Original Research Article

ANALYSIS OF REGRESSION AND CORRELATION ON PRODUCTION OF SUGARCANE IN THE STATES OF PARANÁ, SÃO PAULO AND MINAS GERAIS, BRAZIL

ABSTRACT

Aims: The aims of this work were to analyze the production of the states of Paraná, São Paulo and Minas Gerais, as well as the national production of sugarcane crops, based on statistical tools of regression analysis, and correlation
Study design: A data collection was carried out.
Place and Duration of Study: State University of Western Paraná, Post-Graduation in Agronomy, between July 2018 and December 2018.
Methodology: The data used were obtained from various institutions and, made available by the Sugarcane Industry Union (UNICA), constituting a historical series of 1980/81 to 2016/17.
Results: The regression models that best fit the states of Paraná and São Paulo were the linear model, with correlation equal to 0.9711 and 0.9934 respectively, while for Minas Gerais was the quadratic, with 0.9708 of correlation with the national production. The results obtained showed a greater similarity of the behavior of the production of São Paulo with the national, evidencing its importance in participating in the sugarcane agroindustry sector.
Conclusion: The States of Paraná and São Paulo the best correlation of sugarcane production when comparted with the national production, which prove the representative of those states in sugarcane production in Brazil.

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Keywords: Saccharum officinarum L; Brazilian Sugarcane Production; Cane Industry; Brazilian commodities.

1. INTRODUCTION

Sugarcane (*Saccharum* spp.) is one of the commodities of greater growth in Brazil. Their cultivated area is increasing sharply due to its use in the production of ethanol [1], allied to the concerns with global warming and the possible scarcity of fossil energy resources, increasing the demand for renewable energies [2].

The regions grown in Brazil are the center-south and north-northeast, allowing two harvests per year, which together correspond to the area planted approximately 10 million hectares in the year of 2016 [3], enabling the production of sugar and alcohol for internal and external markets during the whole year, thus representing a major contribution to the economic development of the country [4].

Brazil is the world's largest producer of this culture, with production of 736.8 million tons in the 2016/17 harvest, being that the state of São Paulo was responsible for the production of 400.8 million tons [5]. This condition leads the milling of sugarcane in Brazil, with 55% of the entire national milling, the equivalent to 368,322.65 tons of culture [6].

On the other hand, the state of Paraná shows production around 23164.9 tons intended to produce sugar and 45000.5 tons intended to produce ethanol in the harvest of 2016/17, the total area of 624.6 thousand hectares [7], thus also representative in this sector.

The state of Minas Gerais, in turn, considered new in ethanol production, already featured within the sector. Sugarcane has been occupying areas previously used by livestock and crops such as soya, maize and rice, and the region of the Triângulo Mineiro pointing as the main pole of ethanol and sugar production within the state [8].

Several events contributed to the expansion of the area and the cultivation of sugarcane in Brazil, since 1975 to present, many transformations occurred, highlighting the creation of the Brazilian Agricultural Research Company, as well as changes in Public policies for the sector. This has brought enormous transformations that resulted in significant increases in production, positioning Brazil among the most competitive countries in the sugar-alcohol scenario [9].

Considering all the changes in the sugarcane crop production pattern, this study aimed to relate the total amount of sugarcane produced in the states of Paraná, São Paulo and Minas Gerais with the production of Brazil, by means of a series Historical, comprising the period 1980 to 2016, using regression analysis as well as the correlation between the productions.

2. MATERIAL AND METHODS

The sugarcane production data from the states of Paraná, São Paulo, Minas Gerais and the national production were compiled from the information provided by the Sugarcane Industry Union (Unica), comprising the period from 1980 to 2016, Constituting a series of 36 years.

Initially, the Person correlation coefficient was determined, which measures the existence and degree of relationship intensity between the state's production data and the national one from the formula:

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}$$

The correlation coefficient (r) for sample n pairs of values may present three results, which are, X and Y are positively correlated, or are negatively correlated, or that there is no correlation. It is Verified that the square of the correlation coefficient is equal to the coefficient of determination of the simple linear regression.

For qualitative evaluation of Pearson's correlation coefficient, the criterion established by [10] was adopted, where: if 0.00 < r < 0.30, there is weak linear correlation; If 0.30 ≤ r < 0.60, there is moderate linear correlation; If 0.60 ≤ r < 0.90, there is strong linear correlation; If 0.90 is ≤ r < 1.00, there is very strong linear correlation.

Subsequently, the regression analysis was performed that best adjusted to the data. The analysis of variance was performed to verify the equality of the averages, attesting to the regression effect and that the estimates are dependent.

For the treatment of production data of the states of Paraná and São Paulo was used simple linear regression and for the production data of the state of Minas Gerais was used quadratic polynomial regression due to the better adjustment of data.

