academicJournals

Vol. 11(48), pp. 4931-4938, 1 December, 2016
DOI: 10.5897/AJAR2016.11762
Article Number: 0549F1661965
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Agronomic response of arugula to green fertilization with rooster tree during two culture times

Ênio Gomes Flôr Souza[1]*, Falkner Michael de Sousa Santana[2], Bruno Novaes Menezes Martins[3], Manoel Galdino dos Santos[4], Euvaldo Pereira de Cerqueira Júnior[5], Aurélio Paes Barros Júnior[4], Lindomar Maria da Silveira[4], Francisco Bezerra Neto[4], Hamurábi Anizio Lins[4] and José Ricardo Tavares de Albuquerque[4]

[1]Instituto Federal de Alagoas – IFAL, Brazil.
[2]Universidade Federal do Ceará – UFC, Brazil.
[3]Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP, Brazil.
[4]Universidade Federal Rural do Semi-Árido – UFERSA, Brazil.
[5]Universidade Federal do Vale do São Francisco – UNIVASF, Brazil.

Received 26 September, 2016; Accepted 21 November, 2016

The consumption of arugula is low compared to lettuce and coriander. However, it has been increasing, and there is a lack of information on fertilization and culture times. Growth and development characteristics of arugula were assessed. It was fertilized with different amounts of rooster tree biomass, at different times in the soil. It was cultured at two planting times (spring-summer and fall), in the municipality of Serra Talhada, PE, Brazil. The experimental design was randomized block, with treatments arranged on a 4 × 4 factorial, with three replications. The first factor is the amounts of rooster tree biomass (5.4, 8.8, 12.2 and 15.6 Mg ha^{-1} on a dry base), and the second one is times of incorporating in the soil (0, 10, 20 and 30 days before the planting of arugula). The characteristics of arugula assessed were: Plant height, number of leafs per plant, yield of green and dry mass of the above-ground part. The maximum yield of arugula was obtained at a dose of 15.6 Mg ha^{-1} of green fertilizer. Some synchronicity between the supply of nutrients (green fertilizer) and the period of maximum demand by the arugula plants was observed when they were incorporated 20 days before planting. The culture increased the cycle of arugula during the fall, offering greater green and dry mass yields to the culture.

Key words: *Calotropis procera* (Ait.) R. Br., *Eruca sativa* L., green fertilizer, meteorological conditions, organic fertilization.

INTRODUCTION

The production of vegetables in the Northeast Region of Brazil is done with mineral and organic fertilization, highlighting the use of cattle manure. Animal manure, organic compounds and agro-industrial residues are the target of a series of restrictions as to their use on organic agriculture (Silva et al., 2011), in relation to the nutritional and sanitarian management of the animals that provide these fertilizers. One of the alternatives to the supply of nutrients to vegetables, with increased safety to the consumers, would be through green fertilization. It consists of adding non-decomposed vegetable material to the soil, produced in the location or brought from other areas. This is done with the purpose of preserving and/or restoring the organic matter contents and nutrients on the soil, and also improving it biologically (Calegari et al., 1993).

The use of spontaneous species from the *Caatinga* biome may be a sustainable strategy for the use of the green fertilization practice in the semi-arid region (Oliveira et al., 2011). These species usually adapt to the edapho-climatic conditions of the region, are easy to collect, and have a high production of dry mass, low susceptibility to attack by plagues and diseases, chemical composition with significant nutrient contents and C/N relationship inferior to 30/1 (Liberalino Filho, 2013; Giacomini et al., 2003).

Researchers conducted on the semi-arid region of the state of Rio Grande do Norte (RN), Brazil, have shown the agronomic and economic feasibility of the use of spontaneous rooster tree [*Calotropis procera* (Ait.) R. Br.], hairy woodrose (*Merremia aegyptia* L.) and oneleaf Senna (*Senna uniflora* L.) plants as green fertilizers for the production of leafy and root vegetables (Linhares, 2009; Bezerra Neto et al., 2011; Silva et al., 2011; Batista et al., 2013; Bezerra Neto et al., 2014). However, rooster tree has stood out in relation to the others due to its greater resistance to drought, and due to the fact that it may produce biomass even under severe drought conditions.

The rooster tree belongs to the Apocynaceae family and it has a wide geographic distribution, above all, under arid and semi-arid conditions (Souto et al., 2008; Carvalho Júnior et al., 2010). The plant remains green and exuberant during the entire year, originating a bush with quick growth and vigorous regrowth, and production capacity of 700 kg of dry mass ha^{-1}, within 60 days after cutting (Andrade et al., 2008). The corresponding nitrogen, phosphorus and potassium contents are at 17.4, 4.4 and 23.5 g kg^{-1} of dry mass, respectively, and the C/N relationship is 25/1, favoring the mineralization process of the organic matter.

Batista et al. (2013) highlight the capacity of this spontaneous species in improving the chemical and biological conditions of the soil, with a consequent increase on the productivity of radish, when fertilized with 21 Mg ha^{-1} of the green fertilizer, 21 days before sowing the culture. Linhares (2009), working with this green fertilizer for the fertilization of leafy vegetables (lettuce, arugula and coriander), observed an increase on the height of plants, number of leafs and green, and dry mass yields. Between the highest and the lowest amount of biomass, 6 and 45 Mg ha^{-1}, respectively, the incorporation to the soil by the rooster tree increased 75% on the commercial productivity of carrot roots (Silva et al., 2013).

