

## Use of *Senna uniflora* as Organic Fertilizer in the Production of Lettuce in the Brazilian Semiarid

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Received: February 4, 2020

Accepted: March 21, 2020

Online Published: April 15, 2020

doi:10.5539/jas.v12n5p48

URL: <https://doi.org/10.5539/jas.v12n5p48>

### Abstract

The use of plant resources available on the farm, and of great relevance to the family farmers of the Northeastern semi-arid region, Brazil. The experiment was carried in the experimental area of the agricultural science center, Universidade Federal Rural do Semi-árido (UFERSA), Mossoró, Brazil, with the objective of evaluating use of *Senna uniflora* as organic fertilizer in the production of lettuce in the Brazilian semiarid, from October 2014 to February 2015. The experimental design of randomized complete blocks with the treatments arranged in  $4 \times 4$  factorial scheme, with three replicates. The first factor consisted of amounts *S. uniflora* (0, 1.8, 3.6, and 5.4 kg m<sup>-2</sup> of dry matter) with four incorporation times into the soil (0; 28; 56 and 84 days before transplanting lettuce). The transplanted lettuce cultivar went was the “Elba”. The evaluated characteristics were the following: plant height, diameter plant, number of leaves per plant, green mass production and dry mass production. The best agronomic efficiency was obtained with soil incorporation of 5.4 kg m<sup>-2</sup> in the incorporation period of 56 days after transplanting, with phytomass production of 235.2 g plant<sup>-1</sup>. *S. uniflora* becomes a viable option to be used as an organic fertilizer in lettuce production.

**Keywords:** spontaneous species, agroecological production, family farming

### 1. Introduction

Soil degradation with chemical fertilization causes a decrease in the productive capacity, altering the structure and its soil fauna, besides provoking an entire erosive process, leading to losses of soil and nutrients Sustainable agriculture is the basis of agroecological production, a system of production without the use of chemical inputs. In the semi-arid region of the Brazilian Northeast, family farmers potentiate their production with the use of animal fertilizers, cattle manure and goat. However, because it is a resource with little availability among farmers, it contributes to increasing production costs (Linhares et al., 2014).

In the semi-arid region, several spontaneous species appear annually in the rainy season. Among the species, *Senna uniflora* L., legume that occurs in the rainy season, with spontaneous predominance in areas of agricultural cultivation, is considered as an infesting plant, with dry biomass production of 4.0 t/ha and nitrogen (N) content of 18.5 g kg<sup>-1</sup>, 60 days after the emergency, being harvested and used as organic fertilizer in the production of vegetables (Linhares, 2013).

Among the cultivated vegetables, the lettuce (*Lactuca sativa* L.) of the family Cichoriaceae stands out, being produced all over Brazil using several cultivars, of which about eighteen are national (Filgueira, 2012). This vegetable has played an increasingly important role in the list of food products for the families, being sold in nature in supermarket and agroecological fairs.

According to Linhares (2013) the practice of incorporating or leaving the organic residue in cover brings benefits to the soil-plant system. In addition, it guarantees the producer success in the production and optimization of the resources used. The organic fertilization with spontaneous Caatinga species is an alternative for small farmers in the semi-arid region. Aiming an agroecological production, many researchers and farmers seek for sustainable and diversified agricultural systems with low chemical inputs (Altieri, 2012).

The study of plant species of the Brazilian Northeast as an organic fertilizer is of great importance because they are plants that are present in the growing areas. The agronomic efficiency of these species as organic fertilizer has been verified in some crops, as in arugula (Linhares et al., 2009, 2010); lettuce (Linhares et al., 2011a; Góes et al., 2011; Bezerra Neto et al., 2010); carrot (Linhares et al., 2011b); coriander (Linhares et al., 2012, 2013, 2018); cabbage (Linhares et al., 2014) and beet (Linhares et al., 2015).

Given the importance of the use of Northeastern semiarid species as organic fertilizer in the production of vegetables, the following research hypothesis was presented: The yield of lettuce depends on the greater amount and period of incorporation of *S. uniflora*. Therefore, it was aimed, to study organic fertilization with Use of *S. uniflora* as organic fertilizer in the production of lettuce in the Brazilian semiarid.

