

## ECONOMIC EVALUATION OF LETTUCE FERTILIZED WITH BIOMASS OF *Calotropis procera* IN TWO GROWING SEASONS<sup>1</sup>

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**ABSTRACT** - Vegetable production is an impactful activity, characterized by intensive land use, high input demand, and it requires strategic management adoption, especially in sustainable production systems, where the pillars of sustainability (environmental, social and economic) must be respected. In this sense, the objective of this work was to evaluate economic indicators of lettuce production using *Caatinga* spontaneous species (*Calotropis procera*: rooster tree) as fertilizer and cultivated in two seasons (spring and fall-winter) in the municipality of Serra Talhada, PE. The experimental design was in randomized blocks, arranged in a 4 x 4 factorial scheme, with three replications. The first factor was the biomass amounts of green manure (5.4, 8.8, 12.2 and 15.6 t ha<sup>-1</sup> on a dry basis); and the second was their incorporation times in the soil (0, 10, 20 and 30 days before lettuce transplanting). The green mass yield, production costs, rate of return, and net profit margin were determined. The amount 15.6 t ha<sup>-1</sup> of *C. procera* allowed higher profitability to the organic production of lettuce, and it is considered ideal to incorporate the green manure 11 (spring) and 15 (fall-winter) days before transplanting the vegetable. The spring crop promoted a superior economic return to the fall-winter planting, demonstrating economic viability even in the smallest amount of *C. procera*.

**Keywords:** *Lactuca sativa* L. Rooster tree. Organic farming. Profitability.

## AVALIAÇÃO ECONÔMICA DA ALFACE ADUBADA COM BIOMASSA DE *Calotropis procera* EM DUAS ÉPOCAS DE CULTIVO

**RESUMO** - A produção de hortaliças é uma atividade impactante, que se caracteriza pelo uso intensivo do solo, alta demanda de insumos e requer adoção estratégica de manejo, sobretudo em sistemas de produção sustentável, em que os pilares da sustentabilidade (ambiental, social e econômico) devem ser respeitados. Neste sentido, o objetivo desse trabalho foi avaliar indicadores econômicos da produção de alface adubada com espécie espontânea da Caatinga (*Calotropis procera*: Flor-de-seda) e cultivada em duas épocas (primavera e outono-inverno), no município de Serra Talhada-PE. O delineamento experimental foi em blocos casualizados, com os tratamentos arranjados em esquema fatorial 4 x 4, com três repetições, sendo o primeiro fator: as quantidades de biomassa do adubo verde (5,4; 8,8; 12,2 e 15,6 t ha<sup>-1</sup> em base seca); e o segundo: seus tempos de incorporação ao solo (0, 10, 20 e 30 dias antes do transplântio da alface). Além do rendimento de massa verde e dos custos de produção, foram determinadas as rendas bruta e líquida, taxa de retorno e índice de lucratividade. A quantidade de 15,6 t ha<sup>-1</sup> de *C. procera* possibilitou maior rentabilidade à produção orgânica de alface, sendo considerado ideal incorporar o adubo verde 11 (primavera) e 15 (outono-inverno) dias antes do transplântio da hortaliça. O cultivo de primavera promoveu retorno econômico superior ao plantio de outono-inverno, demonstrando viabilidade econômica mesmo na menor quantidade de *C. procera*.

**Palavras-chave:** *Lactuca sativa* L. Flor-de-seda. Cultivo orgânico. Lucro.

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## INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the most cultivated vegetables in Brazil, with great social, economic, and food importance. In Northeast Brazilian, lettuce presents cultivars adapted to the local climatic conditions: early cycle, low occurrence of pests and diseases, and good acceptance by the consumer market. In order to obtain quality products throughout the year, it is necessary to plan the plantation, mainly observing the microclimates of each region, the growing season of each variety, production costs, and other variables that would affect investment in the lettuce crop.

In the case of organic fertilizers, the soil is rich in nutrients, particularly in tropical soils, where the mineralization of the organic matter is intense (MONTEMURRO et al., 2010). The use of organic sources from the property itself is of fundamental importance for sustainable agricultural production systems. Green manure is a commonly used technique in cultivation, and it involves the incorporation of plant remains produced locally or added to preserve and/or restore soil organic matter and nutrient contents (OLIVEIRA et al., 2011).

*Calotropis procera* (Ait.) R. Br., popularly known as rooster tree, has been highlighted as a potential plant species for use as green manure in the production of vegetables (LINHARES et al., 2014; SOUZA et al., 2017). In addition to adding nitrogen (N) to the system, it improves the chemical, physical and biological characteristics of soils, thus contributing to the increase of soil biological diversity (ESPINDOLA; ALMEIDA; GUERRA, 2004; SOUZA et al., 2012). Considered a ruderal species, *C. procera* occupies areas modified by humans. However, due to its rapid development and easy dissemination, it is considered a dominant invasive plant in abandoned and/or physically and

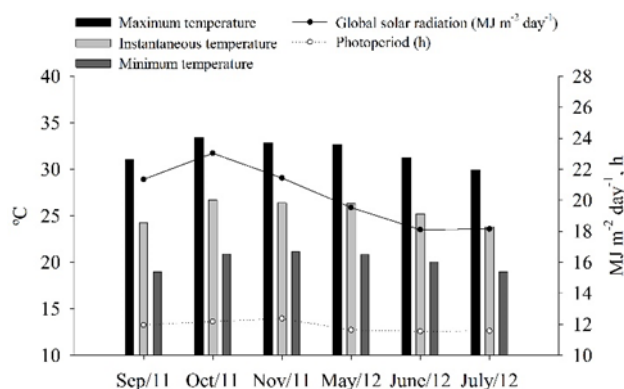
chemically degraded areas, serving as a species indicative of this type of disturbance (SOUTO et al., 2008; CEPAN, 2009).

The use of native or spontaneous species of the *Caatinga* biome as a source of green manure for the production of vegetables is of great importance. In this region, this segment of agriculture is mainly characterized as being practiced under family agriculture, and green manure may minimize the costs of production, since this input would be obtained from the property (LINHARES et al., 2009; LINHARES et al., 2014; OLIVEIRA et al., 2015; SOUZA et al., 2017; SILVA et al., 2017). According to Carvalho and Sabbag (2015), the hypothesis of evaluating efficiency in lettuce production allows mapping products with lower resource consumption, which can in turn lead to greater profitability for those who produce.

The objective of this work was to evaluate the economic viability of lettuce cultivation as a function of different amounts of *C. procera* biomass and their incorporation times in the soil, in two growing seasons (spring and fall–winter), under the conditions of Serra Talhada, Pernambuco.