For the arugula culture (*Eruca sativa* L.), as well as for other leafy vegetables, the use of cattle manure and chemical fertilizers is a usual daily practice in order to meet the nutritional demands from these cultures (Björkman et al., 2011). However, for the arugula culture, green fertilization with spontaneous species has offered significant increases on the yield of green mass (Linhares, 2009; Linhares et al., 2009).

In that sense, the objective of the research is to evaluate the growth and development characteristics of arugula according to different amounts of rooster tree biomass and its times of incorporation to the soil, during two culture times (spring-summer and fall), under the conditions shown at Serra Talhada, PE, Brazil.

MATERIALS AND METHODS

The experiments were conducted in field, during two culture times: Spring-summer (November 15, 2011 to January 23, 2012) and fall (March 23 to June 04, 2012), at Universidade Federal Rural de Pernambuco (UFRPE), Unidade Acadêmica de Serra Talhada (UAST). It is located at 7º57'15" of South latitude and 38º17'41" of West longitude, with 461 m altitude, in the micro-region of Sertão do Pajeú, Northern Pernambuco, Brazil. The local climate, according to Köppen's classification, is Bwh, referred to as semi-arid, warm and dry; it has summer rains, annual thermal means of 24.7ºC and average annual rainfall of 642.10 mm (SUDENE, 1990; Medeiros et al., 2005). The average meteorological data from the period in which the experiments were conducted are shown in Figure 1.

The soil of the experimental area showed a sandy loam texture. During the spring-summer, its chemical characteristics, at 0-20 cm depth are: pH at H_2O (1:2.5) = 7.2; M.O. = 12.8 g kg^{-1}; P = 14.0 mg dm^{-3}; K^+ = 0.5 cmol$_c$ dm^{-3}; Ca^{2+} = 3.9 cmol$_c$ dm^{-3}; Mg^{2+} = 1.2 cmol$_c$ dm^{-3}; Al^{3+} = 0.0 cmol$_c$ dm^{-3}; and its chemical characteristics during the fall are: pH at H_2O (1:2.5) = 6.5; M.O. = 12.7 g kg^{-1}; P = 20.0 mg dm^{-3}; K^+ = 0.4 cmol$_c$ dm^{-3}; Ca^{2+} = 3.4 cmol$_c$ dm^{-3}; Mg^{2+} = 1.1 cmol$_c$ dm^{-3}; Al^{3+} = 0.0 cmol$_c$ dm^{-3}.

The experimental design used in each experiment consisted of randomized blocks, with the treatments arranged on a 4 × 4 factorial, with three replications. The first factor was constituted by four amounts of rooster tree biomass (5.4, 8.8, 12.2 and 15.6 Mg ha^{-1} on a dry base), and the second factor, by four times of incorporation in the soil by this green fertilizer (0, 10, 20 and 30 days before the sowing of arugula).

Each experimental plot had 1.44 m^2, with a useful area of 0.80 m^2. Six rows or planting lines were transversally arranged on each plot, with a distance of 0.20 m from each other, and 0.05 m between the plants on the row. The arugula cultivar that was planted was 'Cultivada', indicated for culture on the Northeast region. The soil preparation in each experiment consisted of the manual lifting of the plants using hoes.

The rooster tree was collected in locations near UAST, and then it was grinded on a conventional foraging machine, producing

*Corresponding author. E-mail: enio.souza@ifal.edu.br. Tel: +55 87 9 96371428.

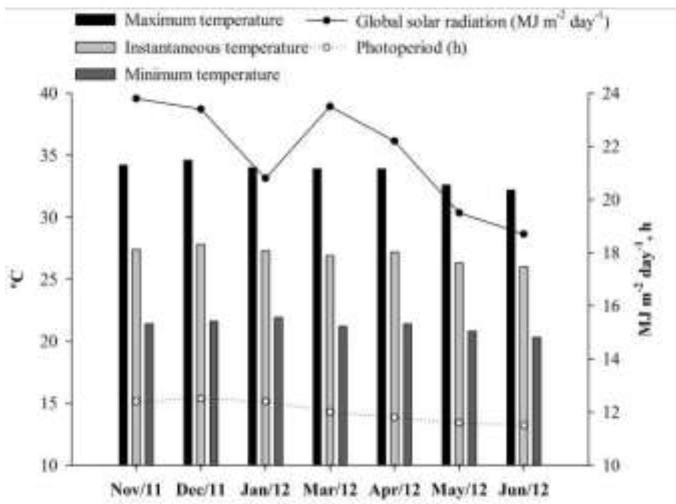

Figure 1. Average monthly values of instantaneous, maximum and minimum temperatures (ºC), global solar radiation (MJ m^{-2} day^{-1}) and photoperiod (h) during the experiments. Serra Talhada, Pernambuco, Brazil, 2011-2012.

fragments between 2.0 and 3.0 cm. It was left to dry until it reach a hay-like condition (10% humidity). From samples of this material, the dry mass nutrient contents were determined (70ºC): N = 17.4 g kg^{-1}; P = 4.4 g kg^{-1}; K = 23.5 g kg^{-1}; Ca = 14.3 g kg^{-1}; Mg = 23.0 g kg^{-1}; B = 71.0 mg kg^{-1}; Cu = 29.0 mg kg^{-1}; Fe = 463.0 mg kg^{-1}; Mn = 90.0 mg kg^{-1}; Zn = 40.0 mg kg^{-1}; Na = 1640.0 mg kg^{-1}; organic matter content = 764.0 g kg^{-1}; C/N relationship = 25/1.

