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Fertilization With Laying Hen Manure and Economic Analysis in Caesar Weed (*Urena lobata* L.) Seed Production in Amazonas, Brazil

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Abstract

The Caesar weed (*Urena lobata* L.), produces a light-colored fiber used in the textile industry for the production of sacks, fabrics, and rugs. The bottleneck in the Caesar weed production chain is the seed production. Because Caesar weed grows in a floodplain for fiber production, it does not complete its growth cycler and produce seeds. Therefore, the seeds used in the state of Amazonas come from the Brazil state of extractivism in Pará, which increases the seed costs for fiber production. It is advantageous to develop production technologies that will produce large quantities of viable Caesar weed seed on land in the state of Amazonas. Fertilizer management is an essential element to the successful crop and seed production. Laying hen manure as an organic fertilizer is one of the most accessible fertilizers for the family farmer. It is produced in large volumes at a low cost. The purpose of this research was to evaluate the impact of different doses of laying hen manure on the production of Caesar weed seeds from the perspective of an economic analysis. The experiment was a randomized complete block design with five doses of laying hen manure (0, 5, 10, 15, 20 t/ha) and four replications. Seed productivity was evaluated from the economic point of view of fertilization. A dose of 12.7 t/ha of laying hen manure is recommended for the production of 890 kg/ha of Caesar weed seeds in low fertility soil with a very clayey texture (Souza, 2012).

Keywords: agrobiodiversity, economic analysis, productivity

1. Introduction

Caesar weed (*Urena lobata* L.) and jute (*Corchorus capsularis* L.) are economically important because they produce fibers used mainly for making sacks, other textile products, and artisanal confections. It was in the lowland areas of the Amazon River that the commercial cultivation of Caesar weed and jute developed on a larger scale. These crops helped absorb a large portion of the labor that became idle due to the decline in rubber production. Caesar weed readily grows in the fertile soils of the floodplainsis, but it is a plant with few nutritional requirements (Souza, 2012).

Caesar weed, which belongs to the Malvaceae (Mallow) family, produces a light-colored fiber, which is in low supply on the world market, and it is easier to handle, more profitable, and preferred by farmers over jute (Crane & Acuna, 1945). Caesar weed is preferred because it is a heavier fiber than jute, which results in higher income due the sale price is based on weight. Also, during processing, it submerges in water more easily and softens faster, speeding up the maceration process, which results in the full use of the stem. This is in contrast to jute, which needs to be weighed down more to submerge it into water, and due to the delay in maceration, the stem end is degraded and unusable (Oral information provided by natural fiber producer João Saraiva D'Ângelo from the municipality of Manacapuru, Amazonas, Brazil).

In the state of Amazonas, the cultivation of this species occurs typically in the water channels of the Amazon and Solimões rivers, specifically in the municipalities of Anamã, Anori, Beruri, Caapiranga, Coari, Codajás, Iranduba, Itacoatiara, Manacapuru and Parintins (Souza, 2012). In Amazonas, production reached more than 18,000 mt in 1990 (Fagundes, 2012).

As the supply of Caesar weed seeds is a strategic issue for the fiber production chain. The government of Amazonas acquires seeds from the state of Pará and distributes them through the State Secretariat for Rural Production (SEPROR), about 100 mt/year of seeds. According to Souza (2012), for the 2009-2010 harvest, around 80,000 kg of Caesar weed seeds were distributed, on average 40 kg per family unit, which is insufficient for the production demand in the state, which requires an increase of at least 30% (24,000 kg). Caesar weed seeds come from extractivism, which results in a low supply, weakens the productive chain of fibers in the Amazon (Bentes et al., 2017).

Experiments with jute and Caesar weed fiber production in the Amazon indicate that, in addition to the problem with the low seed supply and high cost, producers do not have the needed seed production technologies. This culture still follows rudimentary agricultural models and techniques, with little or no introduction of technologies and changes in production processes (Noda, 2010), which includes seed production.