Where Simple linear regression was obtained by (Equation 1):

$$Yi=\beta 0+\beta 1.Xi+ei$$

Where: Yi is the response/dependent variable representing the production in tones and Xi = area harvested in hectares (is the value observed for the dependent variable Y at the i-th level of the independent variable X). B0 represents the value for Y when the variables are null. The terms βi are called regression coefficients, Xi is the i-th level of the independent variable X and the residue (ei) is the deviation of the observed value from the estimate of the corresponding model [11].

The quadratic polynomial regression model with a variable, it's (Equation 2) [12]:

$$Yi=\beta 0+\beta 1.Xi+\beta 2.Xi^2+ei$$

Where: Yi is the value observed for the dependent variable in the i-th level of independent variable X. $\beta 0$ represents the constant of regression. Being that $\beta 1$ represents the regression coefficient and the i-th level of independent variable X. Since $\beta 2$ is the regression coefficient and Xi^2 is the i-th level of independent variable X, squared and the residue (ei) is the standard deviation of the observed value of the estimate of the corresponding template.

Thus, using the Microsoft Excel spreadsheet, the analysis of variance was performed and the graphs were generated.

3. RESULTS AND DISCUSSION

The analysis of variance performed for sugarcane production data in the states of Paraná, São Paulo and Minas Gerais, between 1980 and 2016, were significant at 1% probability (P = .01) by F test.

The National agricultural product grew more than four times between the years 1975 to 2016. In This period, considering the product holdings in the value of production, it is verified that the largest increases in relative participation in the last two decades (2000 to 2016) occurred with soybean grain, orange, banana, chicken and sugarcane [9].

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The production of sugarcane presented important growth mainly after the implantation of Proálcool on november 14, 1975, by Decree No. 76.593. The decree was aimed at stimulating the production of alcohol, aiming to meet the needs of internal and external market and the policy of automotive fuels, passing through a period of stagnation in the decade of 80, however, from 2001, this production began to rise rapidly [13, 14].

The incentives to produce ethanol in Brazil has assisted in strengthening the sugarcane sector, due to the use of alternatives such as the increase of excise duties on petrol, the maintenance of low taxes on ethanol, and the increase in the percentage of anhydrous ethanol from 25% to 27% in the composition of petrol [15].

From this period, there was an increase of 30.7% in the area harvested crops in Brazil, with the incorporation of almost 15 million hectares [16].

The advances in productivity resulting from a set of technological factors, which together have enabled the increase in production, among them the genetic improvement, agricultural zoning, tillage in straw, development of more efficient machinery for harvesting and empowerment of the producer in the management of costs in the production chain [16].

The national production in tons of sugarcane in the analyzed period obtained a R^2 of 0.8983, showing linear growth, from 123681 tons in 1980 to 651841 tons in 2016, reaching a greater increase of five times (Figure 1).

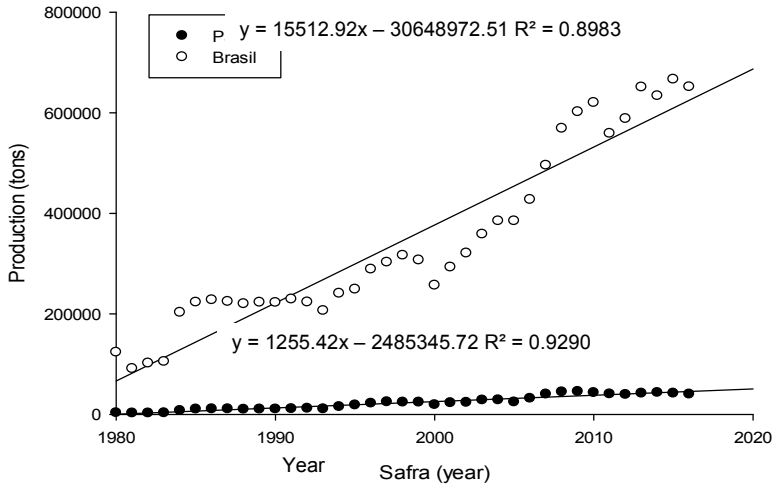

Figure 1 – Brazilian sugarcane production and in the state of Paraná between the periods from 1980 to 2016.

In the state of Paraná between the years 1980 to 2016, the production in tons of sugarcane presents a coefficient of determination (R^2) of 0.9290 and adjustment to the linear regression model. In This period the average production went from 3269 tons to 40417 tons.

The correlation of national production with the state production and sugarcane was high (r = 0.9711) showing high similarity of behavior between the two straight from the figure.

This growth has been justified mainly by increases in productivity associated, among other factors, to the management of crops and the management and conservation of soil since it's considered practically exhausted the possibility of expansion of the agricultural frontier area in the state of Paraná [15].

For the state of São Paulo, it was observed that the linear regression was significant, presenting R^2 of 0.9184. The production in tons of sugarcane from the state has similar behavior to national, obtaining a correlation coefficient (r) equal to 0.9934, which qualifies a very strong linear correlation between the two productions (Figure 2).