The green fertilizer was incorporated in the soil at 0-20 cm layer on the experimental plots, according to the treatments. The daily irrigations were conducted in the morning and afternoon, in order to favor the microbial activity of the soil on the mineralization process of the organic matter.

The planting of arugula during the first culture time (spring-summer) was conducted on December 15, 2011, while during the second time (fall), it was conducted on April 23, 2012. The no-tillage sowing was used, at a depth of 2.0 cm, sowing three seeds per hole. After ten days of the emergency, the thinning was conducted, leaving one plant per hole. The irrigations were conducted by a micro-aspersion system, providing a water blade of approximately 8 mm day^{-1}. Manual hoeing was conducted whenever necessary.

During the spring-summer, arugula was harvested 39 days after sowing (DAS), while, during the fall, it was harvested at 42 DAS. The harvesting point used consisted of the maximum vegetative development without the emission of floral stems. During the harvest, the following characteristics were evaluated: plant height, expressed in cm, obtained by measuring a sample of twenty plants with a ruler from the level of the soil up to the end of the highest leaf; the number of leafs per plant was determined on a sample of twenty plants, by counting directly the number of leafs over 3.0 cm in length, from the basal leafs up to the last open leaf; green mass yield, obtained from the fresh mass of the above-ground part of all plants on the useful area of the plot, expressed in Mg ha^{-1}; and the dry mass of the above-ground part, estimated from the weight of the dry mass of twenty plants of the useful area, after drying in an oven with forced air circulation, with the temperature regulated at 65ºC until a constant mass was reached, and expressed in Mg ha^{-1}.

Analyses of variance were conducted for the evaluated characteristics, where corrections were applied for 70% of the effectively planted area, using the SISVAR 3.01 application (Ferreira, 2003). A joint analysis of these characteristics was conducted. A procedure to adjust response curves was conducted among the evaluated characteristics and the quantitative factors using the SigmaPlot 12.0 program (Systat Software, 2011). Tukey's test ($p<0.05$) was used to compare the means between the culture times.

RESULTS AND DISCUSSION

From the results of the joint analysis of the evaluated characteristics according to the time of culture, the rooster tree biomass amounts and the time of being incorporated in the soil, an interaction was observed between the amount of green fertilizer and the times of incorporation for the number of leafs per plant. In relation to the dry matter of the above-ground part, an interaction occurred between the amount of rooster tree biomass and culture time factors. The interaction among three factors was observed only for the yield of green mass for arugula. The plant height and the number of leafs per plant were influenced by the culture times (Table 1).

It may be observed that, for the planting of arugula during fall, the height and number of leafs per plant were superior to that planted during spring-summer (Table 2). This result is probably because the mean temperature is close to 26ºC and the photoperiod is below 12 h during the fall (Figure 1). This favors the vegetative growth of the culture. On the other hand, at the end of spring and beginning of summer, a mean of maximal temperatures above 34ºC and days with light lasting for over 12 h occurred (Figure 1), which possibly had a negative effect on the growth of arugula. The influence of the meteorological factors on the arugula plants also changed the harvesting period observed by the difference on the culture cycles during spring-summer (39 DAS) and fall (42 DAS).

Similar results were obtained by Tuncay et al. (2011), evaluating the effect of cattle manure (100 Mg ha^{-1}), calcium nitrate (150 kg ha^{-1} of N) and ammonium sulfate (150 kg ha^{-1} of N) on the productivity of arugula during different months of the year. The authors observed better results during the coldest months, since the growth cycle was larger, that is, with more than four weeks.

The height of the arugula plants increased linearly with the growing amounts of green fertilizer incorporated in the soil. For each ton added to the soil, an increment of 0.71 cm (Figure 2A) was recorded. The height of arugula increased in a quadratic manner with the times of incorporation of the green fertilizer in the soil, reaching a maximum value of 24.71 cm at 21.7 days, and then decreasing up to the last time of incorporation of the green fertilizer (Figure 2B). This positive result is probably due to the greater availability of macronutrients (N, P, K, Ca and Mg) on the soil after the green fertilization (Góes et al., 2011). Incorporating the arugula 22 days before sowing favored the mineralization of the green fertilizer constituents, promoting the improvement or maintenance of the fertility of the soil.

Table 1. Summary of the analysis of variance for the plant height (PH), number of leafs per plant (NLP), green mass yields (GMY) and dry mass of the above-ground part (DMAP) of arugula plants fertilized with rooster tree, on two culture times.

Sources of variation	d.f.	PH	NLP	GMY	DMAP
Seasons	1	11.10**	42.05**	83.98**	34.65**
Amounts	3	109.97**	336.65**	83.00**	129.98**
Times	3	88.06**	236.99**	17.36**	21.13**
Seasons × Amounts	3	0.63^{ns}	0.44^{ns}	6.58**	3.94*
Seasons × Times	3	0.66^{ns}	1.20^{ns}	1.91 ^{ns}	2.19^{ns}
Amounts × Times	9	0.64^{ns}	8.12**	1.12^{ns}	0.15^{ns}
Seasons × Amounts x Times	9	0.13^{ns}	1.50^{ns}	2.13*	0.39^{ns}
CV (%)		6.57	2.40	12.55	13.80

^{ns}; ** and *: non-significant, significant at 1 and 5% of probability, according to the F test, respectively.

