreira JN. 2011. Productive performance of lettuce at different amounts and times of decomposition of dry scarlet starglory. Revista Ciência Agronômica **42(1),** 1036-1042.

Hardes WC, Heredia Zárate NA, Vieira MC. 2005. Produção e renda bruta de rúcula (*Eruca sativa* Mill.) Cultivada e de almeirão (*Cichorium intybus* L.) Amarelo, em cultivo solteiro e consorciado. Ciência e Agrotecnologia **29(2),** 775-785.

Kottek M, Grieser J, Rudolf B, Rubel F. 2006. Mapa mundial da classificação climática de Köppen-Geiger atualizada. Meteorologische Zeitschrift **15(2),** 259-263.

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

Kronka SN, Banzato DA. 1995. (Estat) system for statistical analysis 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, Pereira KLV. 2018. Optimized amount of hairy woodrose (*Merremia aegyptia* L.) in the productivity of coriander cultivars. Bulgarian Journal of Agricultural Science **24(2),** 654-659.

Linhares PCF, Maracajá PB, Pereira MFS, Assis JP, 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(2),** 07-12.

Linhares PCF. 2013. Green manure as soil conditioner. Revista Campo e negócios **127(1),** 22-23.

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

Linhares PCF, Pereira MFS, Almeida SMS, Paz AES, Paiva ACC. 2011. Efeito residual do mata-pasto (*Senna uniflora*) no desempenho produtivo do rabanete. Revista Verde de Agroecologia e Desenvolvimento Sustentável **6(2),** 168-173.

Linhares PCF, Oliveira RM, Pereira MFS, Silva ML, Fernandes PLO. 2010. Adubação verde em diferentes proporções de jitirana com mata-pasto incorporado ao solo no coentro. Revista Verde de Agroecologia e Desenvolvimento Sustentável **5(3),** 91-95.

Linhares PCF. 2009. Vegetação espontânea como adubo verde no desempenho agroeconômico de hortaliças folhosas. 109 f. Tese (Doutorado em Fitotecnia: Área de Concentração em Agricultura Tropical)- Universidade Federal Rural do Semi-Árido, Mossoró, Brazil.

Linhares PCF, Silva ML, Borgonha W, Maracajá PB, Madalena JAS. 2009. Velocidade de decomposição da flor-de-seda no desempenho agronômico da rúcula cv. cultivada. Revista Verde de Agroecologia e Desenvolvimento Sustentável **4(2),** 46-50.

Neves APM, Linhares PCF, Souza RP, Assis JS, Neves AM, Cunha LMM, Almeida AMB, Pereira MFS, Alves LS. 2018. Successive crops of lettuce fertilized with bovine manure in the presence and absence of mung bean. International Journal of Development Research **08(1),** 19754-19760.

Purqueiro LFV, Demant LAR, Goto R, Boas RLV. 2007. Efeito da adubação nitrogenada de cobertura e do espaçamento sobre a produção de rúcula. Horticultura Brasileira **25(2),** 464-470.

Rêgo LGS, Martinscm, Silva EF, Silva JJA, Lima RNS. 2016. Pedogenesis and classification of soils of an experimental farm in Mossoró, Rio Grande do Norte, Brazil) Revista Caatinga **29(1),** 1036-1042.

Sala FC, Rossi F, Fabri EG, Rondino E, Minami K, Costa CP. Caracterização varietal de rúcula. In: Congresso Brasileiro de Olericultura, 44., 2004, Brasília. *Resumos...* Brasília: Associação Brasileira de Olericultura, 22, n. 2, jul. 2004. Suplemento.

Solino AJS, Ferreira RO, Ferreira RLF, Araújo Neto SE, Negreiro JRS. 2010. Cultivo orgânico de rúcula em plantio direto sob diferentes tipos de coberturas e doses de composto. Revista Caatinga **23(2),** 18-24.

Taiz L, Zeiger E. 2017. Plant Physiology, 3. ed. Porto Alegre: Artmed 954 p.

Zárate NAH, Vieira MC, Graciano JD, Gassi RP, Ono FB, Amadori AH. 2006. Produção de cebolinha, solteira e consorciada com rúcula, com e sem cobertura do solo com cama-de-frango. Ciências Agrárias **27(2),** 504-514.