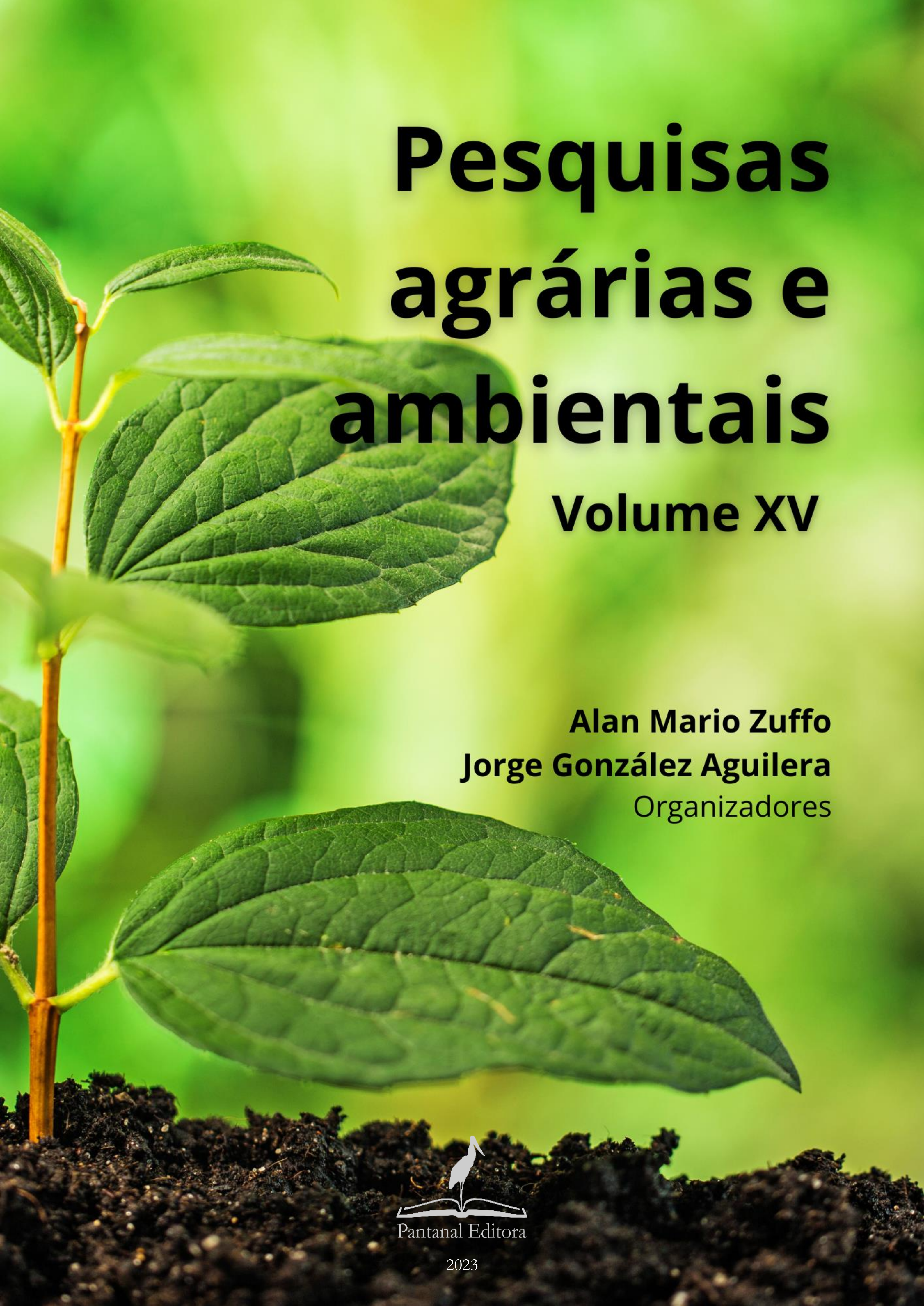

Pesquisas agrárias e ambientais

Volume XV

Alan Mario Zuffo
Jorge González Aguilera
Organizadores

Pantanal Editora

2023

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Pesquisas agrárias e ambientais
Volume XV

Pantanal Editora

2023

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

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

Ficha Catalográfica

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

P474

Pesquisas agrárias e ambientais: Volume XV / Organizadores Alan Mario Zuffo, Jorge González Aguilera. – Nova Xavantina-MT: Pantanal, 2023. 90p. ; il.