Table 2. Mean values for the plant height and number of leafs per arugula plant fertilized with rooster tree, on two culture times.

Culture time	Plant height (cm)	Number of leafs per plant
Spring-summer	21.92^{b1}	14.00^{b1}
Fall	22.92^{a}	14.45^{a}

[1]Means followed by the same letter on the column do not differ from each other according to Tukey's test at 5% of probability.

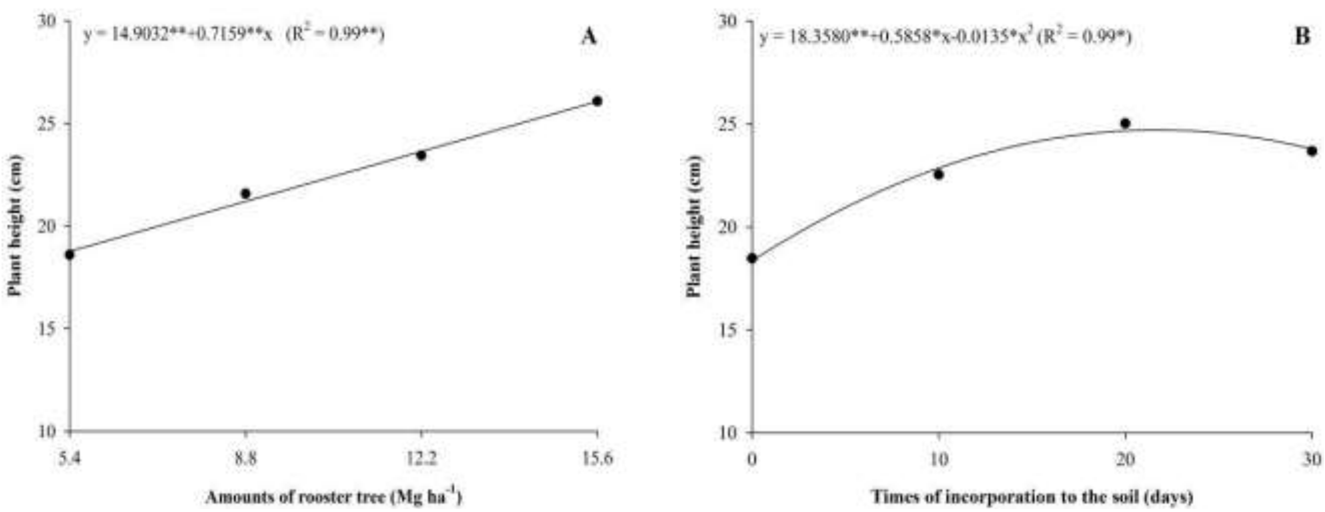

Figure 2. Height of arugula plants in relation to the amounts of green fertilizer, obtained from the rooster tree biomass (A), and to the times of incorporation to the soil (B) before planting.

Analyzing the rooster tree biomass amounts within each time of incorporation in the soil (0, 10, 20 and 30 days), it was observed that the number of leafs also increased with the growing amounts of the green fertilizer, reaching maximum values of 14.3, 15.0, 16.8 and 15.5 leafs per plant at an amount of 15.6 Mg ha^{-1}, respectively (Figure 3A). On the other hand, analyzing the times of incorporation within the amounts of green fertilizer (5.4, 8.8, 12.2 and 15.6 Mg ha^{-1}), it was observed that the number of leafs reached maximum values of 13.4, 15.8, 16.6 and 17.0; on the respective times of 22.6, 23.7, 23.3 and 22.9 days, then, decreasing up to the last time (Figure 3B).

The chemical analyses of the soils of the experimental area revealed that the pH had favorable values for the availability of nutrients for the plants, as well as the C/N proportion (25/1) of the green fertilizer, which probably favored the mineralization of N in relation to the

