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ARTICLE

# Analysis of the green corn production costs under tillage systems in the Sergipano Coastal Tableland

*Análise dos custos de produção do milho verde sob sistemas de cultivo no Tabuleiro Costeiro Sergipano*

Sara Julliane Ribeiro Assunção[1], Alceu Pedrotti[1], Fábio Rodrigues de Moura[2], Francisco Sandro Rodrigues Holanda[3], Raimundo Rodrigues Gomes Filho[1]

[1]Programa de Pós-graduação em Desenvolvimento e Meio Ambiente, Universidade Federal de Sergipe (UFS), São Cristóvão (SE), Brasil. E-mails: julliassuncao@yahoo.com.br; alceupedrotti@gmail.com; rrgomesfilho@gmail.com

[2]Programa de Pós-graduação em Economia, Universidade Federal de Sergipe (UFS), São Cristóvão (SE), Brasil. fabiromoura@gmail.com

[3]Programa de Pós-graduação em Ciência da Propriedade Intelectual, Universidade Federal de Sergipe (UFS), São Cristóvão, (SE), Brasil. E-mail: fholanda@academico.ufs.br

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**Abstract:** Although many green corn producers manage their agricultural properties informally, the production of this vegetable is socioeconomically relevant to the Brazilian Northeast. This work aims to estimate and analyze the production costs, profitability and return of green corn in different cultivation systems, in the Coastal Tablelands of Sergipano. For this purpose, data were collected from the 16th to the 18th year of cultivation of a long-term experiment, in a strip experimental design, where each strip corresponds to the soil management system (conventional cultivation (CC), no-tillage (PD)) and minimum cultivation (CM)), and four previous crops (Beans Caupí, Crotalária, Guandu and Milheto) were randomized to corn. Production costs, Gross revenue, Operating profit, Profitability index and Leveling point were determined. Greater productivity and Gross revenue were observed in the PD, and greater disbursements in the CC (R$ 8,184.59). PD had highest operating profit and profitability ratio, where Guandu/PD had the best performance (R$ 8,847.18 and 52.02% respectively). Guandu/CC presented negative operating profit and profitability index, characterizing itself as a non-viable alternative for the farmer. The identification and analysis of production costs is an important tool, as it enables the identification of more profitable crops, being the PD the most recommended.

**Keywords:** rural, rural development, rural economy, land use, agricultural productivity.

**Resumo:** Embora muitos produtores de milho verde gerenciem suas propriedades agrícolas informalmente, a produção desta hortícola, é socioeconomicamente relevante para o Nordeste brasileiro. Este trabalho objetiva estimar e analisar os custos de produção, rentabilidade e retorno do milho verde em diferentes sistemas de cultivo, nos Tabuleiros Costeiros Sergipano. Para tanto, coletou-se dados do 16° ao 18° ano de cultivo de um experimento de longa duração, em delineamento experimental em faixas, onde cada faixa corresponde ao sistema de manejo do solo (cultivo convencional (CC), plantio direto (PD) e cultivo mínimo (CM)), e foram aleatorizadas quatro culturas antecessoras (Feijão Caupí, Crotalária, Guandu e Milheto) ao cultivo do milho. Determinou-se custos da produção, Receita bruta, Lucro operacional, Índice de rentabilidade e Ponto de nivelamento. Observou-se maior produtividade e Receita bruta no PD, e maiores desembolsos no CC (R$ 8,184.59). O PD apresentou maiores Lucro operacional e Índice de rentabilidade, onde, o Guandu/PD apresentou o melhor desempenho (R$ 8,847.18 e 52.02% respectivamente). O Guandu/CC apresentou Lucro operacional e Índice de rentabilidade negativos, caracterizando-se como alternativa não viável ao agricultor. A identificação e análise dos custos de produção é uma ferramenta importante, pois possibilita a identificação de culturas mais rentáveis, sendo o PD o mais recomendado.

**Palavras-chave:** rural, desenvolvimento rural, economia rural, uso do solo, produtividade agrícola.

## 1. Introduction

In Brazil, the production of green corn on the cob, according to data from the last Agricultural Census in 2017, was 348,904 tons (ton) cropped in 71,045 farms, equivalent to approximately

6.5% of agricultural establishments that perform horticulture (Instituto Brasileiro de Geografia e Estatística, 2017). In the Northeast, the average production is 88,248 tons cultivated in 49,283 farms, corresponding to 69.37% of the agricultural establishments that plant green corn in Brazil. In the state of Sergipe (SE), the production of 8,587 tons is originated in 2,944 rural properties, equivalent to 17.22% of the establishments that practice horticulture in SE, and 5.97% of the establishments that plant green corn in the northeast (Instituto Brasileiro de Geografia e Estatística, 2017). The production in the Northeast is destined to attend the demands of local consumption, as green corn is part of several typical dishes of regional culture, therefore, the great economic niche of this horticultural product is identified there (Santana, 2019).

The cultivation of green corn is predominantly carried out by family farmers on small farms (Tsunechiro & Miura, 2012), mainly due to the ease of the rapid flow of the production, in view of the perishability of the product, local demand and the higher market value achieved (when compared to the corn traded in the form of dry grains). The production systems are quite varied, ranging from subsistence exploration, to the highly techinfied production systems (Cruz et al., 2011), using no-tillage, reduced tillage and conventional tillage management systems.

In general, the soils of Coastal Tablelands naturally present a predominance of low chemical fertility, due to their sandy loam texture and the high index and concentration of rainfall (around 1,200 mm per year), associated with high average temperatures throughout the year. This condition is aggravated by the presence of cohesive horizons that reduce the effective depth, limiting the percolation of water in the profile and the deepening of the root system, causing erosion in addition to the low availability of nutrients. The current lack of conservation practices, such as the use of green fertilizers to cover the soil, prioritizing the replacement of plant residues, can contribute to the recovery of these soils in arable areas. This is because they are more efficient in minimizing the undesirable effects that come from the conventional exploitation of agricultural soils, due to the protective action of organic residues that act by intercepting raindrops and dissipating their kinetic energy (Martins & Rosa Junior, 2005), in addition to promoting the recycling and maintenance of nutrients important to agricultural crops.

According to Hofer et al. (2011) most of these farmers manage their properties informally, without financial and or economic control over the production process. They do not use tools that assist in financial management, since most do not have the knowledge and do not recognize its importance and functionality (Santos et al., 2019). However, because of the increased demand, high competition and periods of economic crisis, the farmer tends to change this behavior regarding the more effectively management of the resources so as not to compromise the future of the enterprise (Borsoi, 2017). In this sense, over the years, there has been an increase in the number of surveys related to the costs of agricultural production, as well as their estimates, given the narrow margin of profitability provided by the crops.

The profits generated by the farming activity are directly related to the costs of the production process. Thus, the presence of items in the production process may contribute significantly to the final cost of the product, but it is necessary to observe the various available production processes and resources to select the best alternative, aiming at greater profit. The analysis of production costs in rural properties is important, as it supports the managerial decision taking by the farmers through the identification of more profitable crops, or the combination of crops which will result in greater profitability among the available resources and technological packages. Furthermore, it guides the government's creation of rural credit and minimum price policies (Leal, 2017).

The associated use of technologies that have already shown a significant contribution to more sustainable agricultural production in important agricultural regions, brings a potential aspect for improving productivity and consequent economic profitability and efficiency for agricultural regions in the Northeast of Brazil. This becomes more significant because tropical conditions prevail throughout the year, with great demand for products of regional interest, such as green corn (due to consumption in various dishes of regional cuisine and in its industrial packaging). In this way, it consists of a market niche and is therefore very important for the sustainability of farms, especially local family farmers who predominantly exploit this crop on the Coastal Tablelands.