## MATERIAL AND METHODS

Two field experiments were conducted in two growing seasons: spring (September 16 to November 18, 2011) and fall–winter (May 20 to July 24, 2012), at the Federal Rural University of Pernambuco (UFRPE) Academic Unit of Serra Talhada (UAST), located at 7°57'15" South and 38°17'41" West, with a 461 m altitude, in the micro region of Sertão do Pajeú, north of Pernambuco. The average meteorological data of the period of the experiments are presented in Figure 1.



**Figure 1.** Mean monthly values of instantaneous, maximum and minimum temperatures, global solar radiation ( $\text{MJ m}^{-2} \text{day}^{-1}$ ) and photoperiod (h) in each season of lettuce cultivation fertilized with *Calotropis procera*.

The soil of the experimental area had a sandy loam texture, whose chemical characteristics, at the depth of 0–0.20 m, before the installation of the experiments were as follows: in spring – pH in  $\text{H}_2\text{O}$

(1:2.5) = 7.2; organic matter (OM) = 12.8  $\text{g kg}^{-1}$ ; P = 14.0  $\text{mg dm}^{-3}$ ;  $\text{K}^+$  = 0.5  $\text{cmol}_c \text{dm}^{-3}$ ;  $\text{Ca}^{2+}$  = 3.9  $\text{cmol}_c \text{dm}^{-3}$ ;  $\text{Mg}^{2+}$  = 1.2  $\text{cmol}_c \text{dm}^{-3}$ ;  $\text{Al}^{3+}$  = 0.0  $\text{cmol}_c \text{dm}^{-3}$ ; and in fall–winter – pH in  $\text{H}_2\text{O}$  (1:2.5) = 6.5; OM =

12.7 g kg<sup>-1</sup>; P = 20.0 mg dm<sup>-3</sup>; K<sup>+</sup> = 0.4 cmol<sub>c</sub> dm<sup>-3</sup>; Ca<sup>2+</sup> = 3.4 cmol<sub>c</sub> dm<sup>-3</sup>; Mg<sup>2+</sup> = 1.1 cmol<sub>c</sub> dm<sup>-3</sup>; Al<sup>3+</sup> = 0.0 cmol<sub>c</sub> dm<sup>-3</sup> (SILVA, 2009).

The experimental design used in each experiment was a randomized complete block, with treatments arranged in a 4 x 4 factorial scheme, with three replications. The first factor being four biomass amounts of *C. procera* (5.4, 8.8, 12.2 and 15.6 t ha<sup>-1</sup> on a dry basis), and the second factor the four time periods of incorporating this fertilizer into the soil (0, 10, 20 and 30 days before lettuce transplanting).

Each experimental unit had a total area of 1.44 m<sup>2</sup>, with a useful plot of 0.64 m<sup>2</sup>. Six rows or planting lines were arranged transversely in each plot, spaced 0.20 m apart and within a line with 0.20 m between plants. The cultivar of planted lettuce was *Babá-de-Verão*, indicated for cultivation in the northeast region. Soil preparation in each experiment consisted of lifting the beds using hoes.

The *C. procera* was collected in localities near the UAST and then crushed in a conventional forage machine, obtaining fragments between two and three centimeters and set to dry until reaching hay condition (10% moisture). The material was analyzed and contained the following nutrient contents in dry matter: N = 17.4 g kg<sup>-1</sup>; P = 4.4 g kg<sup>-1</sup>; K = 23.5 g kg<sup>-1</sup>; Ca = 14.3 g kg<sup>-1</sup>; Mg = 23.0 g kg<sup>-1</sup>; Fe = 463.0 mg kg<sup>-1</sup>; Zn = 40.0 mg kg<sup>-1</sup>; Cu = 29.0 mg kg<sup>-1</sup>; Mn = 90.0 mg kg<sup>-1</sup>; B = 71.0 mg kg<sup>-1</sup>; Na = 1,640.0 mg kg<sup>-1</sup>; OM = 764.0 mg kg<sup>-1</sup>; C/N = 25/1 (SILVA, 2009).

The incorporation of the vegetal biomass was carried out in the 0–0.20 m layer of the soil in the experimental plots, according to the treatments. Daily irrigations were carried out in two shifts with the purpose of favoring the microbial activity of the soil in the process of organic matter mineralization. This was done by a micro-sprinkler system, with daily irrigation in two applications (morning and afternoon), providing a water slide of approximately 8 mm day<sup>-1</sup> (MAROUELLI; SILVA; SILVA, 2008).

The production of lettuce seedlings was carried out in expanded polystyrene trays with 128 cells and use of the commercial substrate Plantmax HT®, housed in a 50% shade nursery. The planting of lettuce in the first growing season (spring) was carried out on September 20, 2011, while in fall–winter it was done on May 25, 2012. On October 16, 2011 (spring) and 19 June 2012 (fall–winter), after the last incorporation of the green manure into the soil, the lettuce seedlings were transplanted. Handwashing was performed whenever necessary.

In the spring, the lettuce harvest was performed 32 days after transplanting (DAT), while in fall–winter it was done 36 DAT. From the green mass yield (t ha<sup>-1</sup>) obtained in the useful area, the yields for each experimental unit were estimated, considering the area effectively planted to 70%. Economic indicators were used to evaluate the efficiency of treatments. Production costs were estimated, which were calculated and analyzed at the end of the production process. The cost modality analyzed in this work corresponded to the total expenditures per hectare of cultivated area, which include services provided by stable capital, i.e. the contribution of working capital and the value of alternative or opportunity costs. Similarly, the proceeds refer to the value of the production of one hectare.

The acquisition cost was obtained by multiplying the price of the variable input used (seeds, fertilizers, casual labor etc.) by the amount of the respective input, referring to the years 2011 (spring) and 2012 (fall–winter), to the city of Serra Talhada, PE. The cost of one ton of *C. procera* green manure was estimated for each quantity factor, quantifying the labor required for cutting, grinding, drying and bagging. The prices in force in the month of November 2011 for the first experiment and in the month of July 2012 for the second experiment in the same city were considered. The daily value paid to rural workers in the region was R\$ 25.00 and R\$ 30.00 for the first and second growing seasons, respectively. The cost of transporting the fertilizer after the cut was also calculated for each quantity (R\$ 75.00 in the spring crop and R\$ 80.00 in the fall–winter crop).

In this way, the final cost of each treatment was determined according to the different quantities incorporated, the time spent for incorporation (variable as a function of quantity) and other production costs. It should also be noted that the treatments corresponding to the incorporation periods (0, 10, 20 and 30 days) did not influence production costs. However, they participated in the combination of the factorial to determine the best economic efficiency in the cultivation of lettuce fertilized with *C. procera*.