Livro em PDF

ISBN 978-65-81460-86-0
DOI https://doi.org/10.46420/9786581460860

1. Agricultura. 2. Meio ambiente. I. Zuffo, Alan Mario (Organizador). II. Aguilera, Jorge González (Organizador). III. Título.

CDD 630

Índice para catálogo sistemático

I. Agricultura

Pantanal Editora

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Nova Xavantina – Mato Grosso – Brasil.
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Apresentação

As áreas de Ciências Agrárias e Ciências Ambientais são importantes para a humanidade. De um lado, a produção de alimentos e do outro a conservação do meio ambiente. Ambas, devem ser aliadas e são imprescindíveis para a sustentabilidade do planeta. A obra, vem a materializar o anseio da Editora Pantanal na divulgação de resultados, que contribuem de modo direto no desenvolvimento humano.

O e-book "Pesquisas Agrárias e Ambientais Volume XV" é a continuação de uma série de volumes de e-books com trabalhos que visam otimizar a produção de alimentos, o meio ambiente e promoção de maior sustentabilidade nas técnicas aplicadas nos sistemas de produção das plantas e animais. Ao longo dos capítulos são abordados os seguintes temas:

Crescimento e desenvolvimento Helicônia; teste de vigor em sementes feijão-caupi; períodos de hipoxia durante o crescimento inicial do milho; valoração da madeira produzida por pequenos produtores florestais no semiárido mineiro; forma-jurídica e forma política-estatal: a crítica Ecossocialista à possibilidade de tutela ambiental adequada nas sociedades burguesas; cultivo orgânico de rabanete; produtividade de alface; contribuição das épocas de incorporação da glória-de-escarlate na produtividade da cenoura; crescimento inicial de feijão-caupi submetido a adubação fosfatada. Portanto, esses conhecimentos irão agregar muito aos seus leitores que procuram promover melhorias quantitativas e qualitativas na produção de alimentos e do ambiente, ou melhorar a qualidade de vida da sociedade. Sempre em busca da sustentabilidade do planeta.

Aos autores dos capítulos, pela dedicação e esforços sem limites, que viabilizaram esta obra que retrata os recentes avanços científicos e tecnológicos na área de Ciência Agrárias e Ciências Ambientais Volume XV, os agradecimentos dos Organizadores e da Pantanal Editora. Por fim, esperamos que este ebook possa colaborar e instigar mais estudantes e pesquisadores na constante busca de novas tecnologias e avanços para as áreas de Ciências Agrárias e Ciências Ambientais. Assim, garantir uma difusão de conhecimento fácil, rápido para a sociedade.

Os organizadores

Sumário

Capítulo 8

Contribution of the periods of incorporation of scarlet starglory (*Merremia aegyptia* L.), rooster tree (*Calotropis procera* L.) and pasture kill (*Senna uniflora* L.) in carrot productivity

Recebido em: 18/03/2023
Aceito em: 01/04/2023
10.46420/9786581460860cap8

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INTRODUCTION

Carrot (*Daucus carota* L.) is a vegetable from the Apiaceae family, from the tuberous root group, and is a source of dietary fiber, antioxidants, minerals and beta-carotene (pro-vitamin A) (Figueira, 2013). In the region of Mossoró, RN, Brazil, many farmers cultivate this vegetable in a family production system, using organic fertilizers of animal origin, manure (beef, goat and poultry). Carrot is one of the main vegetables produced and consumed in Brazil, with an estimated production of 480,000 t in a harvesting area of 13,000 ha (IBGE, 2017).

In these communities of family farmers, carrot cultivation is widespread, given its economic importance, given the acceptance in the local trade where it is sold at agroecological fairs. As it is an organic production within the semi-arid region, it is important that farmers who work in this activity use spontaneous species existing in the production areas, which makes the activity economically attractive

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and environmentally correct from this perspective. Moreover, in region without so many resources available to farmers with low technological level, these species become economically viable.