## 2. Material and Methods

### 2.1 Study Area

The study area was located at the Rafael Fernandes experimental farm, in the period from October 2014 to February 2015, in the district of Alagoinha (5°03'37" S, 37°23'50" W), northwest of Mossoró, State of Rio Grande do Norte, Brazil, which has approximately 400 hectares (Rêgo et al., 2016). The production system is located in the semi-arid region of Brazil.

### 2.2 Characterization of Soil and Climate

The soil of the experimental area was classified as Eutrophic Red Yellow Argissolo, Caatinga hyperxerophilic phase and flat relief (Embrapa, 2018). According to Kottek et al. (2006) and the classification of Köppen, the local climate is BSw<sup>h</sup>, 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 0-20 cm layer and then sent to be processed and analyzed in the Universidade Federal Rural do Semi-árido (UFERSA) Water, Soil and Plant Analysis Laboratory, providing the following results: pH (water 1:2,5) = 6.80; exchangeable cations Ca (calcium) = 0.60 cmol<sub>c</sub>dm<sup>-3</sup>; Mg (magnesium) = 0.80 cmol<sub>c</sub> dm<sup>-3</sup>; K (potassium) = 32.5 mg/dm<sup>3</sup>; Na (sodium) = 9.4 mg/dm<sup>3</sup>; P (phosphorus) (Mehlich) = 2.8 mg dm<sup>-3</sup>; organic matter (OM) = 0.75 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<sup>3</sup>.

### 2.3 Experimental Design and Treatments

The experimental design of randomized complete blocks with the treatments arranged in 4 × 4 factorial scheme, with three replicates. The first factor consisted of different amounts of *S. uniflora* incorporated into the soil (0.0, 1.8, 3.6 and 5.4 kg m<sup>-2</sup>) the second factor to the times of incorporation into the soil (0.0, 28, 56 and 84 days before the transplanting of lettuce).

The propagation of the lettuce seedlings was done in expanded polyethylene trays of 128 cells, containing vermiculite substrate. The seedlings were grown in a greenhouse for 15 days with 50% shading until they reached about 10 cm in height. Each plot had a total area of 1.96 m<sup>2</sup> (1.40 m × 1.40 m) containing 49 lettuce plants spaced of 0.20 m × 0.20 m. The harvest area of each plot was 1.0 m<sup>2</sup> (1.00 m × 1.00 m) containing 25 lettuce plants.

### 2.4 Nutrient Content of *S. uniflora*

*S. uniflora* was harvested in June 2014, in an area of semi-arid shrub vegetation in the flowering period. Soon after being harvested the material was crushed and dried in the sun, being packed in raffia bags to be used as an organic fertilizer. The material was sent to the soil fertility and nutrition laboratory at the UFERSA Agricultural Sciences Center, with a chemical concentration of 16.5 g/kg of N; 870 g/kg of OM; 402 g/kg of organic carbon (C); 24/1 C/N ratio; 0.68 g/kg of P; 5.87 g/kg of K; 1.45 g/kg of Na; 0.23 g/kg of Ca and 0.05 g/kg of Mg.

During the period of stay of residues in the soil, prior to planting, irrigations were made in order to maintain soil moisture at 70% of field capacity, and this is an ideal condition for nitrification (Novais 2007).

### 2.5 Evaluation of the Characteristics Studied

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.

The characteristics evaluated were as follows: plant height (was measured from twenty plants of the useful area, using millimeter rule, being expressed in cm/plant), diameter plant (was estimated through the distance between the opposing edges of the leaf disc, measured with a ruler and expressed in centimeter of twenty plants), number of leaves per plant (was measured with a sample of twenty plants, with result expressed in leaves/plant), green mass production (was obtained by removal all plants of the useful area, weighed in a precision scale of 1.0 g, expressed in g/plant) and dry mass production (measured by determining the dry matter content of lettuce in g/kg, multiplied by green mass production in  $m^2$ , expressed in g/plant).

### 2.6 Statistics Analysis

Analyses of variance were conducted for the evaluated characteristics using the ESTAT software (Kronka & Banzato, 1995). Response curve adjustment for the quantitative factor was performed using the Table Curve software (Systat Software Inc., 2002). 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 ( $R^2$ ), significance of the regression parameters, using the t test at  $p < 0.01$  probability).