Depreciation, defined as the non-monetary fixed cost that reflects the loss of value of a good of production as a function of age, use and obsolescence was determined by the linear method or fixed quota method, which determines the annual value of depreciation from the useful life of the durable good, its initial value and scrap. The latter was not considered, since the capital assets considered do not present any residual value. Taxes and fees, as well as fixed labor, were determined by the amount used in the current months to produce the

crop. The fixed labor force was that dedicated to the management of productive activities, corresponding to the payment of the minimum wage each month during each productive cycle (R\$ 545.00 for the year 2011 and R\$ 622.00 for 2012).

The opportunity cost for stable capital items (buildings, machines, equipment, etc.) corresponded to the annual interest that reflects the alternative use of capital. The chosen interest rate was 6% per annum, equivalent to the savings account gain. For the remuneration of fixed capital, the interest was on the current value throughout the crop. Concerning the opportunity cost of land, the lease of one hectare in the region (R\$ 200.00) was considered as the equivalent of the alternative land cost used in the research.

The value of production per hectare measured gross return (GR) in November 2011 (R\$ 1.50 kg<sup>-1</sup>) and July 2012 (R\$ 1.60 kg<sup>-1</sup>). The net return (NR) calculated by the difference between the gross return (GR) per hectare and the total costs (TC) involved in obtaining it. The TC was calculated for each treatment, taking into account the input cost coefficients and the services used in one hectare of experimental lettuce. The rate of return (RR) was obtained from the relationship between GR and TC, corresponding to how many is received for each real applied in lettuce cultivation as a function of the

used treatment factor. The net profit margin (NPM) consisted of the relationship between NR and GR, expressed as a percentage (BEZERRA NETO et al., 2010).

For each cropping season, an analysis of variance for the characteristics evaluated was performed using the SISVAR application (FERREIRA, 2011). A joint analysis was performed for the characteristic(s) with homogeneity of variances between the growing seasons. The adjustment procedure of response curves was carried out between variables and quantitative factors. The Tukey test ( $p < 0.05$ ) was used to compare the means of the qualitative treatment.

## RESULTS AND DISCUSSION

### Analysis of variance (joint analysis)

From the results of the joint analysis of the variables evaluated as a function of the growing season, the amount of *C. procera* biomass and its incorporation time into the soil, it was observed that there was an interaction between the three factors for yield of green mass, gross return, net return and rate of return (Table 1).

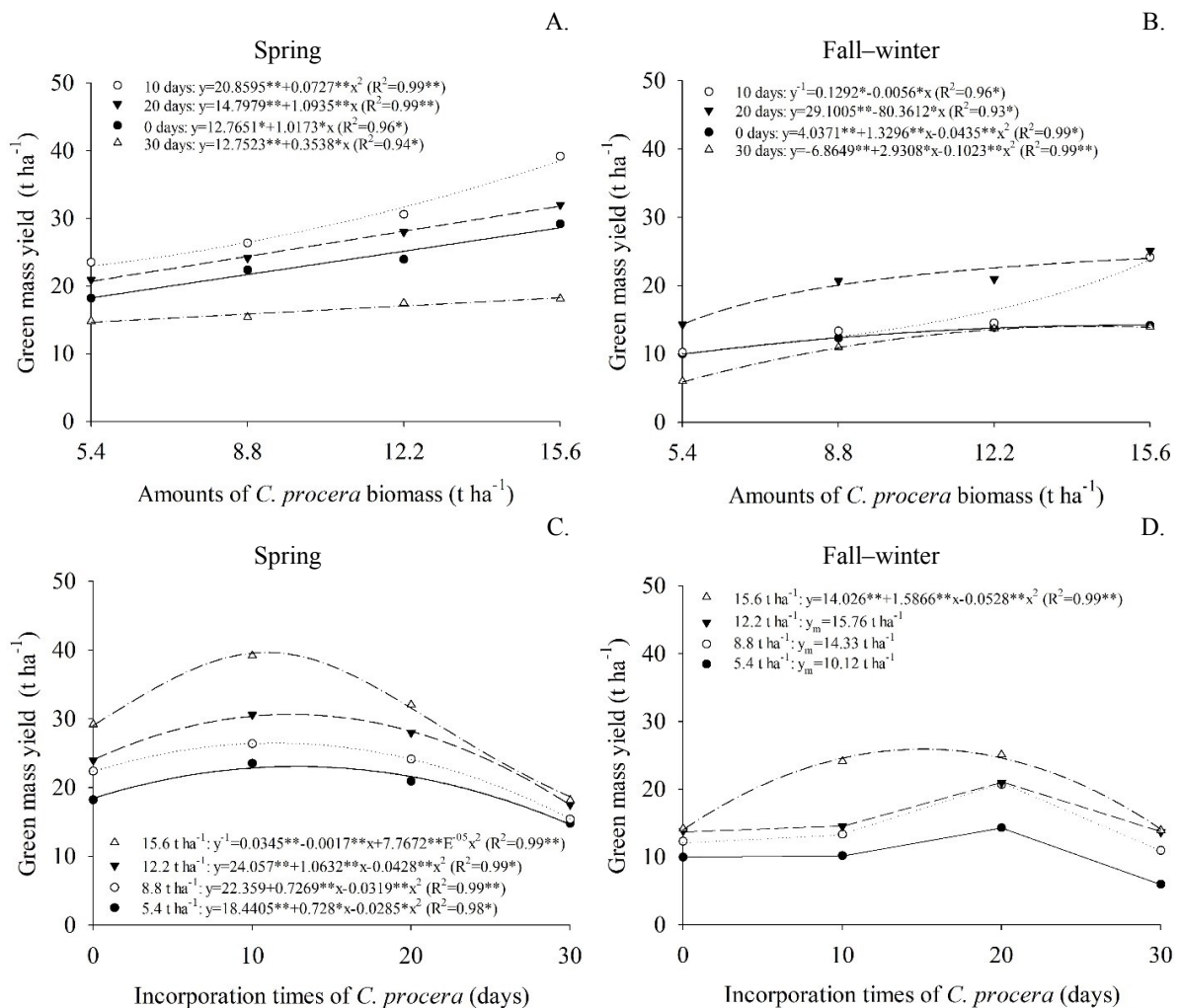
**Table 1.** Summary of the joint analysis of variance (F values) for green mass yield (GMY), gross return (GR), net return (NR) and rate of return (RR) in the production of one hectare of lettuce fertilized with *Calotropis procera*, in two growing seasons.