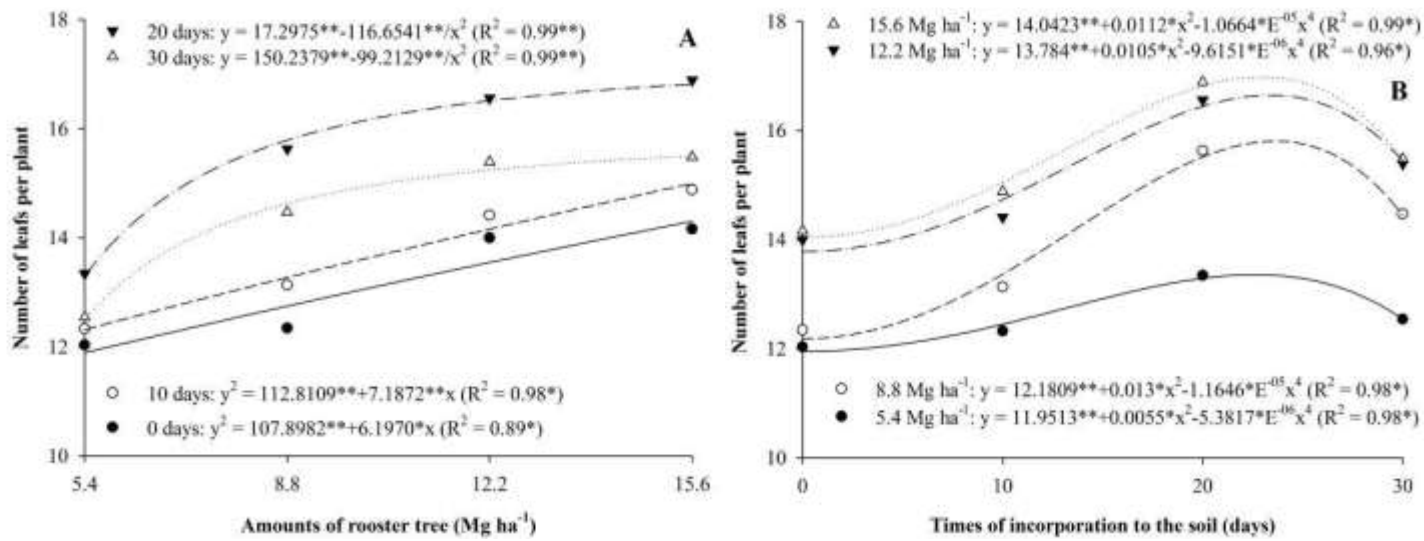

Figure 3. Number of leafs per arugula plant due to the unfolding of the interaction of amounts of green fertilizer, obtained from the rooster tree biomass, within times of incorporation in the soil (A) and its inverse unfolding (B).

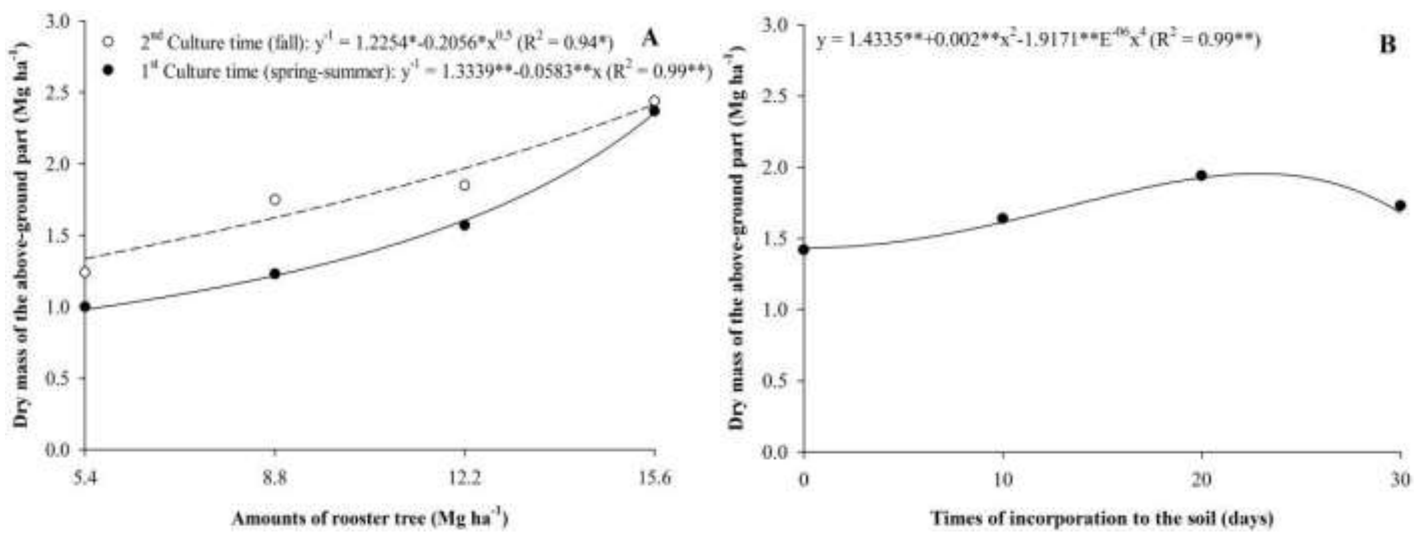

Figure 4. Dry mass of the above-ground part of arugula in relation to the unfolding of the interaction of amounts of green fertilizer, obtained from the rooster tree biomass, within culture times (A) and in relation to the times of incorporation in the soil (B) before planting.

immobilization process (Giacomini et al., 2003). In addition to the increase on the soil fertility, fertilization with vegetable species that occur spontaneously on the region also favors the microbiological aspects of the soil, with the increase on the amount of actinomycetes, fungi and bacteria that benefit the growth of plants, since they work for the solubilization of nutrients of the green fertilizer (Batista et al., 2013). Possibly, the constant irrigation and occurrence of mean temperatures above 26ºC during the experiments (Figure 1) stimulated the microbial activity.

The dry mass of the above-ground part of arugula increased with the growing amounts of fertilizer, reaching maximum values of 2.36 (spring-summer) and 2.42 Mg ha^{-1} (fall) at a dose of 15.6 Mg ha^{-1} (Figure 4A). On the other hand, analyzing the culture times within the amounts of rooster tree, significant differences are observed between the times only with 5.4, 8.8 and 12.2 Mg ha^{-1}, with greater dry mass of the above-ground part on the fall culture (Table 3).

The high temperatures associated with the long days during spring-summer (Figure 1) possibly contributed to damage the formation of leafs and the production of dry mass by arugula (Tables 2 and 3), since these

Table 3. Mean values of the dry mass of the above-ground part of arugula for the unfolding of the interaction of culture times according to the amounts of green fertilizer, obtained from the biomass of rooster tree.