As the consumption of green corn has been growing gradually in our country, these aspects have triggered and attracted attention to the exploration of this crop and because it constitutes an economic alternative both for the horticultural producers of the green belts, who produce corn for consumption on the cob, as well as for processing in the industry, during all months of the year, but there is a lack of local studies on the analysis and economic efficiency of this important regional activity.

For the tropical edaphoclimatic conditions, there is a lack of economic viability information that supports the decisions taken to adopt different managements for crops of agricultural interest (Kappes et al., 2015). Thus, agronomic practices that allow the farmer to increase productivity and reduce production costs, providing a raise in the profitability and return should be studied in order to guarantee the sustainability of the farming activity (Silva et al., 2017). In this context, the objective of this work was to estimate and to analyze the costs of production, profitability and return of green corn in different cultivation systems, in Coastal tablelands in the State of Sergipe.

## 2. Materials and methods

### 2.1 Experiment characterization and conduction

The study was conducted in an experiment set in 2001, at the University Federal of Sergipe experimental farm (10 ° 55’24” S and 37 ° 11’57” W), in the municipality of São Cristóvão, state of Sergipe (SE). The data of this study was collected from the 16th to the 18th year of cultivation. The local soil is classified as dystrophic Red Yellow Argisol (Santos et al., 2018). For the region, the following average climatic indicators are verified: annual rainfall of around 1,200 mm, predominance of the As’ climate according to Köppen (1948), characterized as a rainy tropical with dry and annual summer, with a rainy season from April to September, concentrating 70.0% of the rains (Alvares et al., 2013).

The design of the experiment is in strips, where soil management systems are laid out (conventional tillage with a disc-plow and disc-leveling (CT), no-tillage (NT) and reduced tillage with a disc-plow (RT)), where each strip refers to a management system. In each strip, four crops prior to corn cultivation were randomized in three replicates (Cowpea beans (*Vigna unguiculata*), Sunn hemp (*Crotalária juncea*), Pigeon pea (*Cajanus cajan*) and Millet (*Pennisetum glaucum*)), totaling 12 treatments considered as cultivation systems cultivation (association between management system and the previous crop). In order to estimate production costs, as well as profitability and return, this work considered each of the experimental treatments as a commercial crop.

Each experimental strip has 830 m$^2$, split into 12 plots of 60 m$^2$, spaced 1 m apart. Between January and April, the previous crops were sown at a spacing of 0.5 m in the line and 0.2 m between the lines, and cultivated for approximately 90 days. After, they were cut and placed under the soil. For that, the experimental strips were prepared according to the management system to be evaluated and fertilized according to Sobral et al. (2007) (Planting fertilization: 44.5 kg. ha$^{-1}$ N; 158 kg. ha$^{-1}$ $P_2O_5$ and 33 kg. ha$^{-1}$ $K_2O$; and topdressing fertilization: 66.6 kg. ha$^{-1}$ N). After cutting the previous crops, the soil acidity of the experimental strips was corrected with the application of dolomitic limestone according to Sobral et al. (2007) and again prepared according to the management system to be evaluated. Afterwards, they were sown with corn (Biomatrix Hybrid BM 3061) with an average spacing of 0.2 m in the row and 0.8 m between the lines from March and July. Planting (67 kg. $ha^{-1}$ N; 83 kg. $ha^{-1}$ $P_2O_5$ and 68.5 kg. $ha^{-1}$ $K_2O$) and topdressing (167 kg. $ha^{-1}$ N split in three doses: v2, v4 and v8 stages on corn growth and 68.5 kg. $ha^{-1}$ $P_2O_5$ on v8 stage of corn growth were performed according to Sobral et al. (2007).

Weed control was performed with manual weeding in the cultivation of previous crops. In the corn crop, besides manual weeding during the conduction of the experiment, the selective herbicide *Atrazine* was applied in all experimental strips after sowing. In the NT, spontaneous plants before planting (previous crops and corn) were desiccated by means of full-action herbicides Glyphosate and 2.4 D. For the control of the cartridge caterpillar (*Spodoptera frugiperda*), *Tiodicarb* was used according to technical recommendation.

## 2.2 Data collection and analytical procedures

Annually, the commercial corn cobs (length equal to or greater than 0.2 m with rusk) of the useful area of each plot (19.2 $m^2$) were harvested manually when the grains entered stage R3 (from 70 to 85 days after planting), characterized by having 70.0 – 80.0% moisture in the grains. Then they were counted and weighed to calculate productivity and their values extrapolated to 1 ha. The determination of the average productivity of the treatments (number of commercial corn cobs) was established by the average productivity achieved by each of the treatments between 2016 and 2018 ($16^{th}$ to $18^{th}$ year of cultivation).

For the calculation of the costs, the methodology proposed by the Institute of Agricultural Economics (IEA), described in Matsunaga et al. (1976), where the Total Operating Cost (TOC) is defined by the sum of the Effective Operating Cost (EOC) (disbursement with mechanized operations, manual operations and inputs consumed in the production process) added with the Administrative Costs and Charges (ACC), which are the expenses with direct social charges, rural social-insurance contribution, financial charges, technical assistance and other non-operating expenses.

The costs of mechanized and manual operations were calculated based on the survey on the activities developed during the cycle of the crop, related for each operation performed, the time necessary for its development, being then multiplied by the average value practiced between 2016 to 2018 of the machine leasing (tractor + implement + driver + diesel) provided by the Agricultural Development Company of Sergipe (Empresa de Desenvolvimento Agropecuário de Sergipe, 2018) and increased by 10.00% referring to the maneuvers and adjustments of the machine. Similarly, the costs of the manual operations were also determined, and specified the number of Workers /Day (WD) to carry out the activities surveyed and multiplied by the average value of rural labor in the State of Sergipe (2016 to 2018) provided by EMDAGRO (Empresa de Desenvolvimento Agropecuário de Sergipe, 2018). Input costs were obtained through technical recommendations of the use plus 10.0% for losses and their respective average prices, provided by EMDAGRO (Empresa de Desenvolvimento Agropecuário de Sergipe, 2018), or collected in the market of the Greater Aracaju (area composed of the municipalities of Aracaju, Barra dos Coqueiros, Nossa Senhora do Socorro and São Cristóvão, according to State Complementary Law n. 25, Sergipe, 1995).

For the determination of the ACC, it was defined: 1) Direct social charges, calculated on the basis of the remuneration of the insured, which was 2.70% of charges and 8.0% of FGTS according to Law n. 5899,73 (Brasil, 1973), Decree n. 73626, 74 (Brasil, 1974) and Law n. 13467

(Brasil, 2017); 2) The rural social-insurance contribution, determined on the basis of the gross revenue (1,50%) according to article 14 of Law n.13606, 2018 (Brasil, 2018); 3) Financial charges obtained considering the interest rate of 4.6% per year over the average value (R$ 3,510.82/ha considering an average productivity of 8 to 10 t/h), provided in loan operations by bank branches via PRONAF B – (National Program for Strengthening Family Farming) Costing (costing for values of 20 to 250 thousand reais per crop) for the cultivation of green corn in the experiment region in the 2018/2019 crop; 4) Expenses with technical assistance, which were 4.0% over the average amount (R$ 3,510.82 / ha) provided in loan operations, corresponding to the rate of technical assistance and rural extension -ATER (2.0%); and; 5) Other non-operating expenses calculated on the basis of the crop insurance, a mandatory item in PRONAF financing contracts, with 1.5% of the financed amount.