Fertilizer management for seed production is one of these unused technologies in the Amazon. Organic fertilization is an affordable and efficient alternative to commercial chemical fertilizers and result in a good profit margin, because the chemical fertilizers have to be shipped at greater expense to the seed production area compared to the locally producted organic fertilizers (Bezerra et al., 2020; Bulegon et al., 2012).

Organic fertilization has several advantages compared to chemical fertilization. These advantages include improving the soil physical and biological condition, producing an economic advantage for the small rural producer, as it reduces dependence on industrialized inputs, and makes the plant less susceptible to pests and diseases, according to the trophobiosis theory (Lin et al., 2019; Natalli et al., 2020; Primavesi, 2014).

Laying hen manure is one of the most used and accessible organic fertilizers to the family farmer because it is produced in large volumes and has a low cost. In addition to savings for the farmer, the use of laying hen manure as fertilizer redirects farm waste and do not polluting soil and water resources, therefore, resulting in additional revenue and environmental conservation (Guimarães et al., 2016; Lima et al., 2016).

It is important to note that the maximum physical production (Ymax) does not correspond to the production of maximum economic efficiency. This can be understood by analyzing the classical production function, which is divided into three phases, in which (I) the marginal productivity is maximum (Pma), and the curve presents its greatest slope, meaning the maximum contribution of each additional unit of input in the total physical production, failing to add input at this stage means failing to generate profit; (II) Pma is decreasing and greater than zero, that is, decreasing increases occur, in this stage is the maximum profit; (III) Pma is negative, excess input reduces the amount of physical production (Varian, 2012; Debertin, 1986; Strassburg et al., 2014).

Thus, the use of economic parameters in scientific experiments is recommended to assist in the accuracy of the inferences made in the research. Given the above, the objective of this research was to evaluate the effect of laying hen manure doses on Caesar weed seed production from the perspective of economic analysis.

2. Methodology

2.1 Experiment Area

The experiment was carried out at the Experimental Farm of the Federal University of Amazonas (FAEXP/UFAM), which is located at km 922 of the BR-174 highway with coordinates 2°39′ S and 60°3′ W. According to the Köppen classification, it has an Am climate, tropical, hot, and humid, with average annual temperature and rainfall of 25 to 28 °C and 2,100 mm, respectively, and relative humidity of around 84 to 90% (Dubreuil, Fante, Planchon & Sant'anna., 2018; Ribeiro et al., 1999).

2.2 Implementation of the Experiment

Initially, soil collection and analysis were carried out, later the area was prepared with one plowing and two harrowings. A sample of laying hen manure was sent to the Laboratory of Fertilizers, Correctives, and Organic Residues at the "Luiz de Queiroz" Higher School of Agriculture of the University of São Paulo (ESALQ/USP).

The soil chemical and physical characteristics 0 to 20 cm layer in prior to the experiment were: pH ($CaCl_2$) = 4; MO (calorimetry) = 2 dag/kg; P (Mehlich-1) = 6 mg/dm^3; K (Mehlich-1) = 20 mg/dm^3; Ca (KCl) = 0.5 cmolc/dm^3; Mg (KCl) = 0.3 cmolc/dm^3; Al (KCl) = 1.1 cmolc/dm^3; H+Al (SMP) = 6.4; SB = 0.85 cmolc/dm^3; t = 1.95 cmolc/dm^3; T = 7.25 cmolc/dm^3; m = 56.37%; V = 11.74%; sand = 10.7%; silt = 18%; clay = 71.3, configuring very clayey texture.

The laying hen manure from a commercial farm had the following composition on a dry basis (65 °C): pH (CaCl2) = 7.5; N = 2.41%; P_2O_5 = 8.71%; K_2O = 3.38%; Ca = 22.45%; Mg = 0.97%; S = 0.75%; MO = 29.67%; C = 12.92%; C/N ratio = 6; Cu = 104 mg/kg; Mn = 636 mg/kg; Zn = 5,121 mg/kg; Fe = 3,432 mg/kg; B = 10 mg/kg; Na = 11,933 mg/kg. The doses evaluated were 0, 5, 10, 15, 20 t/ha of laying hen manure with 13.42% moisture and a density of 0.87 g/cm.