Culture time	Dry mass of the above-ground part (Mg ha^{-1})			
	5.4 Mg ha^{-1}	8.8 Mg ha^{-1}	12.2 Mg ha^{-1}	15.6 Mg ha^{-1}
Spring-summer	1.00[b1]	1.23[b]	1.57[b]	2.37[a]
Fall	1.24[a]	1.75[a]	1.85[a]	2.44[a]

[1]Means followed by the same letter on the column do not differ from each other according to Tukey's test at 5% of probability.

meteorological factors stimulate the synthesis of gibberellins, which are related to early bolting, growth of the stem and reduction on the number of leafs on leafy vegetables (Souza et al., 2008; Taiz and Zeiger, 2013).

For the dry mass of the above-ground part of arugula, a growing behavior was also observed with the times of incorporation in the soil of the rooster tree, up to 1.98 Mg ha^{-1} within 23.1 days, then, decreasing up to the last evaluated time (Figure 4B). The study of the time of incorporation in the soil of the green fertilizer allows the identification of the synchronicity moment between the mineralization of the vegetable residue and the period of maximum nutritional demand of arugula (Myers et al., 1994); that is, the fertilization approximately 23 days before planting of the culture offered the ideal time to make the nutrients on its chemical composition available to the soil solution, thus, favoring the absorption and accumulation of the biomass by the plants.

For the green mass yield of arugula, by analyzing the interaction of the amounts of green fertilizer within times of incorporation in the soil and culture times, it was observed that the increase on the amount of rooster tree promoted an increase on the productivity of the culture, with maximum values of 36.79 Mg ha^{-1} (spring-summer) and 44.83 Mg ha^{-1} (fall) within 20 days (Figure 5A and B). The regressions related to the times of 30 days on the spring-summer culture and 10 and 20 days on the fall culture did not allow the adjustment of regression equations; however, the mean values obtained were 27.70, 33.69 and 40.22 Mg ha^{-1}, respectively (Figures 5A and B).

Analyzing the interaction of the times of incorporation in the soil according to the amounts of rooster tree biomass and the culture times, it was observed, on the spring-summer planting, a quadratic response for the fresh mass yield of arugula, considering the maximum value of 36.24 Mg ha^{-1} at a quantity of 15.6 Mg ha^{-1} of the fertilizer, at the incorporation time of 20.8 days before planting. For the amounts of 8.8 and 12.2 Mg ha^{-1}, there were no adjustments of regression equations on the first culture time; however, the productivity mean was 28.35 and 29.92 Mg ha^{-1}, respectively (Figure 5C).

From the same analysis, but for the fall culture, the largest yields of arugula green mass were observed within the incorporation time of 22 days, associated with the amounts of 12.2 and 15.6 Mg ha^{-1} of green fertilizer. Values were estimated on the order of 44.16 and 44.90 Mg ha^{-1}, respectively. For the same combinations of the factorial, it was observed that the productivity of fresh mass of the arugula cultivated during the fall was higher than the values observed for the spring-summer culture (Figure 5D).

According to Grangeiro et al. (2011), the largest demands for nutrients by arugula occur within the period between 25 and 30 days after sowing, therefore, with a greater demand occurring 45 days after the incorporation of the green fertilizer. It is highlighted that this recommended time did not change across the culture times, perhaps because the variation in temperature and solar radiation was unable to promote a change on the speed of the reactions between the microbiota and organic matter of the soil.

Torres et al. (2005) verified that the greater mineralization of N on cultures used as green fertilizers occurred on the first 42 days after being desiccated, relating it to the low C/N relationship of the vegetable material (20-25/1). This proportion is similar to the one observed on the chemical composition of the rooster tree (25/1).

Previous studies with green fertilization that originated from the rooster tree, on the production of arugula, revealed a green mass yield of only 7.9 Mg ha^{-1} when using amounts of over 40 Mg ha^{-1} of rooster tree, associated with the time of 20 days of incorporation to the soil, on the spring culture, in Mossoró, RN, Brazil (Silva, 2012). Such results were inferior to the ones found on this study, probably due to the low fertility of the soil before the implementation of the experiment Silva (2012).

Also in Mossoró-RN, Linhares (2009) obtained, on the spring culture, a fresh mass yield of arugula of 25.09 Mg ha^{-1} when fertilized with 15.6 Mg ha^{-1} of green fertilizer made from rooster tree, and incorporated in the soil 15 days before planting. The author observed that this fertilizer offered greater development for arugula, compared to the use of green fertilizer made from hairy woodrose (*Merremia aegyptia* L.) and one leaf Senna (*Senna uniflora* L.). This was attributed to the potassium content on the rooster tree, since this is the main element demanded by arugula (Grangeiro et al., 2011).

Considering the results, the fertilization of arugula using grinded rooster tree is recommended, on both culture times; however, the fall culture with 15.6 Mg ha^{-1} of the