For the calculation of non-operating expenses, depreciation of machinery and equipment was not considered as described in Galeano & Ventura (2018), Oliveira Neto et al. (2008) and Silva (2016) as it was decided to use the leasing of the machines, as well as the costs related to the transportation and harvesting of the green corn corn cobs, as these disbursements are obligations of the buyer, according to the practice in the study area. However, the cost of soil analysis was included to determine the fertilization and liming recommendation, aiming at environmental sustainability.

For evaluation of the profitability and return, the following indicators were used:
a) Gross revenue (GR) (Martin et al., 1998):

$$GR = Y \text{ x } UP \tag{1}$$

Where, Y = activity yield per unit area; and UP = unit price of the activity product (the unit price was determined by the Average trade value of the 100 hundred green corn cobs from 2016 to 2018, provided by EMDAGRO (Empresa de Desenvolvimento Agropecuário de Sergipe, 2018).
b) Operating profit (OP) (Lazzarini Neto, 1995):

$$OP = GR - TOC \tag{2}$$

Where, GR = Gross revenue; and TOC = Total Operating Cost.
c) Profit Margin (PM) (Martin et al., 1998):

$$PM = \frac{OP}{GR} X100 \tag{3}$$

Where, OP = Operating profit; and GR= Gross revenue.
d) Production Leveling Point (PLP) (Martin et al., 1998):

$$PLP = \frac{TOC}{UP} \tag{4}$$

Where, TOC = Total operating cost; and UP = unit price of the activity product.
e) Trade Leveling Point (TLP) (Rambo et al., 2015):

$$TLP = \frac{TOC}{PR} \tag{5}$$

Where, TOC = Total Operating Cost; and PR = productivity.

In addition to assessing productivity, profitability and return, the data obtained were subjected to analysis of variance by the F test to the Shapiro-Wilk (W) normality test and transformed when necessary, using the Box-Cox transformation. Next, they were subjected to analysis of variance (ANOVA), with the averages of the treatments unfolded and compared by the test of Tukey at 5.0% probability with the aid of the STATA® software (Statacorp, 2017).

## 3. Results and Discussion

### 3.1 Productivity

The number of corn plants and the productivity of green corn in succession to four previous crops are shown in Table 1. It is observed that the soil management system that presented the largest number of plants was the NT, which differs statistically from the results obtained by RT. Such result may be associated with the physical protection offered by the straw on the soil surface in the NT, where the seed is not exposed to attack by rodents and birds, in addition to not being grounded by the drops of water from irrigation or rainfall, hindering the emergence and fixation of the seedling, therefore, inducing a larger stand of corn plants.

Rodrigues (2013) indicates that the characteristics of the sowing bed (topsoil layer where the seeds are deposited and germination, emergence and establishment of the seedling occur) are influenced by the adopted management system as this affects the physical quality of the soil, particularly the structure. In the NT, as there is no soil overturning, in addition to maintaining crop residues on the surface, which offers physical protection to the seed, there are a number of advantages of the sowing bed when compared to systems that present notably soil overturning (Rodrigues, 2013).

Corn plants have the potential to produce a corn cob at each stem node, except the last ones, below the tassel. However, only one or two corn cobs can complete the growth and can be commercialized (Magalhães et al., 2002). According to Lobo et al. (2015), modern hybrids, such as those used in this study, in addition to not tillering, normally produce only one commercial corn cobs per plant. Thus, management systems that have larger stands tend to have higher productivity.

**Table 1** – Average productivity of green corn cropped in succession to four Previous Crops in three soil management systems in São Cristóvão - SE, from the 16$^{th}$ to the 18$^{th}$ cultivation year.

| Soil management | Previous crop | Number of plants (ha) | Number of commercial corn cobs (ha) | Commercial corn cobs weight (kg. ha$^{-1}$) |
|---|---|---|---|---|
| Conventional tillage | Cowpea beans | 63,715 A | 24,41 CDE | 5,762 DF |
| | Pigeon pea | 51,100 AB | 18,576 E | 7,859 BCE |
| | Sunn hemp | 59,201 AB | 25,781 CD | 6,978 CDE |
| | Millet | 61,748 AB | 24,219 CDE | 6,373 DEF |
| | *Mean* | *58,941 ab* | *23,249 b* | *6,743 b* |
| Reduced tillage | Cowpea beans | 58,681 AB | 25,694 CD | 7,470 CE |
| | Pigeon pea | 60,706 AB | 19,444 DE | 5,527 F |
| | Sunn hemp | 49,132 B | 20,660 DE | 5,532 F |
| | Millet | 50,405 AB | 22,396 DE | 6,386 DEF |
| | *Mean* | *54,731 b* | *22,0489 b* | *6,229 b* |
| No-tillage | Cowpea beans | 60,7634 AB | 29,803 BC | 9,112 ABC |
| | Pigeon pea | 59,462 AB | 38,368 A | 11,246 A |
| | Sunn hemp | 59,838 AB | 33,912 AB | 10,475 AB |
| | Millet | 60,243 AB | 33,507 AB | 10,217 AB |
| | *Mean* | *60,077 a* | *33,898 a* | *10,262 a* |

SOURCE: Elaborated with the author's data, 2019. NOTE: Means followed by the same upper-case letter in the column are not statistically different at 5.0% of probability by the test of Tukey. Means followed by the same lower-case letter in the column are not statistically different at 5.0% probability by the test of Tukey.

As expected, the NT presented a greater number of commercial corn cobs (33.898 corn cobs), as well as the heavier corn cobs (10,262 kg. ha$^{-1}$), therefore, differing statistically from the CT and RT, which presented an average reduction of 39.00% of the weight of the corn cobs (Table 1). It was also observed that, in the NT, all previous crops conferred higher green corn productivity (weight and number), when comparing their performance in other soil management systems. This difference is linked to the maintenance of the physical quality of the soil in the NT, enabling a more uniform germination, thus resulting in a small number of late germination plants, which have a small size and difficulty in capturing sunlight for their full development, where the unevenness is noticeable in corn crops, which results in unequal plant stand and impaired productivity (Rodrigues, 2013).

The values observed in this study are lower than those identified by Zárate et al. (2009) (38,000 to 51,000 commercial corn cobs / ha) in the evaluation of production and net income of green corn according to the hilling season. This difference may be the result of the use of a green corn hybrid different from the one used in this study (*Agromen* 2029), as well as the local edaphoclimatic conditions of the crop (hot and temperate climate, with average temperatures of 20ºC, annual rainfall around 1,328 mm, predominance of the Cwa climate according to Köppen (1948), in a dystropheric Red Latosol, with a clayey texture) that influence corn productivity.

Among the cultivation systems, Pigeon pea / NT showed the highest productivity (38,368 commercial corn cobs and 11,246 kg. ha$^{-1}$), therefore, differing from all the CT and RT cultivation systems (Table 1). In the NT system, organic matter from the soil cover of previous cycles is slowly and gradually incorporated into the soil, promoting an increase in the content of the soil organic matter (SOM). There is also an increase in microbial activity that, together with the SOM mineralization, provides nutrients to plants, resulting in an improvement in the productivity of agricultural crops (Alvarenga et al., 2001) as observed in the study. In addition, according to Oliveira et al. (2017) the maintenance of plant residues on the soil surface in the NT, for long periods, as is the case of the experiment, has beneficial effects both on the physical properties, as well as the structure and porosity of the soil, and on the chemical and microbiological properties.