## 3. Results and Discussion

### 3.1 Analysis of Variance

There was interaction between the amounts and periods of incorporation of the *S. uniflora* in the characteristics of the diameter of the plant and green mass of lettuce. However, there was an isolated effect at the level of probability ( $p < 0.01$ ) in the different amounts of *S. uniflora* for plant height, number of leaves/plant and dry mass. In relation to the incorporation periods, there was a difference in the level of probability ( $p < 0.01$ ) for height and number of leaves per plant and dry mass (Table 1).

Table 1. F values for plant height, expressed in cm/plant (BH), number of leaves/plant, expressed in units/plant (NL), diameter for plant, expressed in cm (DP), *green mass production* (GP) and dry mass (DM) of lettuce under different amounts and times of incorporation of *Senna uniflora*

Causes of variation	GL	BH	NL	DP	GP	DM
Amounts (A)	3	10.82**	9.65**	11.45**	11.70**	13.42**
Incorporation (I)	3	8.78**	10.48**	7.85**	13.22**	8.45**
A × B	9	1.56 <sup>ns</sup>	0.41 <sup>ns</sup>	12.5**	17.2**	0.8 <sup>ns</sup>
Treatments	15	-	-	-	-	-
Bloks	2	6.50*	5.1*	10.2**	17.2**	14.5**
Waste	30	-	-	-	-	-
CV (%)	-	13.7	19.4	16.8	18.3	13.5

Note. \*\* =  $P < 0.01$ , statistical significance at 1% probability, \* =  $P < 0.05$ , statistical significance at 5% probability and <sup>ns</sup> = not significant.

### 3.2 Plant Height, Leaves per Plant and Diameter

There was an increase in height and number of leaves per plant, with the addition of *S. uniflora*, reaching maximum values of 25.02 cm/plant and 28.8 leaves/plant, in the amount of 3.6 kg/ $m^2$ , occurring decrease up to the amount of 5.4 kg/ $m^2$  (Figures 1A and 1B). For the periods of incorporation, 54 days before planting promoted the greatest increase in plant height and leaves, with maximum values of 23.65 cm/plant and 31.46 leaves/plant (Figures 2A and 2B).

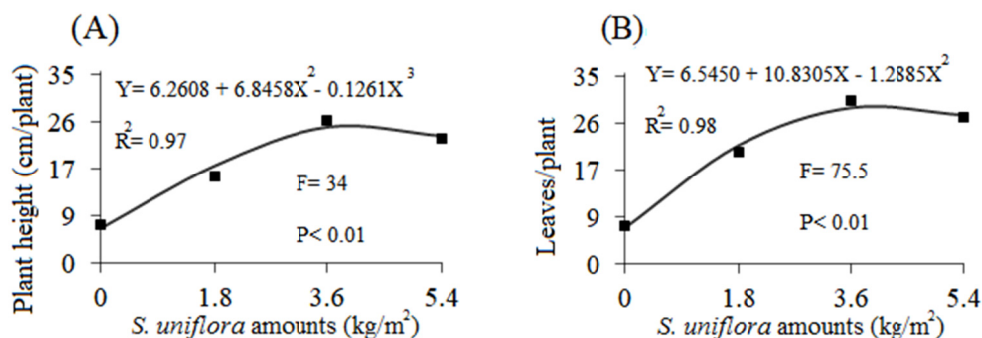


Figure 1. Plant height (A) and leaves/plant of lettuce (B) in function of amounts of *S. uniflora* incorporation into the soil

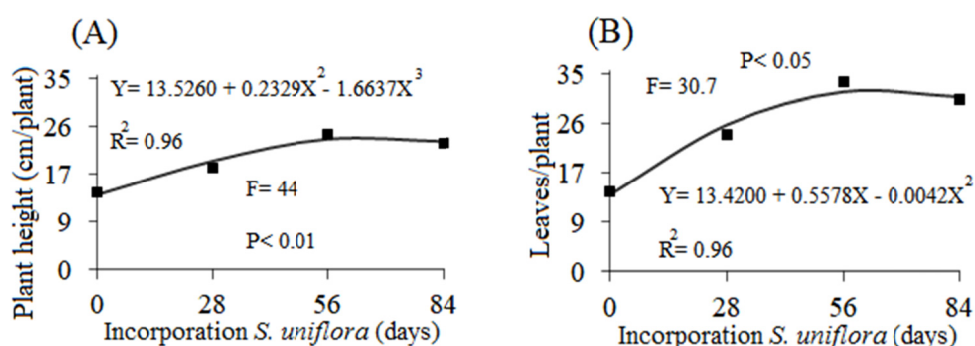


Figure 2. Plant height (A) and leaves/plant of lettuce (B) in function the incorporation periods of *S. uniflora*