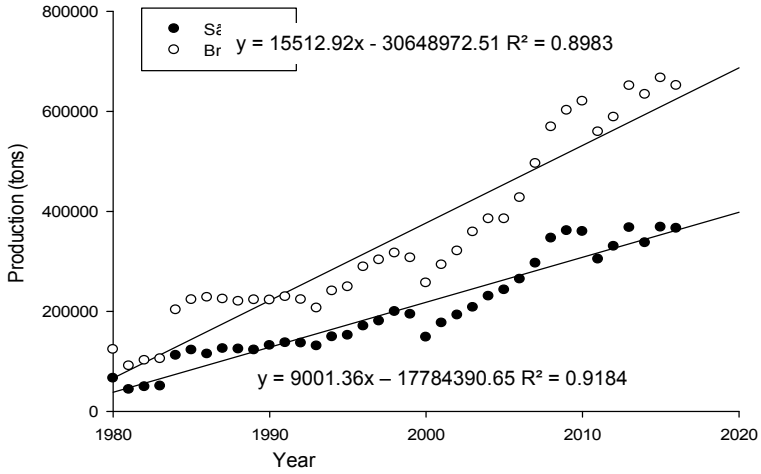

Figure 2 - National sugarcane production and in the state of São Paulo, between the periods from 1980 to 2016.

The state has been the most important representative of the national ethanol industry [17], and in the year 2011 São Paulo represented approximately 54% of national production of sugarcane, 55% ethanol and 59% of sugar [18]. There was an increase in the cultivated area of sugarcane in the southeastern region, with 96.38% of the total area, representing 357183 hectares concentrated mainly in São Paulo, with an increase of 246011 hectare [19].

In 1980 the average production of the state of São Paulo was equal to 65967 tons and in the year 2016 it reached 365990 tons, representing an increase of more than five times in production.

From 2003 there was greater demand for areas to stimulate the production of biofuels, expanding ethanol producing plants. At this time, states such as São Paulo, Minas Gerais and Goiás, regions where traditionally stand out for grain production, began to gain prominence in the production of sugar cane [19].

In the figure 3, the increase in the sugarcane production in the state of Minas Gerais was 90.66% between the years analyzed, showing a correlation coefficient (r) of 0.970 with the national production, with quadratic polynomial behavior, presenting R^2 of 0.9526, with more expressive growth from the beginning of the year 2000.

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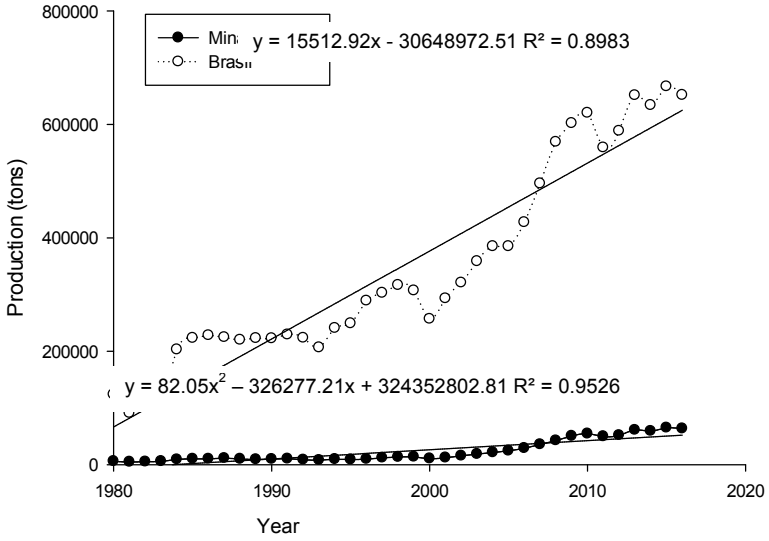

Figure 3 - National and sugarcane production and in the state of Minas Gerais, between the periods from 1980 to 2016.

The sugarcane was one of the cultures that more expanded in the state between the years of 1990 and 2008, there is an incorporation of approximately 961 thousand hectares of cultivable areas, corroborating with the increase of production, especially from the year of 2000. Such expansion was, according to the authors, in replacement of cultures that have lost areas, such as the maize, coffee, beans and rice [13].

Similarly, in the analyze the period of 2007 and 2008, also observed an increase of the cultivated areas, which attributed this growth to the replacement of crops of maize, rice and cassava [20].

4. CONCLUSION

Based in the correlation and regression analyzes obtained, it was found that the state of Paraná and São Paulo had the best relation of sugarcane production with the national prodution, differing from the state of Minas Gerais, where growth in production was observed only from the year of 2000, thereby proving the representativeness of those states of São Paulo and Paraná in sugarcane production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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