Moreover, the planting of legumes such as Pigeon pea promotes the supply of N to the soil, a nutrient required in large quantities by corn plants (Collier et al., 2011) in addition to producing a biomass rich in P, K and Ca and a deep and branched root system, which facilitates the cycling of nutrients available in the soil (Silva, 2016), conserving SOM when associated with the NT, resulting in a cultivation system with an adequate productivity. It is also added that Pigeon pea has an aggressive and deep root system, acting in the breaking of compacted soil layers, showing a good development in poor-fertilized soils (Silva, 2016), in addition to being able to grow in soils with a tendency to form a crust on the surface and have a good potential for absorbing water and recycling nutrients from the deeper layers (Farias et al., 2013). Fosu et al. (2004), when evaluating corn production in Ghana observed a two to four- fold increase in corn productivity when grown under legume residues, corroborating the results found in this study.

## 3.2 Effective and total operating cost

The values of mechanized operations, manual operations, inputs and other expenses used to calculate the operating costs of green corn in succession to four previous crops (Millet, Pigeon pea, Sunn hemp and Cowpea beans) are shown in Table 2. The Effective Operating Cost (EOC) of the green corn production, disregarding the seed value of the previous crops, and considering only the adopted soil management (NT, RT or CT), corresponds to R$ 6,779.5/ha, R$ 7,152.41/ha and

R$ 7,376.81/ha, respectively (Table 2). Therefore, it is assumed that the decrease in the number of mechanized operations directly impacts the cost of the production process, therefore, raising the cost of mechanized operations in CT and RT by 113.92% and 76.90%, respectively, when compared to NT. When estimating production costs and economic efficiency indicators for green corn cultivation in the Ipameri region, Goiás State, Rodrigues et al. (2018) identified at EOC of R$ 4,025.14/ha for the cultivation of green corn for the CT, which is 47.17% lower than that shown in this study. This difference may be linked to the presence of costs with the previous crops used in this study.

The disbursements with EOC (disregarding the seed value of the previous crops and considering only the adopted soil management), over 63.0% (R$ 4,106.99 to R$ 4,797.41) came from the services used (hand manual work, mechanized operations, electric power and soil analysis), while approximately 37.0% results from the acquisition of inputs (fertilizers, limestone, herbicides, corn pesticides and seeds). This result corroborates those found by Zárate et al. (2009) when assessing the influence of hilling seasons, on the green corn productivity and the producer's income, identified that services with machinery (tractor and hydraulic pump) and labor, corresponds from 67.1% to 76.35% of the EOC for production of one hectare of green corn. In a financial analysis of corn conduct on both PIM and conventional system, Peixoto et al. (2017) proved the need for similar investment for inputs (52.3%) and mechanized operations + labor (47.7%). Rocha et al. (2019), when analyzing the economic feasibility of implanting off-season corn crops in succession, identified that the costs with inputs are approximately 4.5 times higher than the disbursements for mechanized operations, differing from the data evaluated. Similarly, Richetti & Garcia (2017), in a study on the economic viability of off-season corn, also presented the inputs (acquisition of seeds, fertilizers and insecticides) as the items that burden production the most.

**Table 2** – Items of the Effective Operating Cost (EOC) of the production of green corn in succession to four previous crops (Millet, Pigeon pea, Sunn hemp and Cowpea beans) and three soil management systems (no-tillage, Conventional tillage and Reduced tillage) in São Cristóvão - SE, 2018.

| EOC Items | Unit of measurement | Unit value | Total Value soil per management system (R$) | | |
|---|---|---|---|---|---|
| | | R$ | NT | RT | CT |
| **A. MECHANIZED OPERATIONS** | | | | | |
| Disc-plow | HM | 94.06 | 0.00 | 0.00 | 224.40 |
| Leveling-disc | HM | 94.06 | 0.00 | 690.41 | 690.41 |
| Planter | HM | 94.06 | 381.64 | 381.64 | 381.64 |
| Sprayer | HM | 94.06 | 224.37 | 0.00 | 0.00 |
| Irrigation | $KW.H^{-1}$ | 0.097 | 1,337.19 | 1,337.19 | 1,337.19 |
| **B. MANUAL OPERATION** | | | | | |
| Liming | HH | 48.45 | 290.70 | 290.70 | 290.70 |
| Herbicide application | HH | 48.45 | 48.45 | 48.45 | 48.45 |
| Replanting | HH | 48.45 | 581.40 | 581.40 | 581.40 |
| Fertilization | HH | 48.45 | 193.80 | 193.80 | 193.80 |
| Weeding | HH | 48.45 | 581.40 | 581.40 | 581.40 |
| Plant cutting | HH | 48.45 | 96.90 | 96.90 | 96.90 |
| Insecticide application | HH | 48.45 | 96.90 | 96.90 | 96.90 |
| Preparation of fertilizers and seeds | HH | 48.45 | 24.23 | 24.23 | 24.23 |

SOURCE: Elaborated using the author's data, 2019. NOTE: NT- No-tillage system, RT- Reduced tillage system, CT- Conventional tillage system, HM – Machine-hour, HH – Person-hour, l – liter, $KW.H^{-1}$ – Kilowatt per hour, ton – Tone, kg – Kilogram, R$ – Reals.

**Table 2** – Continued...

| EOC Items | Unit of measurement | Unit value | Total Value soil per management system (R$) | | |
|---|---|---|---|---|---|
| | | R$ | NT | RT | CT |
| **C. INPUTS** | | | | | |
| *Glyphosat* | l | 26.15 | 143.2 | 0.00 | 0.00 |
| *Atrazine* | l | 16.03 | 60.11 | 60.11 | 60.11 |
| 2,4-D | l | 25.35 | 53.24 | 0.00 | 0.00 |
| Limestone | ton | 3.93 | 103.93 | 207.86 | 207.86 |
| *Tiodicarbe* | l | 266.71 | 123.31 | 123.31 | 123.31 |
| *Lanate* | l | 26.60 | 31.66 | 31.66 | 31.66 |
| Powdered graphite | kg | 21.68 | 3.05 | 3.05 | 3.05 |
| Urea | kg | 1.52 | 959.29 | 959.29 | 959.29 |
| Potassium chloride | kg | 1.50 | 255.00 | 255.00 | 255.00 |
| Single Superphosphate | kg | 1.18 | 284.47 | 284.47 | 284.47 |
| Corn seeds BM3061 | kg | 28.32 | 654.64 | 654.64 | 654.64 |
| Pearl Millet seeds | kg | 13.15 | 5.26 | 5.26 | 5.26 |
| Sunn hemp seeds | kg | 18.32 | 10.85 | 105.85 | 105.85 |
| Cowpea beans seeds | kg | 2.50 | 179.83 | 179.83 | 179.83 |
| Pigeon pea seeds | kg | 12.32 | 687.18 | 687.18 | 687.18 |
| **D. OTHER EXPENES** | | | | | |
| Soil analysis | Unit | 25.00 | 25.00 | 25.00 | 25.00 |

SOURCE: Elaborated using the author's data, 2019. NOTE: NT- No-tillage system, RT- Reduced tillage system, CT-Conventional tillage system, HM – Machine-hour, HH – Person-hour, l – liter, $KW.H^{-1}$ – Kilowatt per hour, ton – Tone, kg – Kilogram, R$ – Reals.