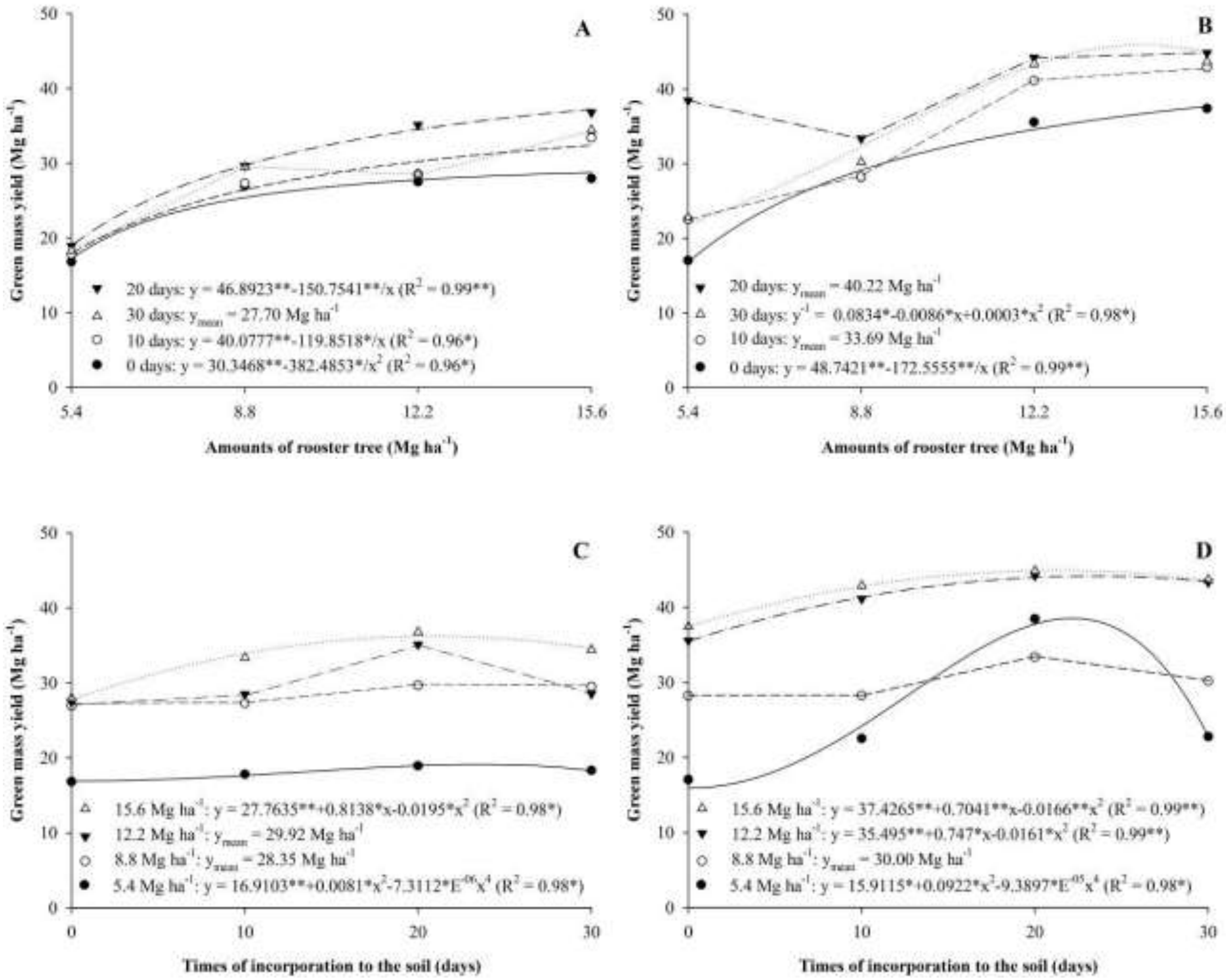

Figure 5. Yields of arugula green mass due to the unfolding of the interaction of amounts of rooster tree biomass, within times of incorporation in the soil (A. spring-summer; B. fall) and the inverse (C. spring-summer; D. fall), within each culture time.

green fertilizer, incorporated in the soil 20 days before sowing may offer 22% increment on the green mass yield in spring-summer culture.

Conclusion

1. Better growth and development of the arugula plants was obtained with the amount of 15.6 Mg ha^{-1} of green fertilizer, of grinded rooster tree plant.
2. The ideal time of incorporation of the green fertilizer in the soil is 20 days before sowing of the arugula.
3. Larger green and dry mass yields of arugula fertilized with rooster tree is obtained in culture produced during the fall season.

Conflict of interests

The authors have declared no conflict of interests.

ACKNOWLEDGEMENTS

To Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE), for financing the research program, and to the Post-Graduation Program in vegetable Production (PGPV), of UFRPE-UAST, for supporting all activities developed on this study.

REFERENCES

Andrade MVM, Silva DS, Andrade AP, Medeiros NA, Pimenta-Filho EC, Cândido MJD, Pinto MSC (2008). Produtividade e qualidade da Flor-de-seda em diferentes densidades e sistemas de plantio. Rev. Bras. Zootecnia 37(1):1-8.

Batista MAV, Bezerra Neto F, Ambrósio MMQ, Guimarães LMS, Saraiva JPB, Silva ML (2013). Atributos microbiológicos do solo e produtividade de rabanete influenciados pelo uso de espécies espontâneas. Hortic. Bras. 31(4):587-594.

Björkman M, Klingen I, Birch ANE, Bones AM, Bruce TJA, Johansen TJ, Meadow R., Molmann J, Seljasen R, Smart LE, Stewart D (2011). Phytochemicals of Brassicaceae in plant protection and human