The fertilizer was applied at the time of sowing, in November 2020. Seeds from the municipality of Capitão Poço (Pará, Brazil) were used. The seeds were submitted to dormancy breaking treatment in water at 80 °C for two minutes, placed to dry at room temperature, and then sown 5 to 7 seeds per hole.

2.3 Experimental Design

The experimental design was in randomized blocks (DBC), with five treatments with doses of laying hen manure (0, 5, 10, 15, 20 t/ha) and four replications. The spacing used was 1.5 m between rows and 0.5 m between plants and 3 m between plots and between blocks. The border effect was taken into consideration (Bentes et al., 2017).

2.4 Experiment Management

Thirty days after sowing, thinning was performed, leaving the two most vigorous plants per hole. To stimulate the sprouting of lateral branches and, consequently, the increase in seed production, the "capação" management was carried out, which consists of apical pruning at 80 cm when the plants reached a height between 80 cm and 100 cm. Four weedings were carried out during the experiments (Dias et al., 2008).

2.5 Experiment Evaluation

The harvest was carried out in November 2021, the stems of the plants from two holes (four plants) per plot were cut with pruning shears, identified, dried in a covered and ventilated place for ten days for drying and leaf fall. After drying, only the burs of each plot were removed and the seeds were manually extracted. Productivity was calculated by weighing the seeds and the data were expressed in t/ha (Dias et al., 2008).

To determine the economic analysis of fertilization, the Production Theory was used, with the production function derived from productivity data (1); in which the dose of laying hen manure was calculated that resulting in maximum physical production (2); and maximum profit (3); as well as the average product—AP (4); the cost—C (5); and the profit—P (6) (Varian, 2012; Debertin, 1986; Strassburg et al., 2014), by the formulas:

$$Y = f(x_1, x_2, \ldots x_n) \tag{1}$$

$$Y' = 0 \tag{2}$$

$$Y' = VMP = Px/Py \tag{3}$$

$$AP = y/x \tag{4}$$

$$C = Px \cdot x \tag{5}$$

$$P = (Py \cdot y) - (Px \cdot x) \tag{6}$$

Where, Y = Production function; Y' = derivative of the production function; VMP = value of marginal product; y = amount of physical production; x = amount of input; Py = value of physical production; Px = input value. The market prices in the year 2022 were: R$ 15 for a 40 kg bag of laying hen manure, and R$ 30.00 for a kilo of seed. The values were standardized in tons to perform the calculations. The value of the real is 0.18 dollars.

2.6 Statistical Analysis

Productivity data were submitted to the normality test, analysis of variance, F test (5% probability), and regression analysis, using the ExpDes.pt package version 1.2.1 in the R Core Team software (2021). The economic analysis was performed using tables in the Excel program. Graphs were generated by an algorithm developed in Python using the Matplotlib library (Ferreira et al., 2021; Hunter, 2007; R Core Team, 2021).

3. Results and Discussion

The dose of 12.7 t/ha of laying hen manure was the one that led to the maximum physical production of Caesar weed seeds (Ymax), being also the dose that led to the maximum profit, resulting in a production of 890 kg/ha of Caesar weed seeds. The analysis of variance showed a significant effect of treatments with doses of laying hen manure, with a p-value lower than 0.05 (Table 1). Regression analysis for Caesar weed seed yield data with doses of 0, 5, 10, 15 and 20 t/ha of laying hen manure (EG) resulted in the equation $Y = -5.3763x^2 + 136.1358x + 27.8732$ (Figure 1).

Table 1. Analysis of variance of the effect of laying hen manure doses on Caesar weed (*Urena lobata* L.)

Source of Variation	DF	SS	MSS	F	P-value
Treatment	4	2599699	649925	4.9647	0.01354
Block	3	471548	157183	1.2007	0.35128
Error	12	1570918	130910		
Total	19	4642165			

Note. DF: Degrees of Freedom SS = Sum of Squares. MSS = Mean Sum of Squares.