This difference in results may be linked to the participation of different items in the evaluation of costs. In this study, the expenditure on electric power used for irrigation of crops, corresponds to 30.0% of the expenditure on services, approaching the values found by Garcia et al. (2012) when analyzing the productivity and economic results of modalities of corn cultivation with forages, in a no-tillage system whose contribution to irrigation was approximately 45.0% of the disbursements for operations. It is also associated with this scenario, the high need for labor in the green corn crop, when compared to other cultures.

In relation to the value of seeds from plants prior to green corn, they vary from R$ 5.26/ha (Millet) to R$ 687.18/ha (Pigeon pea), the latter being of higher cost than seeds of commercial crop (R$ 654.64/ha).The previous crops to be used must be chosen by considering the ease of acquisition, the cost of the seed, the possibility of selling the seeds or grains, the generation of revenues for the producer and further benefits to the soil. Thus, the high cost of seeds becomes a restriction factor for their adoption, since the farmer will need a greater volume of capital to carry out the planting, justifying the adoption in situations of proven significant increase in productivity and profitability of the commercial crop. Similar results were observed by Kappes et al. (2015) when economically analyzing corn in succession to different green fertilizers, soil management and nitrogen doses, regarding the increase in production costs when using millet and Sunn hemp as plants preceding corn production.

To compose the TOC, in addition to the EOC items described in Table 2, there are the ACC disbursements, which are non-operating expenses: financial charges, social-insurance contribution, technical assistance and social charges (Table 3). The disbursement with Social Charges, although calculated under the payroll for the present study, showed constant values, as the costs of manual operations did not differ among the cultivation systems, as they demanded the same volume of operations and respective costs. Similarly, expenses with Technical Assistance and Financial Charges, as they are determined on the average amount paid by bank institutions for the cultivation of green corn in the study region, (R$ 3,510.82/ha for the 2018/2019 crop), also showed constant values. It should be stressed that, despite being constant, these items have different weights of participation in the TOC in face of the cultivation system adopted. Out of the non-operating expenses, only the Social Insurance Contribution owed by the rural producer was variable (Table 3), as it depends on the gross revenue generated by the activity (1.5% on the gross revenue).

**Table 3** – Cost and Administrative Burdens: Non-operating expenses related to green corn production under 12 Cultivation Systems in São Cristóvão - SE, 2018.

| Non-operating expenses | Value (R$) |
|---|---|
| Direct social burdens | 191.38 |
| CESSR* | ** |
| Technical assistance | 140.43 |
| Financial burdens | 81.53 |
| Financial Burden-Crop Insurance | 26.23 |

SOURCE: Elaborated using the author's data, 2019. NOTE: R$: Reals, * Social Insurance Contribution; ** Variable value depending on the generated gross revenue (1.5%).

The highest TOC achieved in the green corn production was provided in the CT management (R$ 8,184.59 average value) regardless of the previous crop used, and the lowest was achieved in NT (R$ 7,689.00 average value) (Table 4), which was a value higher than that showed by Technical Assistance and Rural Extension Company (Empresa de Assistência Técnica e Extensão Rural, 2017) for the cultivation of green corn (R$ 5,785.42 / ha). This difference (R$ 2,399.17) may be associated with the costs of implementing and conducting the crop of the previous crops. Although the NT presents a higher cost with herbicides than the other managements, its lower cost with limestone and mechanized operations mainly result in the CT with a higher cost (linked to a higher EOC), when compared to the RT (increase of R$ 201.47) and NT (increase of R$ 495.59). Different results were found by Kaneko et al. (2010) when evaluating the effect of soil management and nitrogen fertilization on the production costs and profitability of corn cultivated under NT, heavy harrow + leveling disc, and scarifier + leveling disc in Selviria, State of Mato Grosso do Sul, where the lowest values of TOC were found in the heavy harrow + leveling system (reduced form of preparation, reduced tillage).

**Table 4** – Operating costs of the production of green corn in succession to four previous crops and three soil management systems, São Cristóvão, SE, from the 16th to the 18th cultivation year.

| Soil management | Previous crop | Effective operating cost (EOC) (R$) | % TOC | Total Operating Cost (TOC) (R$) | Unit Cost * (R$) |
|---|---|---|---|---|---|
| Conventional tillage | Cowpea beans | 7,556.65 | 92.99 | 8,126.12 AB | 0.33 |
| | Pigeon pea | 8,064.00 | 93.74 | 8,602.38 A | 0.46 |
| | Sunn hemp | 7,482.66 | 92.84 | 8,059.37 B | 0.31 |
| | Millet | 7,382.07 | 92.85 | 7,950.47 B | 0.33 |
| *Mean* | | *7,621.35* | *93.11* | *8,184.59 a* | *0.36* |
| Reduced tillage | Cowpea beans | 7,332.25 | 92.32 | 7,942.67 B | 0.31 |
| | Pigeon pea | 7,839.60 | 93.23 | 8,408.46 A | 0.43 |
| | Sunn hemp | 7,258.26 | 92.64 | 7,835.20 B | 0.38 |
| | Millet | 7,157.67 | 92.40 | 7,746.15 B | 0.35 |
| *Mean* | | *7,396.95* | *92.65* | *7,983.12 b* | *0.37* |

SOURCE: Elaborated using the author's data, 2019. NOTE: R$: Reals. * production cost of green corn cobs commercial. Means followed by the same upper-case letter in the vertical are not statistically different at 5.0% probability by the test of Tukey. Means followed by the same lower-case letter in the vertical are not statistically different at 5.0% probability by the test of Tukey.

**Table 4** – Continued...

| Soil management | Previous crop | Effective operating cost (EOC) (R$) | % TOC | Total Operating Cost (TOC) (R$) | Unit Cost * (R$) |
|---|---|---|---|---|---|
| No-tillage | Cowpea beans | 6,959.34 | 91.61 | 7,597.08 C | 0.25 |
| | Pigeon pea | 7,466.69 | 91.49 | 8,161.38 AB | 0.21 |
| | Sunn hemp | 6,885.35 | 91.19 | 7,550.41 C | 0.22 |
| | Millet | 6,784.76 | 91.11 | 7,447.13 C | 0.22 |
| *Mean* | | *7,024.04* | *91.35* | *7,689.00 c* | *0.32* |

SOURCE: Elaborated using the author's data, 2019. NOTE: R$: Reals. * production cost of green corn cobs commercial. Means followed by the same upper-case letter in the vertical are not statistically different at 5.0% probability by the test of Tukey. Means followed by the same lower-case letter in the vertical are not statistically different at 5.0% probability by the test of Tukey.

Considering that NT management has the lowest production cost, which associated with the lowest cost previous crop (Millet: R$ 5.26/ha) (Table 2), will result in the least costly cultivation system (lowest TOC). Thus, the cultivation system with the lowest TOC was Millet/NT followed by Sunn hemp/NT (Table 4). On the other hand, the highest cost management associated with the previous crop with the highest disbursement per hectare will tend to have a higher TOC. As a result, Pigeon pea/CT was the most expensive cultivation system (R$ 8,602.38), followed by Pigeon pea/RT, since the high value of the previous crop overcame the difference in production cost among the adopted managements (Table 4).