health – Influences of climate, environment and agronomic practice. Phytochemistry 72(7):538-556.
Bezerra Neto F, Góes SB, Sá JR, Linhares PCF, Góes JB, Moreira JN (2011). Desempenho agronômico da alface em diferentes quantidades e tempos de decomposição de jitirana verde. Rev. Bras. Ciênc. Agrárias 6(2):236-242.
Bezerra Neto F, Oliveira LJ, Santos AP, Lima JSS, Silva IN (2014). Otimização agroeconômica da cenoura fertilizada com diferentes doses de jitirana. Rev. Ciênc. Agronômica 45(2):305-311.
Calegari A, Mondardo A, Bulisani EA, Costa MBB, Miyasaka S, Amado TJC (1993). Aspectos gerais da adubação verde. In Costa MBB (ed.) Adubação verde no sul do Brasil. 2. ed. Rio de Janeiro: Assessoria e Serviços a Projetos em Agricultura Alternativa pp. 1-56.
Carvalho Júnior SB, Furtado DA, Silva VR, Dantas RT, Lima ISP, Lima VLA (2010). Produção e avaliação bromatológica de espécies forrageiras irrigadas com água salina. Rev. Bras. Engenharia Agríc. Ambient. 14(10):1045-1051.
Ferreira DF (2003). Programa SISVAR: sistema de análise de variância. Versão 4.6 (Build 6.0). Lavras: DEX/UFLA.
Giacomini SJ, Aita C, Vendruscolo ERRO, Cubilla M., Nicoloso RS, Fries MR (2003). Matéria seca, relação C/N e acúmulo de nitrogênio, fósforo e potássio em misturas de plantas de cobertura de solo. Rev. Bras. Ciênc. do Solo 27(2):325-334.
Góes SB, Bezerra Neto F, Linhares PCF, Goes GB, Moreira JN (2011). Productive performance of lettuce at different amounts and times of decomposition of dry scarlet starglory. Rev. Ciênc. Agronômica 42(4):1036-1042.
Grangeiro LC, Freitas FCL, Negreiros MZ, Marrocos STP, Lucena RRM, Oliveira RA (2011). Crescimento e acúmulo de nutrientes em coentro e rúcula. Rev. Bras. Ciênc. Agrárias 6(1):11-16.
Liberalino Filho J (2013). Adubação verde. In Dias NS, Brígido AR, Sousa ACM (eds.) Manejo e conservação dos solos e da água. São Paulo: Livraria da Física pp.177-183.
Linhares PCF (2009). Vegetação espontânea como adubo verde no desempenho agroeconômico de hortaliças folhosas. Tese de Doutorado. Universidade Federal Rural do Semi-Árido, Mossoró. 109f.
Linhares PCF, Silva ML, Bezerra Neto F, Pereira MFS, Félix MG (2009). Adubação verde com jitirana na produção de rúcula. Rev. Caatinga 22(3):215-219.
Medeiros SS, Cecílio RA, Melo Júnior JCF, Silva Júnior JLC (2005). Estimativa e espacialização das temperaturas do ar mínimas, médias e máximas na Região Nordeste do Brasil. Rev. Bras. Engenharia Agríc. Ambient. 9(2):247-255.
Myers RJK, Palm CA, Cuevas E, Gunatilleke IUN, Brossard M (1994). The synchronization of nutrient mineralization and plant nutrient demand. In: Woomer PL, Swift MJ (eds.) the biological management of tropical soil fertility. New York: John Wiley and Sons pp. 81-116.
Oliveira MKT, Bezerra Neto F, Barros Júnior AP, Lima JSS, Moreira JN (2011). Desempenho agronômico da cenoura adubada com jitirana antes de sua semeadura. Rev. Ciênc. Agronômica 42(2):364-372.
Silva ML, Bezerra Neto F, Linhares PCF, Bezerra AKH (2013). Produção de cenoura fertilizada com Flor-de-seda (*Calotropis procera* (Ait.) R. Br.). Rev. Ciênc. Agronômica 44(4):732-740.
Silva ML, Bezerra Neto F, Linhares PCF, Sá JR, Lima JSS, Barros Júnior AP. (2011). Produção de beterraba fertilizada com jitirana em diferentes doses e tempos de incorporação ao solo. Rev. Bras. Engenharia Agríc. Ambient. 15(8):801-809.
Silva ML (2012). Viabilidade agroeconômica de hortaliças fertilizadas com Flor-de-seda (*Calotropis procera* (Ait.) R. Br.). Tese de Doutorado. Universidade Federal Rural do Semi-Árido, Mossoró. 83f.
Souto PC, Sales FCV, Souto JS, Santos RV, Sousa AA (2008). Biometria de frutos e número de sementes de *Calotropis procera* (Ait.) R. Br. no semi-árido da Paraiba. Revista Verde de Agroecologia e Desenvolvimento Sustentável 3(1):108-113.
Souza MCM, Resende LV, Menezes D, Loges V, Souto TA, Santos VF (2008). Variabilidade genética para características agronômicas em progênies de alface tolerantes ao calor. Hortic. Bras. 26(3):354-358.
Superintendência do Desenvolvimento do Nordeste – SUDENE (1990). Dados pluviométricos mensais do Nordeste: Estado de Pernambuco. Recife: Grafset 363 p.
Systat Software (2011). SigmaPlot for Windows. Version 12.0. San Jose: Systat Software Inc.
Taiz L, Zeiger E (2013). Fisiologia vegetal. 5. ed. Porto Alegre: ArtMed 918 p.
Torres JLR, Pereira MG, Andrioli I, Polidoro J, Fabian AJ (2005). Decomposição e liberação de nitrogênio de resíduos culturais de plantas de cobertura em um solo de cerrado. Rev. Bras. de Ciênc. do Solo 29(4):609-618.
Tuncay Ö, Esiyok D, Bülent Y, Okur B (2011). The effect of nitrogen sources on yeld and quality of salad rocket grown in different months of the year. J. Plant Nutr. 34(4):477-491.