Sources of variation	DF	F			
		GMY	GR	NR	RR
Blocks (Season)	4	3.14*	3.10*	3.10*	3.41*
Season (S)	1	1,609.98**	1,166.17**	1,567.83**	2,222.14**
Amounts (A)	3	320.78**	310.65**	220.94**	160.80**
Times (T)	3	380.71**	365.64**	365.64**	399.92**
S x A	3	5.31**	4.06*	4.45**	4.13**
S x T	3	87.94**	81.03**	81.03**	96.80**
A x T	9	18.72**	18.22**	18.22**	14.71**
S x A x T	9	5.88**	5.73**	5.73**	5.61*
CV (%)		5.74	5.86	11.71	18.76
Mean		19.46	29,932.17	14,980.05	1.81

ns, \*\* and \*: significant at the 1% and 5% probability levels, by the F test, respectively. DF = degrees of freedom. CV = coefficient variation.

For the green lettuce mass yield, it was verified that maximum values were observed when fertilized with 15.6 t ha<sup>-1</sup> of *C. procera* at the incorporation times of 11 (spring) and 15 (fall–winter) days before the crop was transplanted, reaching estimated yields of 39.61 t ha<sup>-1</sup> in the first growing season and 25.94 t ha<sup>-1</sup> in the second (Figure 2). Probably, the increase in the amount of *C. procera* allowed a higher availability of the macro and micronutrients in its composition, promoting improvements in soil fertility and microbial flora

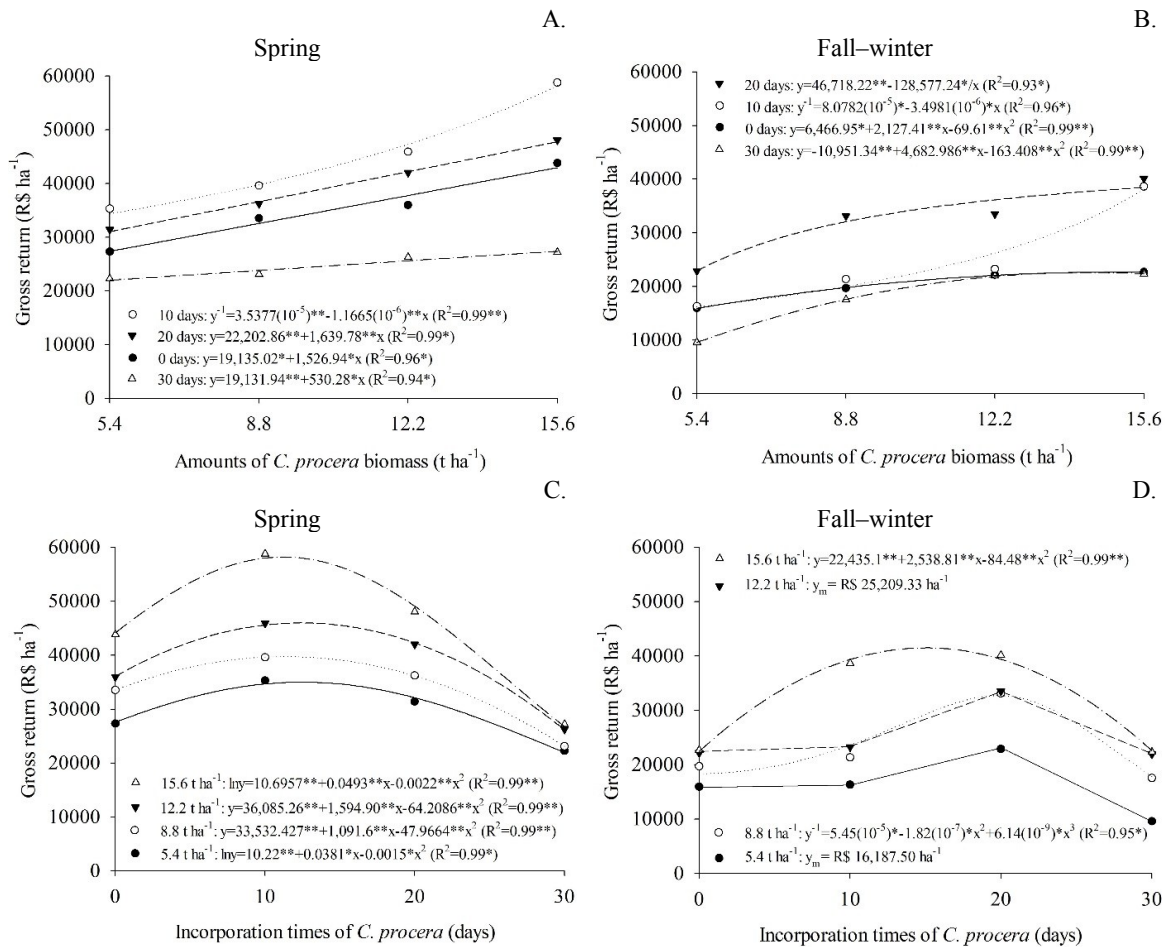
(BATISTA et al., 2013, 2016). Concerning the better incorporation times, which were different between the growing seasons, it can be inferred that the mineralization of the green manure in the spring was faster than in the fall–winter, mainly due to the occurrence of higher temperatures during the spring planting (Figure 1). The meteorological conditions also showed the adaptability of lettuce cv. *Babá-de-Verão* for production in environments of high temperatures and luminosity.



**Figure 2.** Green mass yield (t ha<sup>-1</sup>) of lettuce fertilized with *Calotropis procera* as a function of the interaction of the amounts and the incorporation times of the green manure (A. spring; B. fall-winter), within each season of cultivation, and reverse unfolding (C. spring, D. fall-winter).

Since the price paid for lettuce did not vary between growing seasons (R\$ 1.50 to R\$ 1.60), the gross return results had similar statistical behavior to that observed for green mass yield (Figure 3), that is, the cultivation of spring was more favorable to the development of lettuce, with the amount of 15.6 t ha<sup>-1</sup> of green manure associated with the time of 11

days reaching maximum gross return of R\$ 58,183.72 ha<sup>-1</sup>, which was considered superior to the best combination of factors in fall-winter, whose income was estimated at R\$ 41,508.18 ha<sup>-1</sup> at the dose of 15.6 t ha<sup>-1</sup> of *C. procera*, incorporated 15 days before transplanting vegetables (Figure 3).



**Figure 3.** Gross return (R\$ ha<sup>-1</sup>) of lettuce fertilized with *Calotropis procera* as a function of the interaction of the amounts and the incorporation times of the green manure (A. spring; B. fall-winter), within each growing season, and reverse unfolding (C. spring, D. fall-winter).

Positive effects of green manuring with spontaneous *Caatinga* species were also found by Oliveira et al. (2015) and Souza et al. (2015) in arugula cultivation, where they observed an increase in gross return with increasing doses of *C. procera*, reaching a gross return of R\$ 40,622.48 ha<sup>-1</sup> and R\$ 69,492.65 ha<sup>-1</sup>, respectively, in the higher doses applied. These results demonstrate the importance of using *C. procera* as green manure because it increased the gross return of lettuce through benefits provided by the higher availability of nutrients and the retention of water in the soil.