The higher plant height was probably due to higher availability of nitrogen at the time of increased plant demand. The number of leaves is a characteristic of great importance for leafy vegetables, in view of being this organ responsible for photosynthesis, besides being the commercialized part of the vegetable. The higher plant height was probably due to higher availability of nitrogen at the time of increased plant demand. higher value was observed by Góes et al. (2011) studying the productive performance of lettuce at different amounts and times of decomposition of dry scarlet starglory, they found plant height of 25.3 cm/plant. Oliveira et al. (2009) obtained lower results using organic fertilizers in the culture of the lettuce, obtained an average of 24.6 leaves using organic manure management of mucuna-preta.

Santi et al. (2013) Agronomic performance of crisphead lettuce fertilized with filter cake in protected environment, found an average value of leaves of 27.8 units/plant, being superior to said research.

Partitioning of the amounts of *S. uniflora* within of the periods of incorporation was observed in the diameter of the lettuce, with values of 19.10; 19.02; 24.02 and 22.33 cm, in the amount of 3.6 kg/m<sup>2</sup>, corresponding to the incorporation periods of 0; 28; 56 and 84 days after sowing (Figures 3A, 3B, 3C and 3D). For the incorporation periods, there was partitioning within the amounts of *S. uniflora*, with values of 16.16, 19.80 and 22.17 in the amounts of 1.8, 3.6 and 5.4 kg/m<sup>2</sup>, respectively (Figures 4A, 4B and 4C).

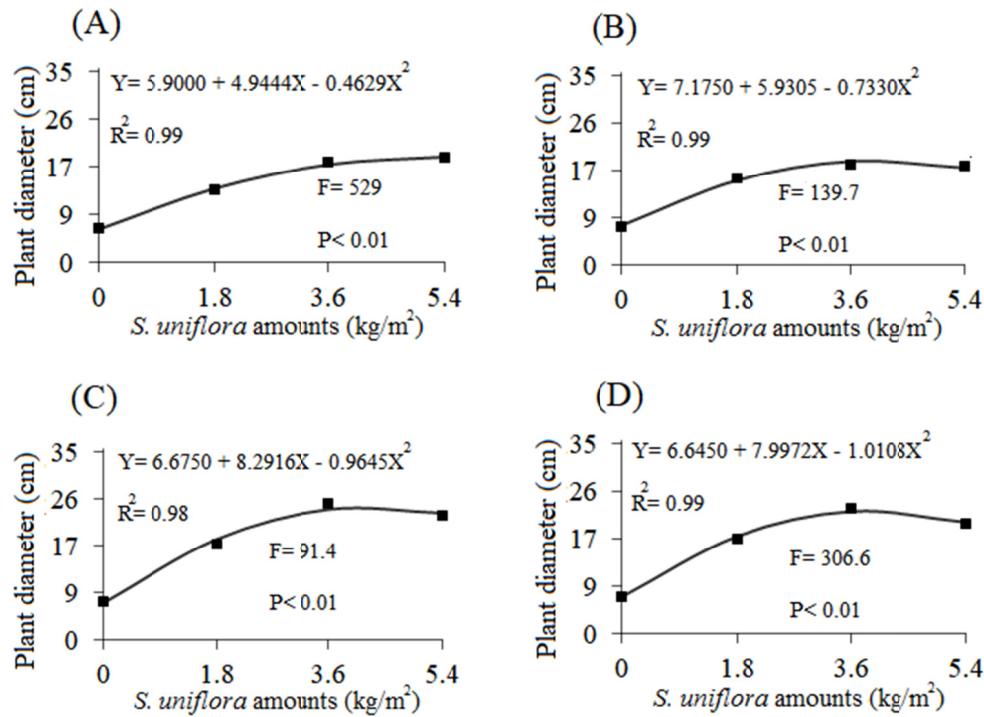


Figure 3. Diameter of lettuce plant, in function of partitioning of the amounts of *Senna uniflora* within of the periods of 0 day (A), 28 days (B), 56 days (C) and 84 days (D) of incorporation in the soil