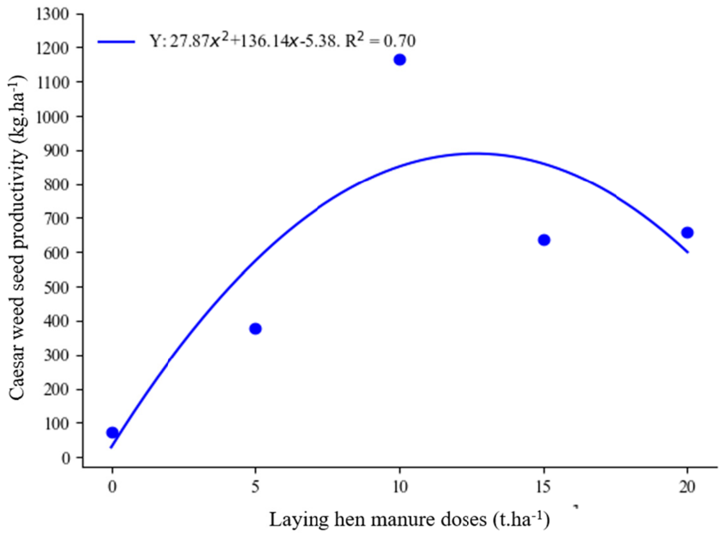

Figure 1. Productivity of Caesar weed (*Urena lobata* L.) seeds as a function of laying hen manure doses

The derivative of this function (Y' = 136.136 − 10.7526x) equal to zero results in the dose of LHM (x) that leads to the maximum physical production (Ymax). It was found x = 12,661 kg/ha and Ymax = 889,663 kg/ha.

To find the dose of LHM that leads to the maximum profit (Pmax), input and output prices in January 2022 in the local market were considered. Thus, the value of the marginal product (VMP) in this scenario was 0.0125. Equating Y' to VPma, x = 12,660 kg/ha and Pmax = 889,663 kg/ha were found.

Thus, the average product (AP) is approximately 0.07, that is, 1 kg of laying hen manure produces 0.070 kg of Caesar weed seeds, or even 1 t of laying hen manure produces 70 kg of Caesar weed seeds. The cost (C) of fertilization with 318 bags of LHM was R$ 4,770.00 (four thousand, seven hundred and seventy reais), the cost with 2 kg of seeds was R$ 60.00, resulting in profit (P) of R$ 26,640.00 (twenty-six thousand, six hundred and forty reais), disregarding the other production factors.

These results are in agreement with Varian (2012), since the amount of input that led to the maximum production amount was not exactly the same, it was higher than the amount that led to the maximum profit. However, this difference was only 1 kg/ha of the LHM input, reaching the same amount of production, 889,663 kg/ha of Caesar weed seeds. This represents a reduction of only R$ 0.25 in the production cost of 1 ha, which can be considered negligible. This irrelevant difference between Ymax and Pmax is due to the low input price and high production price, making it expected that the more input is added until reaching the maximum physical production, the greater profit will be obtained. After the dose of 12.7 mt of laying hen manure, the addition of the input causes a reduction in production, entering the irrational phase III of the production curve (Varian, 2012).

The results also corroborate those found by Ferreira et al. (2020), who reached Ymax in the sweet potato crop with the dose of 13 t/ha of laying hen manure and Pmax at the dose of 12 t/ha, in soil and manure with the same characteristics of the present study (Ferreira et al., 2020).

According to Oliveira et al. (2018), fertilization with laying hen manure provides greater increases in photosynthesis, transpiration and water use efficiency. This is probably due to the high levels of magnesium, which makes up the chlorophyll molecule, acting in photosynthesis, and phosphorus, which plays a role in the transformation of light energy into chemical energy (Prado, 2008).

In work carried out with cotton, belonging to the same botanical family as mallow, it was observed that organic fertilization improved the growth, development, and production of cotton, proving to be an alternative to the use of inorganic fertilizers (Ferreira et al., 2018).

In the analysis of the other production factors, labor is the one that most burdensome costs. If the area is mechanized, 11 h of agricultural tractor per ha (R$ 350 per hour/machine) are added (SEPROR, 2022).