Table 2 shows the sum of variable, fixed and opportunity costs, which varied between R\$ 11,836.60 ha<sup>-1</sup> (spring) and R\$ 13,392.60 ha<sup>-1</sup> (fall-winter). The total cost of producing one hectare of lettuce fertilized with *C. procera* was estimated for each quantity incorporated into the soil of the green manure (5.4, 8.8, 12.2 and 15.6 t ha<sup>-1</sup>), and the following amounts were verified, respectively: R\$ 12,916.10; R\$ 13,622.44; R\$ 14,331.30 and R\$ 15,037.66 for the spring crop, and R\$ 14,673.60; R\$ 15,508.44; R\$ 16,346.30 and R\$ 17,181.16 for the fall-winter crops (Table 3).

**Table 2.** Coefficients of variable, fixed and opportunity costs in the production of one hectare of lettuce according to the growing seasons.

Components of Production Costs	Unit	Quantity	Total (R\$)	
			Spring	Fall-winter
Variable costs			9,160.60	10,562.60
1 – Inputs				
Seeds: Lettuce cv. <i>Babá-de-Verão</i>	kg	2.5	3,870.00	4,257.00
Commercial substrate: Plantmax HT®	25 kg	170	300.00	330.00
2 – Labor			3,570.00	3,927.00
Manufacture of beds	daily	40	5,075.00	6,090.00
Filling trays	daily	20	1,000.00	1,200.00
Sowing lettuce	daily	20	500.00	600.00
Roughing of lettuce	daily	30	750.00	900.00
Transplanting lettuce	daily	20	500.00	600.00
Hand weeding	daily	30	750.00	900.00
Irrigation	daily	5	125.00	150.00
Harvest of lettuce	daily	15	375.00	450.00
Transport of lettuce	daily	40	1,000.00	1,200.00
	daily	3	75.00	90.00
3 – Energy			215.60	215.60
Energy used for irrigation	kW	980.0	215.60	215.60
Fixed Costs			2,276.00	2,430.00
4 – Depreciation				
Irrigation pump	month*	2	1,176.00	1,176.00
Irrigation Pipes	month	2	115.00	115.00
Connections	month	2	7.00	7.00
128-cell trays	month	2	26.00	26.00
Micro Sprinklers	month	2	798.00	798.00
Forage	month	2	80.00	80.00
	month	1	150.00	150.00
5 – Taxes				
Rural territorial tax	ha	1	10.00	10.00
6 – Fixed labor force			1,090.00	1,244.00
Aux. Administrative	Salary	2	1,090.00	1,244.00
Opportunity Costs			400.00	400.00
7 – Remuneration by land				
Lease land	ha	1	200.00	200.00
8 – Remuneration of fixed capital (0.5% per month)			200.00	200.00
Infrastructure and equipment	R\$ 100.00 month <sup>-1</sup> **	2	200.00	200.00
Total (Variable + Fixed Costs + Opportunity)			11,836.60	13,392.60

\*Relationship between the market value and the useful life of the equipment, multiplied by the time of use; \*\*regarding the value of fixed capital (R\$ 20,000.00) multiplied by its remuneration over the crop.

**Table 3.** Total costs in the production of one hectare of lettuce according to the quantities of *Calotropis procera* and growing seasons.

Components of Production Costs	Unit	Quantity	Total (R\$)	
			Spring	Fall–winter
<b>1 – 5.4 t ha<sup>-1</sup> of <i>Calotropis procera</i></b>				
Cutting	daily	20.0	500.00	600.00
Transportation	freightage	1.0	75.00	80.00
Crushing	daily	2.5	62.50	75.00
Energy (forrage)	kW	100	22.00	22.00
Drying	daily	5.0	125.00	150.00
Bagging	daily	1.0	25.00	30.00
Distribution and incorporation	daily	10.8	270.00	324.00
Variable, fixed and opportunity costs			11,836.60	13,392.60
Production cost for application of 5.4 t ha <sup>-1</sup>			12,916.10	14,673.60
<b>2 – 8.8 t ha<sup>-1</sup> of <i>Calotropis procera</i></b>				
Cutting	daily	32.6	815.00	978.00
Transportation	freightage	2.0	150.00	160.00
Crushing	daily	4.1	102.50	123.00
Energy (forrage)	kW	162.9	35.84	35.84
Drying	daily	8.1	202.50	243.00
Bagging	daily	1.6	40.00	48.00
Distribution and incorporation	daily	17.6	440.00	528.00
Variable, fixed and opportunity costs			11,836.60	13,392.60
Cost of production for application of 8.8 t ha <sup>-1</sup>			13,622.44	15,508.44
<b>3 – 12.2 t ha<sup>-1</sup> of <i>Calotropis procera</i></b>				
Cutting	daily	45.2	1,130.00	1,356.00
Transportation	freightage	3.0	225.00	240.00
Crushing	daily	5.6	140.00	168.00
Energy (forrage)	kW	225.9	49.70	49.70
Drying	daily	11.3	282.50	339.00
Bagging	daily	2.3	57.50	69.00
Distribution and incorporation	daily	24.4	610.00	732.00
Variable, fixed and opportunity costs			11,836.60	13,392.60
Cost of production for application of 12.2 t ha <sup>-1</sup>			14,331.30	16,346.30
<b>4 – 15.6 t ha<sup>-1</sup> of <i>Calotropis procera</i></b>				
Cutting	daily	57.8	1,445.00	1,734.00
Transportation	freightage	4.0	300.00	320.00
Crushing	daily	7.2	180.00	216.00
Energy (forrage)	kW	288.9	63.56	63.56
Drying	daily	14.4	360.00	432.00
Bagging	daily	2.9	72.50	87.00
Distribution and incorporation	daily	31.2	780.00	936.00
Variable, fixed and opportunity costs			11,836.60	13,392.60
Cost of production for application of 15.6 t ha <sup>-1</sup>			15,037.66	17,181.16

Activities ranging from harvesting to the preparation of green manure were responsible for 8.5, 13.4, 17.7 and 21.6% of the total costs related to increasing amounts of *C. procera* (5.4, 8.8, 12.2 and 15.6 t ha<sup>-1</sup>), respectively (Table 3). Labor costs corresponded on average to 49.8 (spring) and 52.5% (fall–winter) of the total costs of each treatment in the cultivation of lettuce fertilized with *C. procera*. These results are somewhat lower than those found by Araújo Neto, Ferreira and Pontes (2009) in the organic production of lettuce and by Barros Júnior et al. (2008) in conventional lettuce production, in which both also observed that the most expensive costs are labor costs, corresponding to 78.8% and 53.3% (crisp lettuce) and 60.1% (American lettuce), respectively. In the case of the employment of family labor, these costs are considered as income to the farmers themselves.