Regardless of the cultivation system that was analyzed, the largest expenses required for the production process are related to the EOC (92.37%) (Table 4). Thus, roughly 7.63% of the TOC are related to the non-operating expenses. Similar results were found by Furlaneto & Esperancine (2010), when evaluating the profitability of off-season corn in the NT system, using medium and high technology, observed that 9.0% of the TOC corresponds to the ACC, and by Franciosi & Nunes (2017) whose ACC accounts for 8.6% of the costs with the off-season corn crop. Rodrigues et al. (2018) when estimating the production costs and economic efficiency indicators of the green corn crop in Goiás, indicated that only 5.07% of the TOC corresponds to social-insurance expenditure, also corroborating with the study data.

Out of the items that make up the TOC, those that contribute most significantly are the manual operations (24.49% R$ 1,913.78 NT; 23.86% R$1,913.78 RT; 23.40% R$ 1,913.78 CT); limestone and fertilizers (20.86% R$ 1,602.69 NT; 21.39% R$ 1,706.62 RT; 20.88% R$ 1,706.62 CT), and electric power (17.41%, R$ 1,337.19 NT; 16.86%, R$ 1,337.19 RT; 16.35% R$ 1,367.16 CT) (Table 2). These results are from the high need for labor during the annual cycle (2 replanting, 2 weeding, 5 topdressing fertilizations, 2 applications of pesticides, 1 application of post-planting herbicide, 2 cuttings).

As pointed by Melo et al. (2009), the aspect of the greater financial expenditure related to labor highlights the great importance of the crop as an activity that generates jobs in rural areas, showing the social notoriety of the green corn cultivation in the northeast which shelters approximately 70.0% of agricultural establishments that grow green corn in Brazil (Instituto Brasileiro de Geografia e Estatística, 2017). On the other hand, Gonçalves et al. (2017) points out that the fact that labor is the most representative item of production cost, it indicates a low investment in technology for production, so these systems are characterized as low cost. However, it should be observed that the labor of the family farmer who owns or leases the land was considered for the calculation of labor participation in the TOC, since if the employee worked as a contractor in another rural enterprise, he or she would receive such remuneration.

Similar results were found by Zárate et al. (2009) when evaluating the production and net income of green corn according to the hilling season, which identified labor as the factor that most burdened production, corroborating with the data found in this experiment. However, Kaneko et al. (2010) when evaluating the effect of soil management and nitrogen fertilization on production costs and profitability and return of corn grown under three different managements, found that fertilizer expenses were more expensive, corresponding to 42.0% of the TOC.

Although the present study did not present fertilizers and limestone as the largest contributor to TOC (21.0% on average, ranking the second position), its share in costs is significant, indicating a high dependence on these inputs in the result of the production process. The correct dimensioning of the fertilization is possible through the analysis of the soil, which in turn will influence the productivity of the crop. Despite being often neglected, soil analysis represents an operating cost of R$ 250.00/ha (10 sample/ha (3.0% of TOC) (Table 2). Thus, this item appears as one of the most important, as it will allow the correct use of limestone and fertilizers since these items are the second largest source of disbursement in the cultivation systems. According to Zhang et al. (2015) the use of fertilizers in the quantities required by the plant promotes its maximum development and, consequently, its maximum productive potential. Sobral et al. (2007) stress out that the soils of the State of Sergipe are mostly of natural fertility and reduced productivity, being only economically viable when the nutritional contribution is carried out.

For all soil managements, when the previous Pigeon pea crop is used, seed acquisition becomes costly, ranking the fourth position in the NT (8.43%) and in the RT and the fifth place on CT (8.17 and 8.00%, respectively), regarding the participation in the TOC (Table 2 and 4). In the other cultivation systems with the other previous crops, the corn seed (8.69%) and the mechanized operation (8.04%) ranks the fourth and fifth position in the greatest burden in the NT. In relation to RT and CT, the order of impact is reversed with the mechanized operation accounting for 13.67 and 16.12% respectively, and corn seed for 8.34 and 8.13% of TOC, respectively (Table 2 and 4). When performing correlation analysis to verify the association between the variables that make up the cost of corn crop at the Brazilian level with the gross revenue per hectare, Artuzo et al. (2017) found a strong association between the total production cost and the labor variables, seeds, fertilizers and pesticides, corroborating the results of this study. Aguiar et al. (2008), in an economic analysis of different cultural practices in corn crop (NT using Sunn hemp and *Mucuna pruriens* as previous crops, NT in fallow and CT), involving different hybrids and N doses, identified that the lowest values were observed in the NT without the use of cover plants, followed by the CT, indicating that the presence of plants increases production costs, as observed in this study.

### 3.3 Revenue, profitability index and Profit margin

The NT showed higher productivity and also higher GR regardless of the previous crop used (Table 5). Among the cultivation systems, it is observed that the highest GR was achieved by Pigeon pea/NT (R$ 17,008.56), followed by Sunn hemp/NT (R$ 15,033.21), while Pigeon pea/CT (R$ 8,234.91) obtained the lowest GR to attend the production needs (Table 5). The values obtained with the commercialization of the green corn for the CT, were lower than those observed by Rodrigues et al. (2018) (R$ 12,375.00/ha in CT). This difference may be attributed to the average productivity achieved in this study (41,250 corn cobs /ha). On the other hand, the value observed is lower than that obtained for the NT (R$ are lower than those observed for the NT (R$ 1,502.79), and this result comes from the commercialization value of the corn cobs (R$ 0.44/unit; mean from 2016 to 2018, according to EMDAGRO (Empresa de Desenvolvimento Agropecuário de Sergipe, 2018)). Such results are higher than that used in the study of the referred author (R$ 0.30/unit) (Table 1 and Table 5).

**Table 5** – Gross revenues, Indices of Profitability and Return of green corn subjected to four previous crops and three soil management systems, São Cristóvão - SE, from the 16th to the 18th cultivation year.

| Soil management | PC | GR (R$) | OP (R$) | PM (%) | PLP (corn cobs) | TLP (R$) |
|---|---|---|---|---|---|---|
| Conventional tillage | Cowpea beans | 10,825.96 CDE | 2,699.84 BCD | 24.94 BC | 18,331 B | 33.28 CD |
| | Pigeon pea | 8,234.91 D | -367.47 F | -4.46 E | 19,406 A | 46.31 A |
| | Sunn hemp | 11,428.83 CDE | 3,369.46 CD | 29.48 BC | 18,181 B | 31.26 CD |
| | Millet | 10,736.17 CDE | 2,785.71 BCD | 25.95 BC | 17,935 C | 32.83 CD |
| *Mean* | | *10,306.47 b* | *2,121.88 b* | *18.72 b* | *18,463 a* | *36.08 a* |
| Reduced tillage | Cowpea beans | 11,390.35 CD | 3,447.68 CD | 30.27 BC | 17,918 AC | 30.91 CD |
| | Pigeon pea | 8,619.72 DE | 211.27 BF | 2.45 DE | 18,968 A | 43.24 AB |
| | Sunn hemp | 9,158.45 DE | 1,323.26 BDF | 14.45 CDE | 17,675 D | 37.92 ABC |
| | Millet | 9,928.07 DE | 2,181.92 BDF | 21.98 CD | 17,474 D | 34.59 BC |
| *Mean* | | *9,774.15 b* | *1,791.03 b* | *16.59 b* | *18,009 b* | *37.08 a* |
| No-tillage | Cowpea beans | 13,211.78 BC | 5,614.70 BC | 42.50 AB | 17,138 D | 25.49 DE |
| | Pigeon pea | 17,008.56 A | 8,847.18 A | 52.02 A | 18,411 B | 21.27 E |
| | Sunn hemp | 15,033.21 AB | 7,482.79 AB | 49.78 A | 17,033 D | 22.26 E |
| | Millet | 14,853.63 AB | 7,406.50 AB | 49.86 A | 16,800 D | 22.23 E |
| *Mean* | | *15,026.79 a* | *7,337.79 a* | *48.33 a* | *17,345a* | *22.92 b* |

SOURCE: Elaborated using the author's data, 2019: PC – Previous crops, GR – Gross revenue, OP – Operating profit, PM – Profit Margin, PLP – Production Leveling Point, TLP – 100- corn cobs Trade Leveling Point. Means followed by the same upper-case letter in the vertical are not significantly statistically different at 5.0% probability by the test of Tukey. Means followed by the same lower-case letter in the vertical are not statistically significantly different at 5.0% probability by the test of Tukey.