In this context, green manuring becomes of paramount importance in family farming systems, in the use of species that promote the same benefits as legumes, with regard to the incorporation of phytomass rich in nitrogen, contributing to the improvement of physical and soil chemistry. According to Araújo Neto et al. (2014) the contribution of plant residues to soil dynamics is largely related to the essential role of the substrate responsible for maintaining diversity and increasing soil biological activity. This biological activity contributes to a better degradation of the organic material, making essential elements available in the soil.

According to Linhares et al. (2021) the species most used as green manure are legumes, due to the fact that they produce quantities of very labile green and dry phytomass, which favors a narrow carbon-nitrogen (C/N) ratio. Spontaneous species from the semi-arid region have agronomic potential to be used as green manure due to the availability of green and dry phytomass and the levels of macronutrients, in which the scarlet starglory (*Merremia aegyptia* L.) stands out, with production of green and dry phytomass of around 42 .0 t ha^{-1} and 6.04 t ha^{-1}, respectively, with a nitrogen content of 22.4 g kg^{-1} in dry matter and a carbon-nitrogen ratio of 17/1 at the phenological stage of 126 days after emergence.

Another species with potential use as green manure, and rooster tree (*Calotropis procera*) is a species adapted to the semi-arid region with the capacity to supply phytomass throughout the year. It is an evergreen shrub and abundant in the region of Mossoró, RN, throughout the year (Linhares et al., 2022). Another species with potential to be used as green manure is the pasture kill (*Senna uniflora* L.), which occurs widely in the semi-arid region, with phytomass production of 60 and 9.0 t ha^{-1} of green and dry biomass, respectively, with a nitrogen content of 19.0 g kg^{-1} in dry matter at the beginning of the flowering period.

The use of these species as source of fertilizer for vegetable crops is extremely important, considering that these species are present within the cultivation areas in the region of Mossoró, RN, Brazil, reducing production costs, ensuring a greater return on invested capital. Thus, the objective was to study the Contribution of the periods of incorporation of scarlet starglory (*Merremia aegyptia* L.), rooster tree (*Calotropis procera* L.) and pasture kill (*Senna uniflora* L.) in carrot productivity.

MATERIALS AND METHODS

Characterization of the experimental area

The experiment was carried out in the research area of the Rafael Fernandes Experimental Farm of the Universidade Federal Rural do Semi-Árido (UFERSA), located in the district of Alagoinha, 20 km from Mossoró-RN, municipality (5° 03' 37" S and 37° 23'50" W, 70 m altitude) (Rêgo et al., 2016). According to Carmo Filho et al. (1995) and the Köppen classification, the local climate is BSwh', dry and very hot, with the dry season normally from June to January and the rainy season from February to May. The average annual precipitation is 673.9 mm, and the average relative humidity is 68.9%. The soil of the research area was classified as Red–Yellow Latosol Sandy loam (Embrapa, 2018).

Before installing the experiment, soil samples were taken at a depth of 0-20 cm, which were air-dried and sieved through a 2 mm mesh and then analyzed at the Laboratory of Soil Chemistry and Fertility at UFERSA. The results were as follows: pH (water 1:2.5) = 7.0; Ca = 2.1 cmol dm^{-3}; Mg = 0.7 cmolc dm^{-3}; K = 16.0 mg dm^{-3}; Na = 13.0 mg dm^{-3}; P = 24.0 mg dm^{-3} and M.O. = 0.5 g kg^{-1}.

Experimental Design

The experimental design used was complete randomized blocks with treatments arranged in a 5 x 3 factorial scheme, with 3 replications, with 72 plants per plot, the first factor consisting of incorporation periods (14; 28; 42; 56 and 70 days after sowing), and the second factor by the spontaneous species of the semi-arid region (scarlet starglory, rooter tree and pasture kill). Incorporations were carried out between the rows of carrots during the incorporation periods mentioned above. A standard dose of 1.6 kg m^{-2} bed was used. For this purpose, 50% of the standard dose was used at planting. The remaining 50% were incorporated into the soil according to the incorporation periods mentioned above.

The total area of the plot was 1.44 m^2 and the useful area was 0.8m², containing forty plants, corresponding to a population of 350000 plants ha^{-1}. In evaluating the crop's performance, the plants in the central rows were considered as a useful plot, excluding the first and last plants in each row and the borders (Figure 1).