Between the growing seasons, the cost became higher in the fall and winter, mainly due to the readjustment in the daily price paid to the rural worker (from R\$ 25.00 to R\$ 30.00). It should be noted that the difference in cost of production is related to the costs of cutting, transport, crushing, electric energy of the forage, drying, bagging, distribution and incorporation of *C. procera*, with differences between expenses, which increased according to the amount of biomass of the green manure.

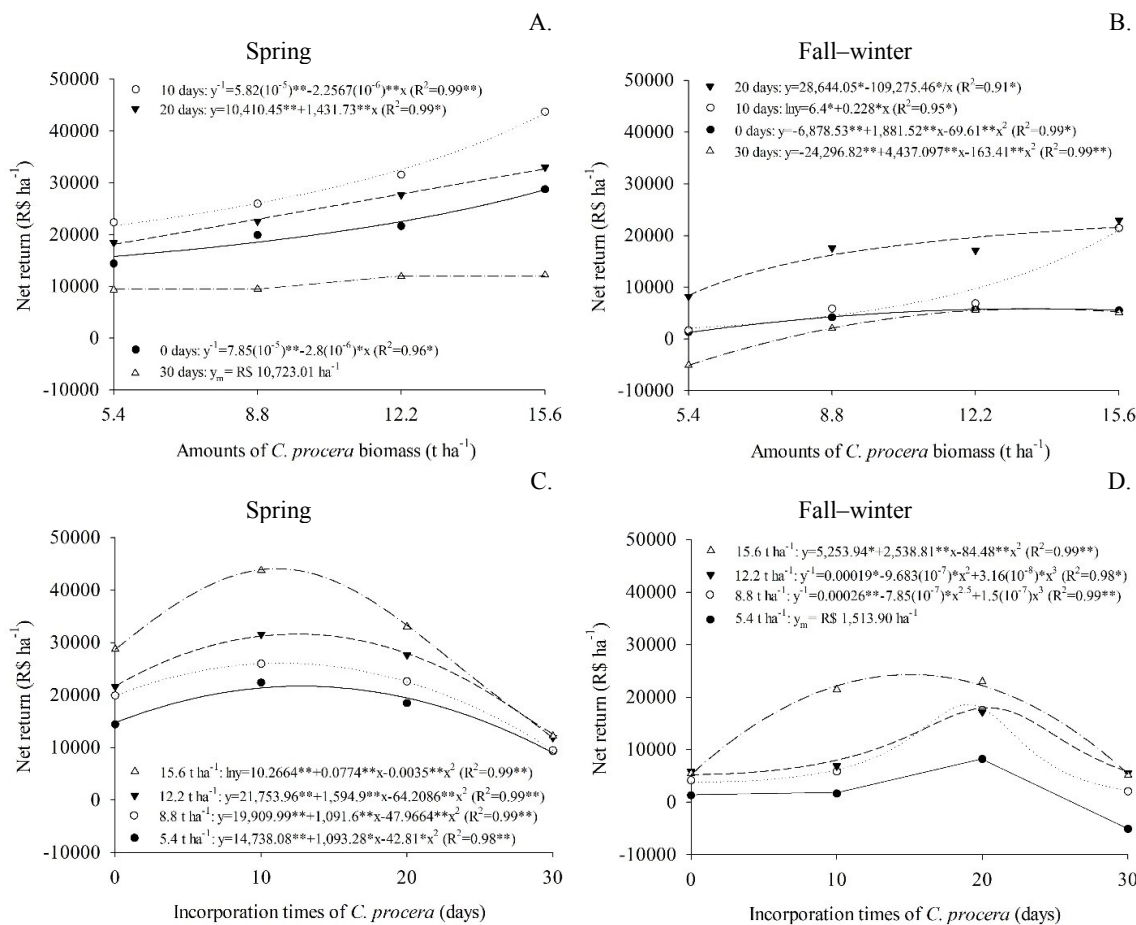
Evaluating different amounts of *C. procera* and their time of incorporation to the soil in the production of one hectare of arugula, Souza et al. (2015) reached lower production costs compared to the present research, with values of R\$ 6,705.08, R\$ 7,406.42, R\$ 8,110.28 and R\$ 8,811.64 for the spring–summer crop, and R\$ 7,628.60, R\$ 8,463.44,



R\$ 9,301.30 and R\$ 10,136.16 in the fall, for the amounts of 5.4, 8.8, 12.2 and 15.6 t ha<sup>-1</sup>, respectively. This difference is a result of the additional costs of lettuce seedling production.

From the difference between gross return and total production costs, there was a net return from production, which reached a maximum of R\$ 43,940.08 ha<sup>-1</sup> (spring) and R\$ 24,327.02 ha<sup>-1</sup> (fall-winter), associated with fertilization with 15.6 t ha<sup>-1</sup> and incorporation times of 11 and 15 days before lettuce transplanting, respectively (Figure 4). The

superiority of net return in spring results from the gross return on investment in this growing season (R\$ 58,183.72 ha<sup>-1</sup>), which was about 40% higher than the gross return of the best fall-winter treatment (R\$ 41,508.18 ha<sup>-1</sup>). Besides, spring production costs were 14.2% lower than in the fall and winter, contributing to an increase in net return. According to Bezerra Neto et al. (2012), the net profit better expressed the economic value than the gross return, because the costs of production are deducted from them.



**Figure 4.** Net return (R\$ ha<sup>-1</sup>) of lettuce fertilized with *Calotropis procera* as a function of the interaction of the amounts and the incorporation times of the green manure (A. primavera; B. fall-winter), within each growing season, and reverse unfolding (C. spring, D. fall-winter).

Silva et al. (2015), working with green fertilization with *C. procera* on radish cultivation, observed results similar to the present research, in which there was an increasing behavior of net return as a function of the biomass amounts of *C. procera*, reaching the maximum values of R\$ 34,845.85 ha<sup>-1</sup> (spring-summer) and R\$ 35,330.49 ha<sup>-1</sup> (fall-winter) at a dose of 15.6 t ha<sup>-1</sup>. On the other hand, Oliveira et al. (2015) obtained a higher net return of R\$ 30,091.04 ha<sup>-1</sup> when they fertilized arugula plants with 70.0 t ha<sup>-1</sup> of *C. procera*, in a low soil fertility condition in the experimental area. These results also