Among the evaluated soil managements, NT showed the highest profitability (R$ 7,337.79), which differed statistically from the RT and CT (Table 5). This behavior is due to a lower disbursement with mechanized operations and limestone, leading the management system to a lower EOC (which represents over 90.0% of the TOC), and consequently lower TOC, reflecting greater profitability, as observed. Furthermore, this result is also a response to the high productivity of this management, showing the quality of the soil cultivated under NT. Similar results were obtained by Kaneko et al. (2010) when evaluating the effect of soil management and nitrogen fertilization in the of corn crop grown under three different managements, where the NT obtained the greatest profitability, corroborating the results achieved in the present study.

It can be seen in the CT that the use of Pigeon pea caused a loss of R$ 367.47/ ha (Table 5). This poor performance is possibly linked to the high production costs of this cultivation system, related to soil preparation and the seed cost of the previous crop (R$ 687.18 / ha). Thus, in view of the conditions observed in this study, it is not recommended to use Pigeon pea in the CT as a previous crop to green corn cultivation, as it reduces the farmer's net worth. According to the neoclassical economic principles of the firm's theory, like any other firm, the rural enterprise is the place that uses technologies (crop management), buys inputs (seeds, fertilizers, pesticides, among others), processes (implementation, development and harvest of the crop) and sells the product (commercialization of the crop) on the market, therefore generating goods or services, maximizing the profits obtained (Vasconcellos & Pinho, 2002). Thus, the continuity of the activity with the use of this previous crop is not justified. However, in the NT, Pigeon pea was the PP that promoted the highest OP (R$ 8,847.18/ha) regarding the cultivation and commercialization of the green corn (Table 5), showing the importance of the association of the PP with a soil management system that promote better nutritional supply to plants, as observed in agricultural systems under NT system.

Among the cultivation systems, Pigeon pea/NT produced an OP of R$ 8,847.18/ha followed by Sunn hemp/NT (R$ 7,482.79). The lowest profits were obtained by Sunn hemp/RT (R$ 1,32.,26 / ha) (Table 5), since Pigeon pea/NT caused a loss of R$ 367.47 / ha. Alvarenga et al. (2001) indicates that the species used as vegetation cover (previous crops) are frequently of a small commercial value, justifying their use when they can compensate the production costs in the form of an extra gain, as observed as the use do Pigeon pea and Sunn hemp in NT. Kappes et al. (2015) observed higher profitability of corn in Sunn hemp /NT without the addition of nitrogen fertilizer, when compared to other previous crops such as Millet, similar to the results observed in this study. Nevertheless, Aguiar et al. (2008) in an economical evaluation of the effect of different soil management systems, N doses and the use of previous crops, including Sunn hemp, found a better cost/benefit ratio of corn grown in CT than that planted in NT/Sunn hemp, regardless of the dose of N used, different from what was observed in this study.

Because it is a sandy soil, with low-retention capacity clay, the nutritional input and the cycling of nutrients from the organic matter of the previous crops play an important role in the availability of nutrients for corn, even in the face of the additional chemical fertilization. Thus, the greater natural availability of N by Sunn hemp and Pigeon pea and the lower C/N ratio associated with the beneficial effects of the NT on the soil (biological, physical and chemical) promote corn productivity, which when linked to a lower production cost also promotes its higher profitability as observed.

It should be observed that only the profitability does not indicate the best investment option, as it becomes necessary to evaluate the return that the invested capital is effectively providing. Two sources of capital were considered in the study: Third-party capital (R$ 3,510.82) from financing via PRONAF-B, and Equity (R$4,441.41 on average). Thus, the return provided by each cultivation system must be evaluated, checking whether there is economic viability in the investment. Fernandes (2017) highlights that profitability is the “soul of the business”, because without it, the continuity of the company will be compromised, since the objective of the resources invested in the enterprise is to obtain further profits, and should always be positive and greater than the return provided by another investment alternative. Therefore, the PM of the activity should be evaluated as an indicator of economic efficiency.

Following the results exhibited for productivity, GR and OP, the soil management with the best PM was the NT (48.33), differing statistically from the RT and CT (Table 5). Similar to OP, in CT, Pigeon pea presented a negative PM (- 4.46). In RT, the cultivation of Cowpea beans preceding the production of green corn was the one that provided the highest RI (30.27), while the lowest was provided by Pigeon pea (2.45) (Table 5).

For the cultivation systems, Pigeon pea/NT (52.02) was the most profitable, although this does not present a significant difference with the other PPs for this soil management. The lowest profitability was shown by Pigeon pea/RT (2.45%), not considering the negative PM system (Table 5). Similar results were found by Kaneko et al. (2010), where the corn profitability index followed the OP trend, in which the NT provided the highest profitability indices; as well as the results obtained by Santos et al. (2004) who found greater profitability with the NT when compared to the other managements.

The PMs displayed by Millet/NT (49.86%) and Sunn hemp/NT stand out, which did not differ statistically from Pigeon pea/NT (Table 5). This performance is associated with the low TOC of these cultivation systems (Table 4), due to the small seed value (Millet R$ 5.26/ha and Sunn hemp R$ 105.85/ha), being the lowest among the evaluated PP in this experiment. Millet has been one of the major previous crops used for the production of straw for NT system in Brazil, due to the rapid growth, high production of phytomass even in conditions of low fertility, and high C/N ratio, therefore, contributing to the maintenance of straw under soil (Pacheco et al., 2009).

For any activity, the amount of production necessary to cover the costs must also be known, or the minimum trade value that must be practiced to cover costs, that is, the Leveling Points. For the PLP (number of corn cobs to pay the production costs), lower values are desirable, as the less part the OP will be used to meet the obligations. Thus, a lower PLP was observed in the NT (17,345 corn cobs), which differed from the other soil management systems. In the CT, RT and NT, the smallest PLP were provided by the Millet (Table 5). This behavior was linked to the low value of the PPs seed when compared to the others used in this study.

For the cultivation systems, Millet/NT (16.800 corn cobs) had the lowest PLP and Pigeon pea/CT (19,406 corn cobs) the highest (Table 5). The Pigeon pea /NT system, although presenting the highest OP and PM, does not have the lowest PLP, as it is linked to the costs of the production process, presenting results similar to those seen for GR. Thus, systems with Pigeon pea are more costly due to the cost of seeds (R$ 687.18 / ha), requiring greater production of corn cobs to comply with their financial obligations.