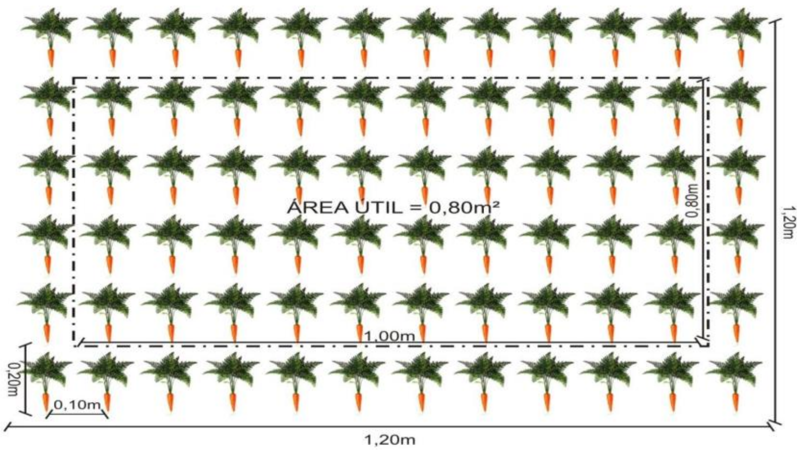

Figura 1. Graphical representation of the carrot experimental plot planted at 0.20 m x 0.10 m spacing, under different periods and types of green manure incorporated into the soil. **Photograph:** Agronomist Engineer Jessyca Duarte de Oliveira.

Installation and conduct of the experiment

Soil preparation consisted of weeding and building the beds with a manual hoe, removing vegetation from the site, raising the beds to a height of 0.3 m for planting (Figure 2). During the period of incorporation of spontaneous species, after sowing, irrigation was carried out in order to maintain soil moisture between 50 and 70% of field capacity, which is an ideal condition for the nitrification process (Novaes et al., 2007). Thirty days after emergence, thinning was performed, leaving one plant per hole. The carrot cultivar planted was Brasília, recommended for the semi-arid conditions of the Brazilian Northeast, as it has high productivity (Lopes et al., 2008). This cultivar has dark green foliage, cylindrical roots with a light orange color and a low incidence of green or purple shoulder, resistance to heat, late blight by Alternaria and premature bolting.

Figure 2. Representation of blocks with experimental plots of carrots planted in spacing of 0.20 m x 0.10 m under different periods of incorporation and types of green manures. **Photograph:** Agronomist Engineer Jessyca Duarte de Oliveira.

Scarlet starglory, rooter tree and pasture kill were collected from native vegetation near the UFERSA campus, at the beginning of the flowering period, when the plant has the highest concentration of nutrients (Figure 3). The whole plant was harvested for the scarlet starglory and pasture kill species, for the rooter tree species, the cut occurred from the apex to the green insertion of the stem, this being the correct way to obtain this material, given that the lignified part contributes to the decrease in the nitrogen content and consequently the increase in the carbon/nitrogen ratio, not being ideal for vegetable fertilization. Then, grinding was carried out in a conventional forage machine, obtaining segments of 2.0 and 3.0 cm, placed to dry on the ground, obtaining material with a moisture content of 10; 12.0 and 13.0% for scarlet starglory, rooster tree and pasture kill, respectively.

(A) **(B)** **(C)**

Figure 3. Illustration of the scarlet starglory (*Merremia aegyptia* L.) (**A**); pasture kill (*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.

On the occasion of the installation of the experiment, five samples of each of the species were taken (scarlet starglory, rooster tree and pasture kill), sent to the soil fertility laboratory of the department of Agronomic and Forestry Sciences, for analysis of the following characteristics : nitrogen (N); phosphorus (P); potassium (K+); calcium (Ca2+); magnesium (Mg2+) and carbon/nitrogen ratio. For scarlet starglory (*Merremia aegyptia* L.) the results were: 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 and nitrogen/carbon ratio (23/1). For rooster tree (*Calotropis procera*): 20.0 g kg^{-1} N; 13.0 g kg^{-1} P; 20.0 g kg^{-1} K; 11.0 g kg^{-1} Ca; 13.5 g kg^{-1} Mg and nitrogen/carbon ratio (29/1). For pasture kill (*Senna uniflora* L.): 21.5 g kg^{-1} N; 14.0 g kg^{-1} P; 11.0 g kg^{-1} K; 13.2 g kg^{-1} Ca; 15.0 g kg^{-1} Mg and nitrogen/carbon ratio (26/1).