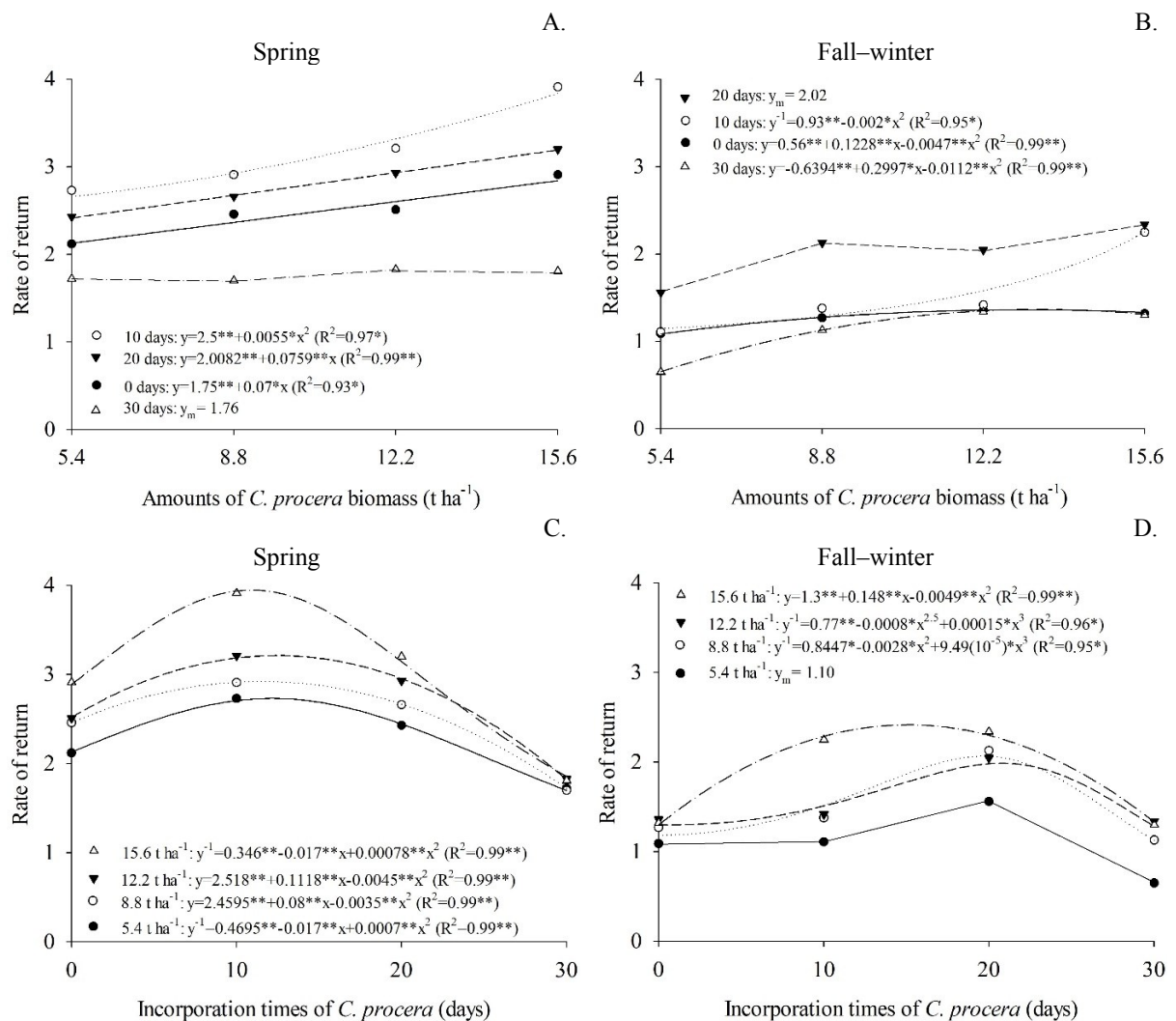
demonstrated the feasibility of using *C. procera* biomass, but indicate that the amounts should be adjusted according to the vegetable to be produced and the current condition of soil fertility.

In spring, the highest rate of return (R\$ 3.95) was obtained with the use of 15.6 t ha<sup>-1</sup> of *C. procera* added to the soil 11 days before lettuce transplanting (Figures 5A and 5C), corresponding to an increase of 124.4% in relation to the lower result of this growing period. In the fall-winter period, the 15.6 t ha<sup>-1</sup> dose of green manure in the 15-day period had a maximum estimated rate of return of R\$ 2.41 per

invested real (Figure 5D). In both growing seasons, yields of green lettuce mass in the above treatment combinations provided high gross returns, which offset the investment in the largest amount of green manure, whose production, preparation and incorporation costs were 196% higher.

Rezende et al. (2009) evaluated the yield of several vegetables in single and intercropping cultivation systems and observed a return rate of 7.46 in single lettuce cultivation, which is considered elevated when compared to the current research,

mainly due to the reduced costs of seedling production and chemical fertilization. Although the rate of return is lower, this does not invalidate the adoption of green manure as a cultural practice in the production of lettuce, since it presented a rate higher than 1.0, which represents a profit from investment (BATISTA et al., 2013, 2016), making it more sustainable in the medium and long-term. In addition, the sustainable cultivation of vegetables allows access to specific markets, where products can become more valued.



**Figure 5.** Rate of return of one hectare of lettuce fertilized with *Calotropis procera* as a function of the interaction of the amounts and the incorporation times of the green manure (A. spring, B. fall-winter), within each growing season, and reverse unfolding (C. spring, D. fall-winter).

### Analysis of individual variance

Individual variance analysis of the net profit margin revealed that no variance homogeneity was observed between growing seasons. In this way, the

analysis of variance of each experiment was performed. There was an interaction between the amounts and the time of incorporation of *C. procera* in the two growing seasons (Table 4).

**Table 4.** Summary of the individual analysis of variance (F values) for net profit margin (NPM) in the yield of one hectare of lettuce fertilized with *Calotropis procera* in two growing seasons.

Sources of variation	DF	NPM	
		Spring	Fall–winter
Blocks	2	3.05 <sup>ns</sup>	2.90 <sup>ns</sup>
Amounties	3	70.37**	53.07**
Times	3	529.16**	67.91**
Quantities x Times	9	4.51**	9.46**
CV (%)		2.79	34.11
Mean		58.65	24.89

ns and \*\*: nonsignificant and significant at the 1% probability level, by the F test, respectively. DF = degrees of freedom. CV= coefficient variation.

In spring, the amount of 15.6 t ha<sup>-1</sup> of *C. procera*, together with the incorporation of green manure 11 days before lettuce transplanting, promoted a maximum net profit margin of 75.0% (Figure 6A and 6B). It is important to note that, regardless of the factors (quantity or incorporation time), the yield of the lettuce crop in the spring was higher than 40%, demonstrating the agronomic and economical viability of the sustainable production of this vegetable. The use of the lower dose of *C. procera* during this growing season would be an alternative for the less capitalized farmer, allowing profitability compatible with the investment made. Bezerra Neto, Gomes and Oliveira (2007) reached a net profit margin of 68.8% in conventional lettuce cultivation in the semi-arid region of Potiguar, Brazil, indicating that the green manure with *C. procera* can also be a profitable alternative to the rural producer.