For the TLP, the minimum value to be sold for 100 corn cobs, considering the adopted soil management was on average R$ 22.92 in the NT; R$ 37.08 in the RT and R$ 36.08 in the CT (Table 5). Similar results were found by Kaneko et al. (2010), where the corn produced in the NT system obtained lower TLP, when compared to other types of soil management. In CT and RT, the largest TLP was conferred by PP Pigeon pea (Table 5), and in the NT, PP Cowpea beans was the one that conferred the greatest TLP (R$ 25.49). It is observed that this behavior is linked to a low OP and productivity conferred by the PP to the green corn, which ends up causing the need for higher commercialization value of the corn cobs, consequently, not generating losses.

For cultivation systems, Pigeon pea conferred the highest and lowest TLP (Table 5). In the CT, Pigeon pea presented a high TLP and PLP due to the damage that this cultivation system provides under the conditions presented in this study, resulting from the high cost of soil preparation and the cost of PP seeds (Table 2). Gonçalves et al. (2017) claims that the Leveling Point (commercial or production) is the meeting of the equivalent revenues and expenses, there being no profit or loss. Thus, to prevent this system in generating losses, it would be necessary to trade it at a higher value than that practiced for the period of the study, being important to carry out the analysis of likely commercialization scenarios. On the other hand, because Pigeon pea/NT has a high productivity (Table 1), GR, OP and PM (Table 5) can be sold at a lower market value and still fulfill its financial obligations.

As it is a horticultural crop, there is no continuous monitoring of production and productivity data, with a lack of information regarding more efficient cultivation systems, as well as production costs and profitability. The data used in the study refer to almost 2 decades of continuous cultivation in the area, which allowed the construction of a fertility that can be studied economically. However, only economic data from 3 consecutive years of cultivation were used, indicating the continuity of the study for a longer period of time, as well as its correlation with climate change.

### 3.4 Scenario Analysis

The scenario analysis provides a perspective of the economic efficiency behavior of the enterprise, given the price volatility. Thus, three different revenue scenarios were estimated considering: the average price (R$ 44.33 per 100 corn cobs) whose data have already been presented and discussed; the average minimum market price (R$ 35.33 per 100 corn cobs) and the average maximum market price (R$ 54.17 per 100 corn cobs) achieved by green corn (2016 to 2018), according to data systematically collected and provided by EMDAGRO (Empresa de Desenvolvimento Agropecuário de Sergipe, 2018).

As expected, the highest costs were observed in the scenario with the highest market price, since this price will determine the revenue generated. No changes were observed in the systems that presented higher and lower costs or GR (lowest cost Millet/NT followed by Sunn hemp/NT, and the highest costs in Pigeon pea/CT, followed by Pigeon pea/RT; Pigeon pea/NT, followed by Sunn hemp/NT highest GR, while Pigeon pea / CT obtained the lowest GR). The highest OP was obtained when corn was sold at the maximum price and the results were partially similar to those found for the average price: Pigeon pea/NT and Sunn hemp/NT presented the highest OP in the three marketing scenarios of green corn corn cobs. For maximum commercialization value, no damage was observed in any of the evaluated treatments. The lowest OP was observed in the Pigeon pea/CT system, followed by Pigeon pea/RT.

For the scenario with the minimum commercialization value, Pigeon pea/CT, Pigeon pea/RT and Sunn hemp/RT were the systems that caused financial losses to the farmer, presenting a negative OP, indicating that the cultivation systems were unable to pay the investments made for the production (Figure 1). This loss was caused by the fall in the GR of the systems, since productivity was maintained. It is noteworthy that similar results were also found for PM, PLP and TLP.

Among the cultivation systems evaluated, Pigeon pea/NT showed the best productivity (38,368 corn cobs / ha), consequently obtaining the best Gross Revenue (R$ 17,008.56), the greatest profitability (R$ 8,847.18), the highest profitability index (52.02%) and the lowest TLP (R$ 21.27). However, it should be observed that this cultivation system did not present the lowest production costs or the lowest PLP, as it is a system whose expenses are accentuated, particularly the seed cost of the previous crops.

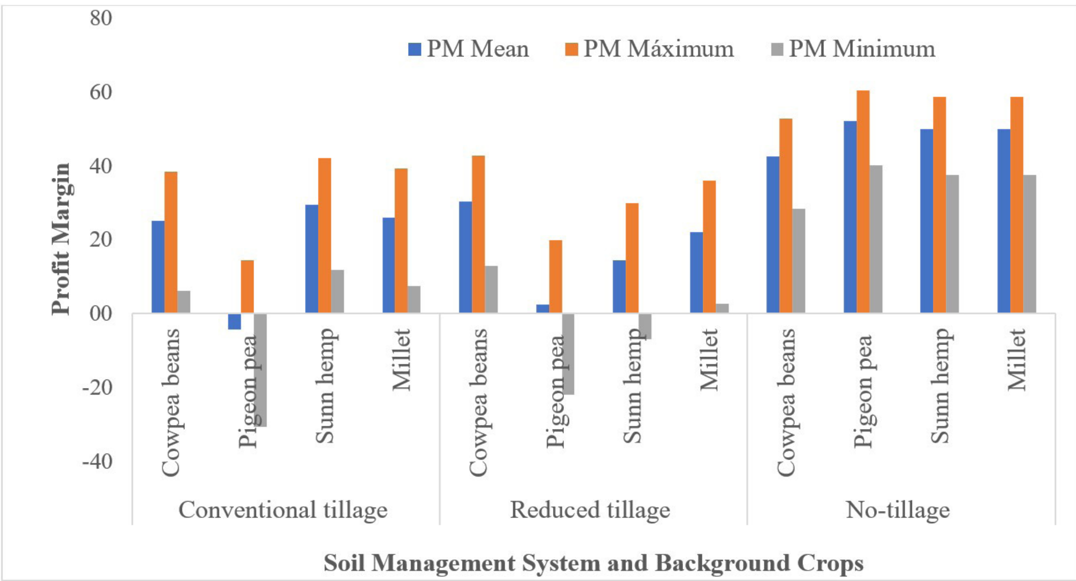


**Figure 1**- Profit Margin of green corn subjected to different previous crops and soil management system in a scenario of maximum, mean and minimum commercialization prices, São Cristóvão -SE, 2018. SOURCE: Elaborated with the authors' data, 2019. NOTE: Maximum price (R$ 54.17 -100 corn cobs). Mean Price (R$ 44.33 -100 corn cobs). Minimum price (R$ 35.08 -100 corn cobs).

## 4. Conclusions

In the present study, for the production of green maize under the edaphoclimatic conditions of the Coastal Tablelands of Sergipe, it is concluded:

The use of the Conventional tillage associated with the previous crop of Guandu provides higher production costs. On the other hand, the No-till associated with the previous crop of millet and PD associated with Crotalaria provides lower production costs, followed by the Minimum cultivation system with the previous crop of Guandu.

The items that contribute to the production cost of green corn in the studied cultivation systems (Conventional cultivation, Minimum cultivation and No-till) on a decreasing scale are: Labor, Fertilizers, Limestone and Electricity energy

The no-tillage system provides a more economically viable condition when evaluated by the parameters: Productivity, Gross revenue, Operating profit and Profitability when compared to Conventional and Minimum tillage.

The Conventional tillage system associated with the previous crop of Guandu provides lower Productivity, Operating profit and Profitability index with negative values.

The No-till system associated with the previous crop of Guandu provides higher levels of Gross revenue, Operating profit and Profitability index, this technology being recommended to farmers.

The use of the association of previous crops with conservation cultivation systems (No-tillage and Minimum Cultivation) should be evaluated as an alternative to identify the increase in productivity with a reduction in production costs, as it is a reliable, precise and coherent expression.

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