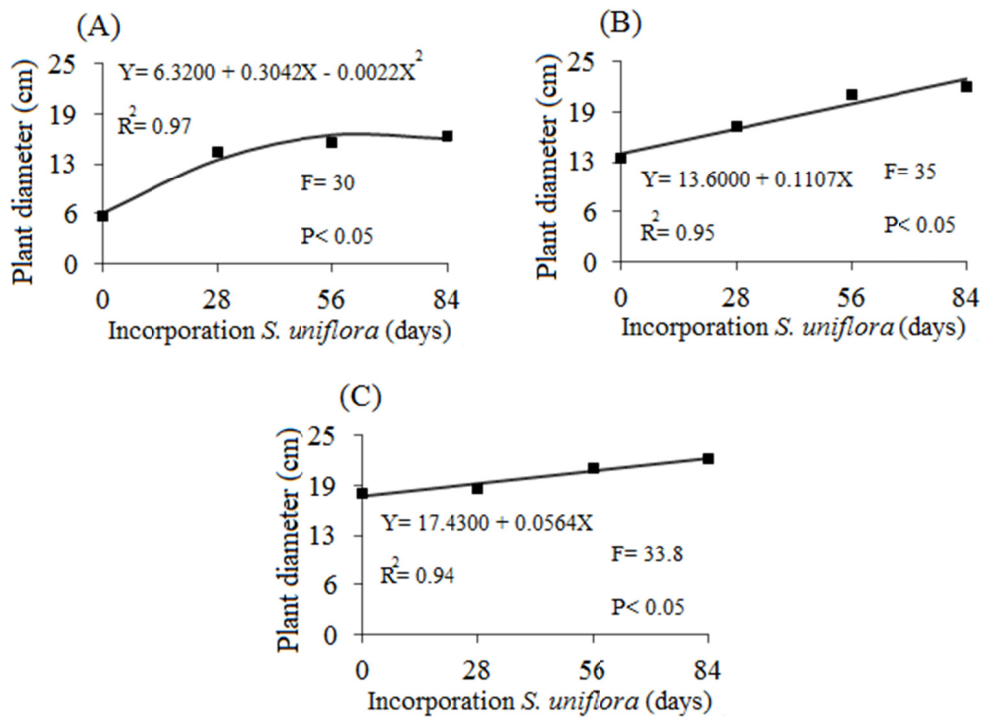


Figure 4. Diameter of lettuce plant, in function of partitioning of the incorporation periods in the amounts of 1.8 (A), 3.6 (B) and 5.4 kg/m² (C) of *Senna uniflora* incorporation in the soil

At the agroecological fair in northeastern Brazil, the commercial diameter of commercialized lettuce is between 20 and 25 cm. Santi et al. (2013) evaluating agronomic performance of crisphead lettuce fertilized with filter cake in

protected environment with plant diameter of 29.5 cm in tainá cultivar. In a similar study, Linhares (2009), cultivating the lettuce cultivar ‘Babá de Verão’ between winter and spring in northeastern Brazil, achieved a plant diameter of 22.90 cm, fertilizing with 15.6 t ha<sup>-1</sup> of roostertree manure incorporated into the soil 15 days before transplanting.

### 3.3 Green Mass Production and Dry Mass

Increasing linear function and a quadratic function were adjusted for partitioning of the amounts of *S. uniflora*, within the periods of incorporation, with maximum values of 171.0; 203.8; 235.2 and 176.8 g/plant in the green mass, for the incorporation periods of 0; 28; 56 and 84 days after transplanting, respectively (Figures 5A, 5B, 5C and 5D). Partitioning incorporation periods within of amounts of *S. uniflora* with maximum values of 160; 165 and 192 g/plant in the green mass, for the amounts of 1.8; 3.6 and 5.4 kg/m<sup>2</sup> (Figures 6A, 6B and 6C).