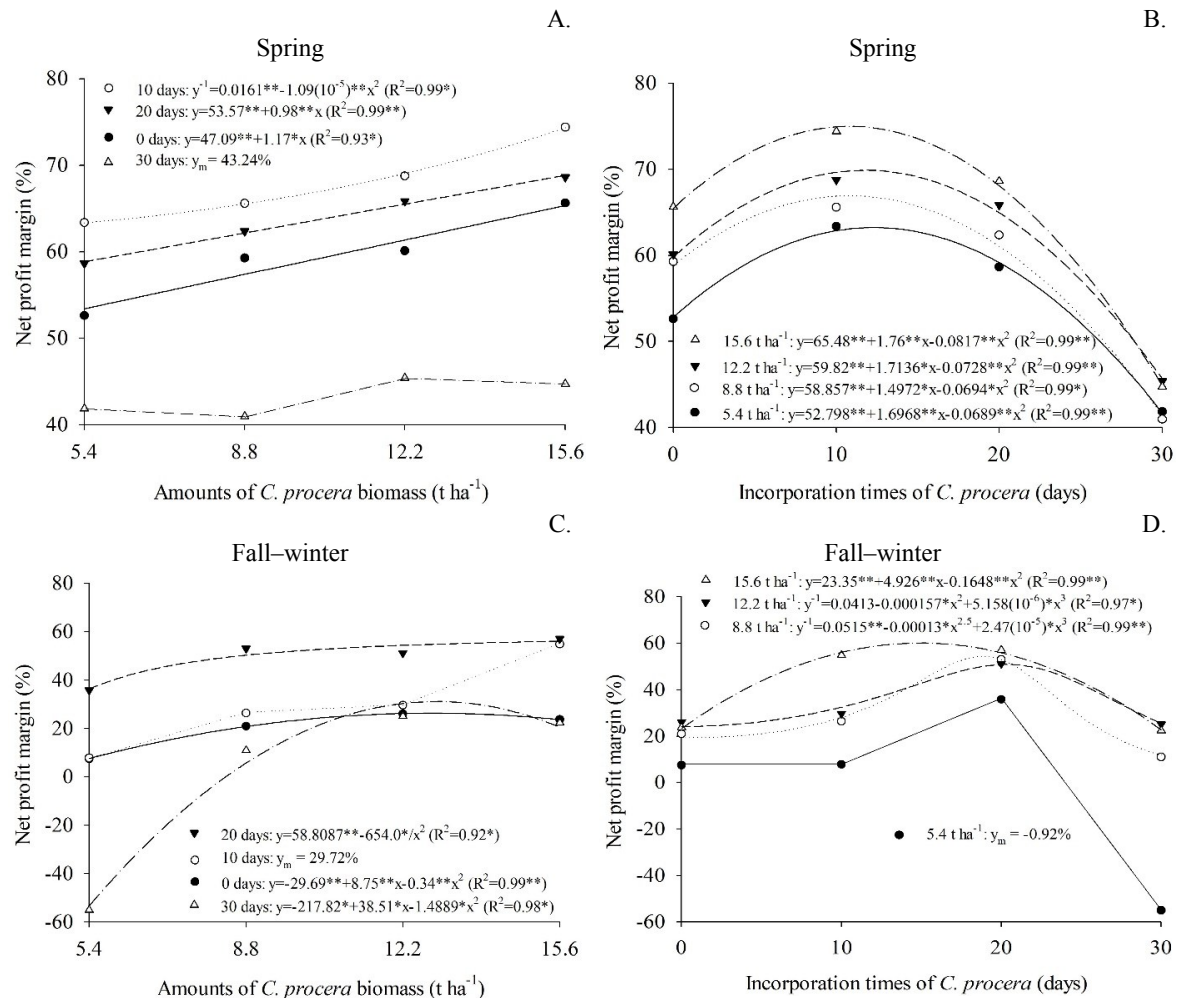
In fall–winter, it can be observed that the net profit margin varied little between the biomass amounts of *C. procera* and the incorporation time of 20 days before lettuce transplanting (Figure 6C). According to Figure 6D, lettuce yields were higher when applied 15.6 t ha<sup>-1</sup> and 15 days (60.1%) than the treatments with 8.8 t ha<sup>-1</sup> and 19 days (54.3%); 12.2 t ha<sup>-1</sup> and 20 days (50.8%) and 5.4 t ha<sup>-1</sup> and 20 days (35.9%). Although it did not influence the production costs, the incorporation time of the green manure was determinant for a satisfactory and positive economic return of the lettuce produced in fall and winter, because the synchrony between the release of the nutrients present in *C. procera* and the

period of nutritional requirement of the crop is reflected in higher productivity for lettuce, with a consequent increase in the net profit margin.

Some previous studies found net profit margins close to the present research. Studying green manure with *C. procera* on the cultivation of beetroot (BATISTA, 2011), radish (SILVA et al., 2015) and arugula (SOUZA et al., 2015; OLIVEIRA et al., 2015), and with *Merremia aegyptia* L. (scarlet starglory) in carrot culture (OLIVEIRA et al., 2012; BEZERRA NETO et al., 2014), the researchers demonstrated the agro-economic feasibility of green manure with spontaneous of the *Caatinga* species in leafy and root crops.

In general, these results indicate that lettuce responds very well to green manure with *C. procera*, reflecting the yield of green mass and the profitability of the investment tied to a reduced production cost. In addition, sustainable cultivation allows better use of local environmental resources, reducing dependence on external inputs.

Production costs can be reduced by using family labor for cultivating and preparing green manure on the farm itself, thus reducing transportation costs. In this way, the farmer, even with few resources to invest in the activity, can increase the yield of the crop through a locally available and easily renewable fertilizer, because *C. procera* has high potential for regrowth (ANDRADE et al., 2008). In addition, this green manure is conserved in the form of hay (SILVA et al., 2010; SILVA et al., 2012), favoring its storage for several years, without prejudice to its nutritional qualities.



**Figure 6.** Net profit margin (%) of one hectare of lettuce fertilized with *Calotropis procera* as a function of the interaction of the amounts and the incorporation times of green manure in spring (A and B) and fall-winter (C and D).

## CONCLUSIONS

The best economic performance of lettuce cv. *Babá-de-Verão* was obtained via green manure in the form of 15.6 t ha<sup>-1</sup> of *C. procera*.

The ideal incorporation time of the green manure was 11 (spring) and 15 (fall-winter) days before transplanting the lettuce seedlings.

Cultivation in the spring promoted a higher economic return to the production of lettuce fertilized with *C. procera*.

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