Table 2. Costs for implementing 1 ha of Caesar weed seed production field (*Urena lobata* L.)

Production Factors	**Unit**	**Quantity**	**Unit Price**	**Total Price**
Variable Costs				
Mechanization—Agricultural Tractor	Time/machine	11	350.00	3,850.00
Labor for sowing and fertilization	Daily rate	4	50.00	200.00
Weeding labor	Daily rate	4	50.00	200.00
Labor for trim	Daily rate	2	50.00	100.00
Apical pruning labor	Daily rate	2	50.00	100.00
Labor for harvest	Daily rate	6	50.00	300.00
Caesar weed seed	Kg	2	30.00	60.00
Laying hen manure	Bag (40 kg)	318	15.00	4,770.00
Labor for processing	Daily rate	2	50.00	100.00
Fuel (cutter and shredder)	Liter	40	7.29	291.60
Fixed Costs				
Brushcutter depreciation	Unit	1	3,779.00	755.80
Crusher depreciation	Unit	1	2,600.00	520.00
Engine depreciation 5 hp	Unit	1	2,200.00	440.00
Fan depreciation	Unit	1	1,500.00	300.00
Depreciation of the machete	Unit	4	37.00	29.60
Depreciation of sieves	Unit	2	35.00	14.00
Total Cost				**12,031.00**
Gross Revenue				**26,700.00**
Net Revenue (Profit)				**14,669.00**

Note. For depreciation, useful life of 5 years was considered. The prices practiced in the local market (Manaus/Amazonas/Brazil) in January 2022 were considered.

Regarding crop management, branch breakage was observed by the action of the winds (Figure 2), pointing to the need for a study to evaluate pruning management during the crop cycle, as a way of improving the plant architecture, avoiding breaks, and increasing the number of reproductive side branches (Verdin et al., 2019).

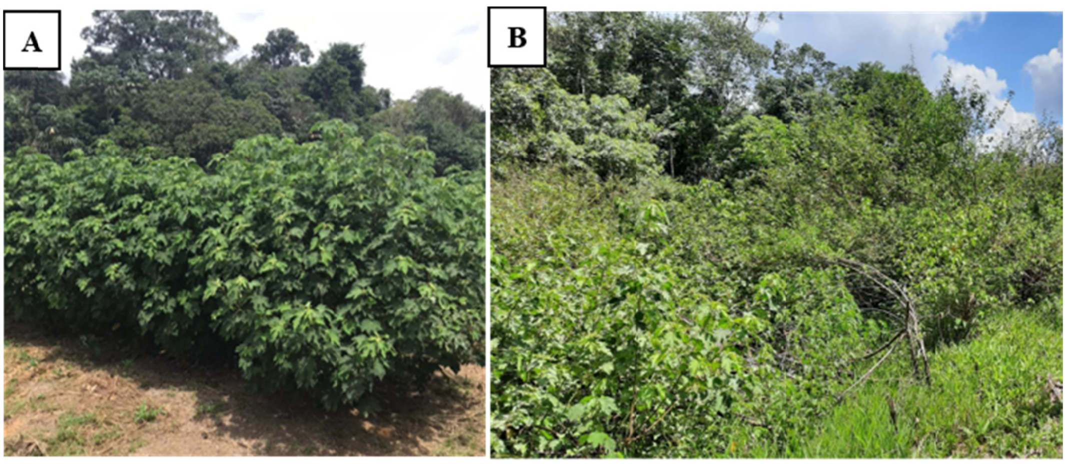

Figure 2. Caesar weed plants for seed production (A) and plants with branches broken by the wind due to the fragility of the plant architecture (B)

4. Conclusion

The amount of input applied to lead to maximum physical production is greater than what leads to maximum profit. However, in a scenario of low input price and high production price, the recommendation of the amount of input applied may be the one that leads to maximum physical production.

The dose of 12.7 t/ha of laying hen manure is recommended for the production of 890 kg/ha of Caesar weed seeds in low fertility soil with a very clayey texture, characteristic of most of the Amazon soils.

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