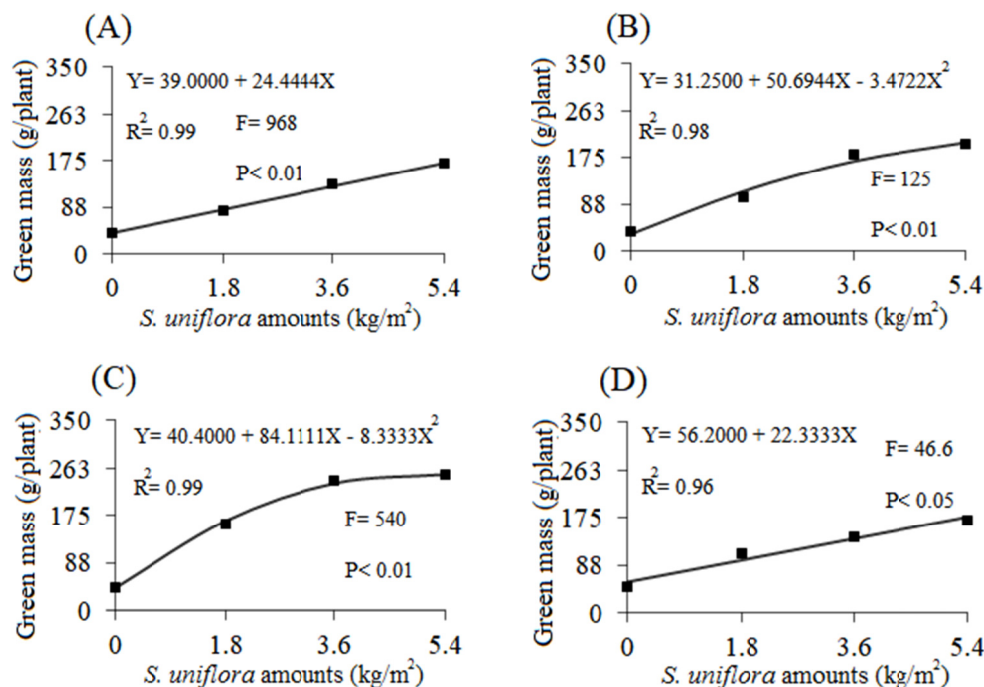


Figure 5. Green mass of lettuce, in function of partitioning of amounts of *Senna uniflora* in the times of incorporation into the soil of 0 day (A), 28 days (B), 56 days (C) and 84 days (D) of incorporated before transplanting

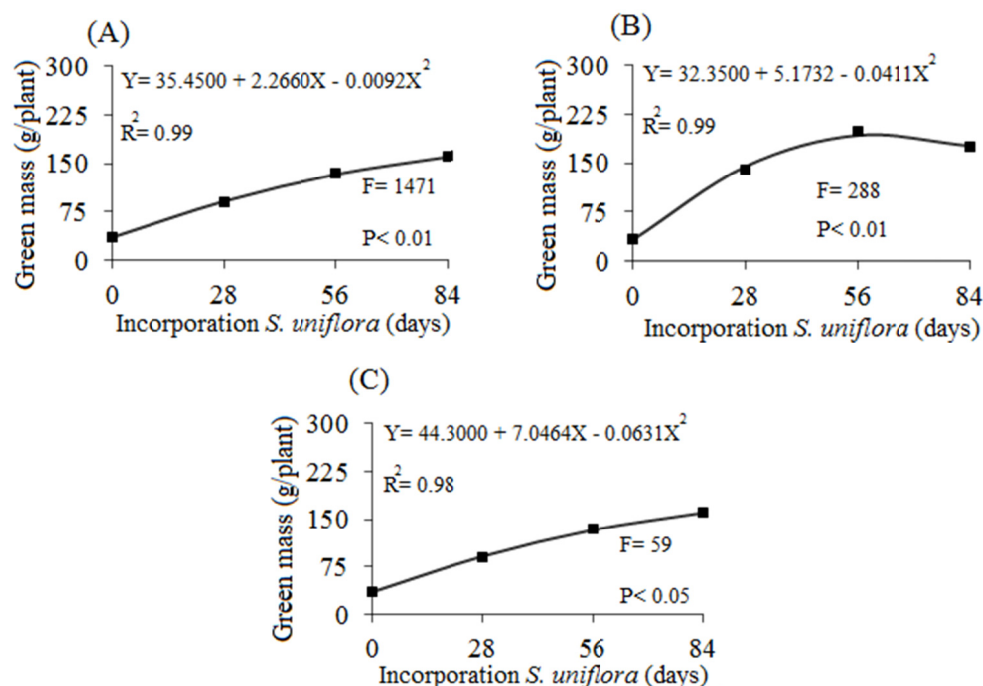


Figure 6. Green mass of lettuce, in function of partitioning of incorporation of *Senna uniflora* in the amounts of 1.8 kg/m<sup>2</sup> (A), 3.6 kg/m<sup>2</sup> (B) and 5.4 kg/m<sup>2</sup> (C)