At the time of harvest, the harvested plants were taken to the post-harvest laboratory of the Department of Agronomic and Forestry Sciences to determine the following characteristics: plant height (determined in a sample of twenty plants in the field, using a millimeter ruler, measuring from the base to the apex, expressed in cm $plant^{-1}$); number of stems (performed by counting the number of stems of twenty plants, expressed in $plant^{-1}$ units); length (measuring twenty carrots longitudinally with a millimeter ruler, expressed in cm); diameter (Using the same twenty carrots from the length assessment, expressed in mm); Commercial productivity (the commercial productivity of carrots, quantified from the fresh mass of roots free of cracks, bifurcations and mechanical damage, weighed on a 1.0g precision scale, expressed in kg m^{-2}) and dry mass of roots (The dry mass of shoots and roots was obtained after drying in an oven with forced air circulation, with temperature regulated at 65 ºC, until reaching a constant mass and expressed in kg m^{-2}).

Statistical Analysis

Statistical analysis was performed according to conventional methods of analysis of variance (Banzatto; Kronka, 2006), using ESTAT statistical software. The response curve fitting procedure was performed using the ESTAT Software.

RESULTS AND DISCUSSION

There was interaction between periods of incorporation and types of green manure for the commercial productivity of carrots, with no interaction for the other characteristics (Table 1).

An ascending curve in shoot height was observed in relation to the different incorporation periods, with an average increase of 13.3 cm plant^{-1} between the longest period (55 days) with maximum value of 31.1 cm plant^{-1} (Figure 4). In relation to the types of green manures, a statistical difference was observed, with scarlet starglory statistically superior to rooster tree and pasture kill, with mean values of 30.0; 28.8 and 27.7 cm plant^{-1}, respectively (Table 2). Plant height is a characteristic greatly influenced by nitrogen, as this element is responsible for leaf expansion. The green manures used had a nitrogen concentration above 20 g kg^{-1} in dry matter similar to that of leguminous species.

Table 1. F values for plant height, expressed in cm plant-1 (AT), number of stems plant^{-1} (NH), carrot length, expressed in cm (CR), carrot diameter, expressed in mm (DR), commercial productivity, expressed in kg m^{-2} (PC) and dry matter of carrot roots, expressed in kg m^{-2} (RC).

Causes of variation	GL	AT	NH	CR	DR	PC	MSR
Incorporation times (A)	4	30.1**	18.0**	19.20**	11.8**	25.6**	20.2**
Green manures (B)	2	18.2**	20.0**	16.45**	12.7**	17.6**	2.1^{ns}
A X B	8	1.4^{ns}	1.8^{ns}	0.17^{ns}	0.5^{ns}	18.3**	1.6^{ns}
Treatments	14	12.2*	20.2**	16.65*	16.2*	19.5**	10.4**
Blocks	2	1.6^{ns}	2.1^{ns}	5.07^{ns}	11.5*	2.1^{ns}	2.2^{ns}
Residue	28	------	-------	--------	-------	------	-------
CV (%)		15.9	10.15	9.10	10,56	11.4	9.85

**= P<0.01; * = P<0.05;^{ns} = P>0.05

A similar behavior was observed by Oliveira (2009), who evaluated the agroeconomic viability of carrots fertilized with scarlet starglory, found average height of 30.8 cm plant^{-1}. Nogueira et al. (2015) studying the use of carnauba straw as a physical soil conditioner on carrot yield, found a plant height of 33.7 cm plant^{-1} with an application of 16.0 t ha^{-1} of carnauba straw, higher than that mentioned search.