The greatest production of green mass occurred at 56 days before transplanting, with a reduction in the time of 84 days, probably the synchronization of nutrient availability in the time of greatest requirement of the crop, was determinant for such an event. The use of *S. uniflora* becomes an economically feasible option, due to the availability of this resource in the farms, reducing the costs in the acquisition of agricultural inputs. It is worth noting that this species appears spontaneously in the rainy season every year, guaranteeing the availability of resources to the producer.

Lower values were found by Góes et al. (2011) evaluating the productive performance of lettuce at different amounts and times of decomposition of dry scarlet starglory, with production of 66 g/plant incorporating 0.8 kg/m<sup>2</sup> of scarlet starglory. Linhares et al. (2009) studying the influence of scarlet starglory in coverage with green manuring on the agronomic performance of lettuces, with a green mass of 120 g/plant at 42 days of incorporation. Silva et al. (2018) evaluating green manure and spatioal arrangement in the sustainability improvement of lettuce-beet intercrops, found fresh lettuce mass equivalent to 130 g/plant, inferior value to said research.

Higher value was obtained by Meneses et al. (2016) studying the growth and productivity of lettuce under different types of soil cover, found a fresh mass of 334 g when using as cover, vegetable mass. Probably, the soil cover promoted satisfactory soil conditions for the best development of the crop.

The higher production of lettuce is probably due to the improvement of soil properties, which are fundamental to the good development of plants and crop production (Costa et al., 2013; Oliveira et al., 2014).

There was an accumulation of 37.5 and 30.3 g/plant dry mass as a function of the amount (5.4 kg/m<sup>2</sup>) in the incorporation period of 84 days after transplanting (Figures 7A and 7B).



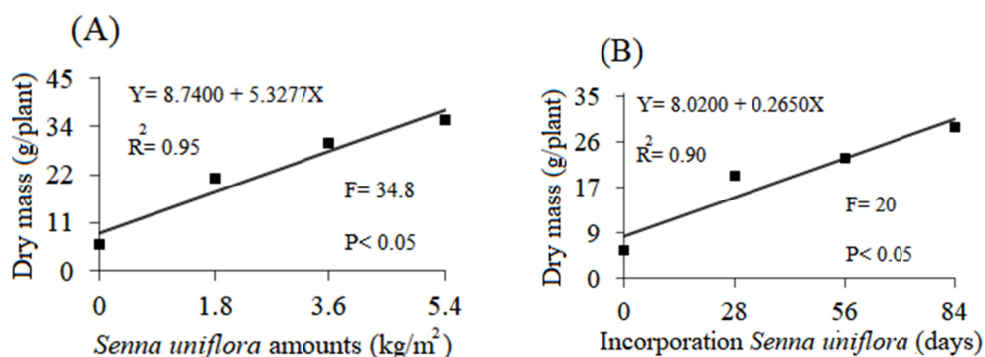


Figure 7. Dry mass of lettuce, in function of amounts (A) and times of incorporation into the soil (B) of *Senna uniflora*

The dry mass is a characteristic that reflects the growth of the vegetable (Taiz & Zeiger, 2017), being of great importance in the vegetative evaluation.

Neves et al. (2018) evaluating two successive cultivation of lettuce fertilized with bovine manure in the presence and absence of mung bean, with a dry mass of 16.5 g/plant, in organic production system, which differs from said research. Oliveira et al. (2014), assessing the chemical characteristics of the soil and the production of lettuce biomass fertilized with organic compounds, found a shoot dry matter of 5.0 g/plant. This inferiority probably occurs due to the source of fertilizer used.

#### 4. Conclusions

Considering the result of the research, it was observed variation of the amounts and periods of incorporation of the biomass of *S. uniflora*. The best agronomic efficiency was obtained with soil incorporation of 5.4 kg m<sup>-2</sup> in the incorporation period of 56 days after transplanting, with phytomass production of 235.2 g/plant.

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