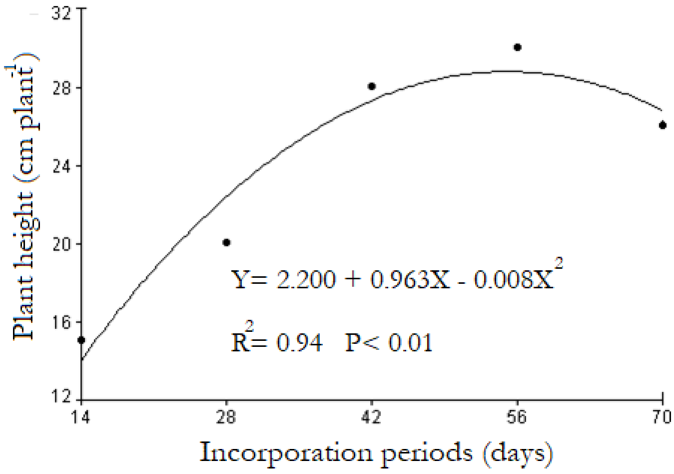

Figure 4. Incorporation periods of spontaneous semiarid species in carrot plant height.

For the number of stems per plant, a maximum point was observed, in the period of 52 days, with a value of 11.0 stems plant^{-1}, with an average increase of 5.0 stems plant^{-1} in relation to the lowest incorporation period (14 days) (Figure 5). Among the green manures, a statistical difference was observed, with mean values of 11.4; 10.8 and 10.8 stems plant^{-1}, respectively for scarlet starglory, rooster tree and pasture kill (Table 2). Oliveira et al. (2011) found no variation in the number of leaves plant^{-1} depending on the different amounts of scarlet starglory incorporated into the soil, with an average value of 6.8. Like Teófilo et al. (2009), where they evaluated the growth of three carrot cultivars (Alvorada, Brasília and Esplanada), and found an average of seven stems per plant at 84 days after sowing, and Nogueira et al. (2015) studying the use of carnauba straw as a physical soil conditioner on carrot yield, found a number of leaves of 9.8 plant^{-1} plant height of 33.7 cm plant^{-1} with the application of 16.0 t ha^{-1} of carnauba straw, higher than that research, these works lower than this research, works that are inferior to this research.

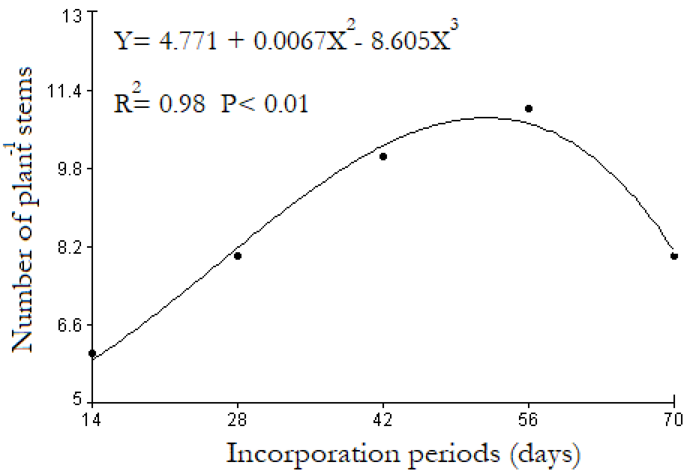

Figure 5. Incorporation periods of spontaneous semiarid species in carrot number of stems.

With regard to maximum root length and diameter, these characteristics were influenced by the green manure incorporation periods, with maximum values of 19.8 and 4.3 cm plant^{-1} and 43 in the period of 53 and 51 days, respectively. (Figures 6A and 6B).

In relation to the types of green manures, scarlet starglory was statistically superior to rooter tree and pasture, with mean values of 21.4; 19.0 and 19.2, respectively for length. For the diameter, the mean values were 4.0; 3.4 and 3.5 for scarlet starglory, rooster tree and pasture kill, respectively (Table 2). These values are within commercial standards at the agroecological fair in Mossoró, RN, Brazil, where carrots have a length and diameter of 12 to 18 cm with a diameter of 40 mm.

The incorporation period is of paramount importance, considering that if there is no synchronization between the moment of demand of the crop and the moment of availability of nutrients, the crop will not be able to express its productive potential (Linhares et al., 2012 and Linhares 2009). Nogueira et al. (2015) studying the use of carnauba straw as a physical soil conditioner on carrot yield, found length and root diameter of 18.2 cm and 40 mm, respectively, which is lower than the aforementioned research.

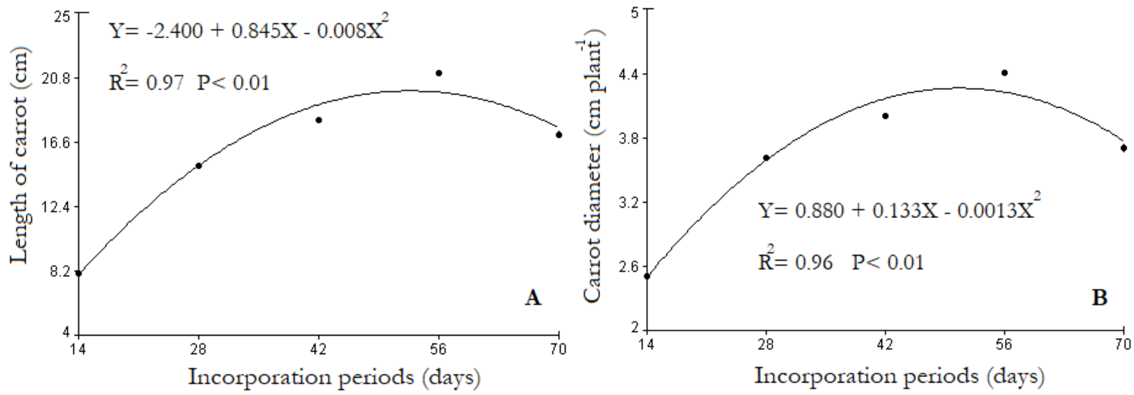

Figure 6. Periods of incorporation of spontaneous semiarid species in the length (A) and diameter (b) of the carrot.

Unfolding the incorporation periods within the green manure species, a maximum point was observed in the commercial productivity of carrots with maximum values of 2.4; 2.2 and 2.4 kg m^{-2} of bed in periods of 53; 55 and 56 days of incorporation for scarlet starglory, rooster tree and pasture kill, respectively (Figure 7).

When the splitting of green manure species was carried out within the incorporation periods, the period of 56 days was the one that presented the highest average values (2.5; 2.0 and 2.0 kg m^{-2} of bed) for scarlet starglory, rooter tree and pasture kill, respectively (Table 3). These productivity values are within the average productivity of family farmers in the region of Mossoró, RN, Brazil, who work in the organic production system.

Linhares et al. (2014) studying the organic cultivation of carrot fertilized with rooter tree(*Calotropis procera*) in amounts and forms of application found an increase for total productivity with the application of silk flower, with average values of 34.6 t ha^{-1} and 3.8 kg m^{-2} of bed, as well as, Paulus et al. (2012) studying the production and acceptability of carrots under organic cultivation in winter and summer, found commercial productivity of 20 t ha^{-1}, equivalent to 2.0 kg m^{-2} of seed bed, the results being inferior to this research.

Tabela 2. Height, expressed in cm $plant^{-1}$ (AT), number of stems, expressed in $plant^{-1}$ units (NH), length, expressed in cm (COMP), diameter, expressed in cm (DIÂM) and dry matter, expressed in kg m^{-2} (MMS) of carrot roots under different periods of green manure incorporation.

Types of green manures	AT	NH	COMP	DIÂM	MMS
Scarlet starglory (*Merremia aegyptia*)	30.0 a	11.4 a	21.4 a	4.0 a	0.20 a
Rooter tree (*Calotropis procera*)	28.8 b	10.8 b	19.0 b	3.4 b	0.20 a
Pasture Kill (*Senna uniflora*)	27.7 b	10.8 b	19.2 b	3.6 b	0.19 a
Averages of green manures	28.8	11.0	19.8	3.6	0.20
CV (%)	10.3	9.10	10.5	13.2	12.5

Means followed by different letters in the column differ at the 5% level of probability by Tukey's test.

Regarding dry matter, there was an increase depending on the periods of incorporation, with greater accumulation at 56 days, with a maximum value of 0.20 kg m^{-2} of bed (Figure 8). There was no statistical difference between species with mean values of 0.20; 0.20 and 0.19 kg m^{-2} of bed for scarlet starglory, rooster tree and pasture kill, respectively (Table 2).

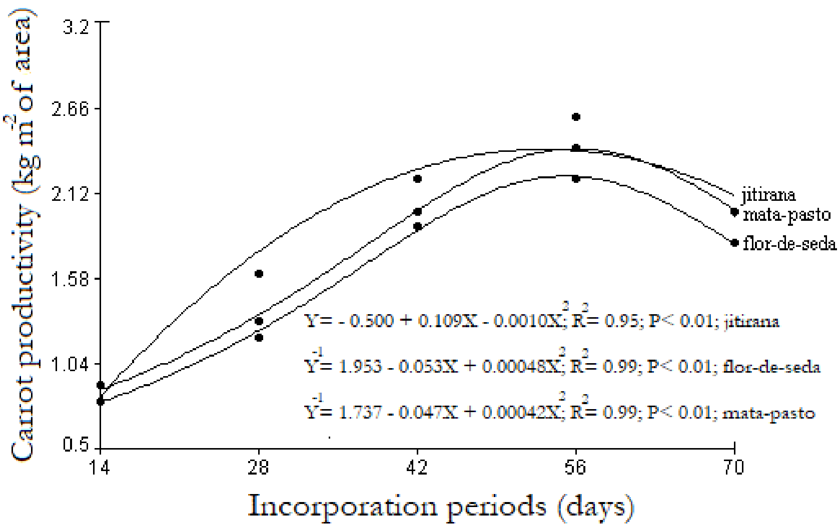

Figure 7. Unfolding of periods of incorporation into green manures (scarlet starglory; rooter tree and pasture kill) on carrot productivity.

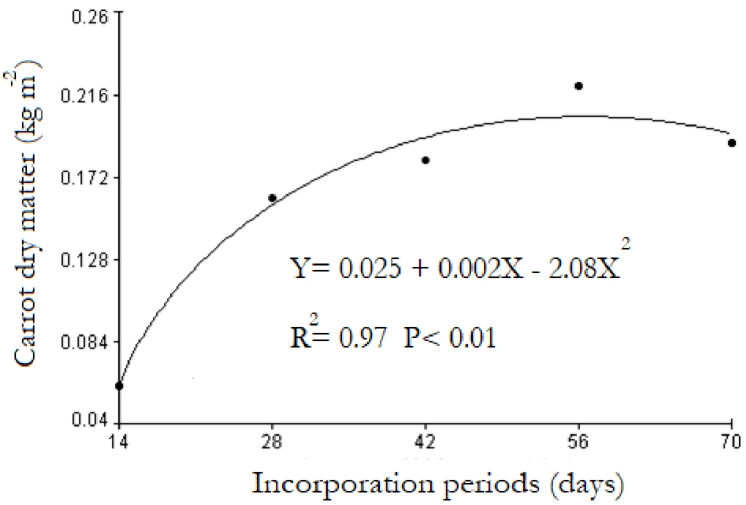

Figure 8. Incorporation periods of spontaneous semiarid species in carrot dry matter.

Table 3. Unfolding of types of green manure within periods of incorporation in commercial productivity of carrots.

Characteristic	Types of green manures	Incorporation periods (days)				
		14	28	42	56	70
Productivity (kg m^{-2})	Scarlet starglory (*Merremia aegyptia*)	0.6a	1.5a	1.8a	2.5a	2.1a
	Rooter tree (*Calotropis procera*)	0.5a	1.2b	1.5b	2.0b	1.8b
	Pasture Kill (*Senna uniflora*)	0.4a	1.3b	1.5b	2.0b	1.7b

Means followed by different letters in the column differ at the 5% level of probability by Tukey's test.

FINAL CONSIDERATIONS

The highest carrot productivity was observed in the incorporation periods of 53; 55 and 56 days of incorporation after sowing, with values of 2.4; 2.2 and 2.4 kg m^{-2} of area for scarlet starglory, rooster tree and pasture kill.

The period of incorporation of spontaneous species from the semi-arid region to the soil is of great importance for the full development of the carrot, promoting an increase in the evaluated characteristics.

ACKNOWLEDGMENT

Special thanks to the jitirana (*Merremia aegyptia* L.) research group, committed to the study of spontaneous species from the semi-arid region as green manure in olericolas, beyond Department of Agronomic and Forestry Sciences the Federal Rural SemiArid University (UFERSA), for the support to conduct in the conductings research.

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