Review Article

Analysis the components of soybean production in the state of Parana-Brazil in two decades

ABSTRACT

Introduction: Soy is a culture of great socioeconomic importance. Thus, the analysis of the dynamics of the cultivated area, production and yield of grains are important, since, it makes possible to align actions of research and transfer of technology to the producers.
Aims: In order to fit a mathematical model to establish quantitative relationships between soybean production components, the regression analysis techniqueand correlation to evaluate thepanoramaof production,the plantedarea andthe production and yield of soybean production in the state of Paraná, in the last two decades.
Study design: Search and tabulation of information in database
Place and Duration of Study: State University of Western Paraná, Post-Graduation in Agronomy, between July 2018 and December 2018.
Methodology: The data were obtained at the Portal of the Brazilian Institute of Geography and Statistics, for the years 1997 to 2017. We used the Pearson correlation coefficient andthe linear regression analysis.
Results: The results obtained, it was possible to observe significant increases of soybean production in Paraná in relation to Brazilin this period of 20 years. The Paraná obtained an increase of 105% in area planted, 190% in production and 60% of production with the average yield.
Conclusion: The regression and correlation analyzes were efficient to describe the adjustment between the production components in the soybean crop.

Keywords: Production, yield, Area Planted, *Glycine max.*

1. INTRODUCTION

The soybean (*Glycine max* (L.) Merrill) is a crop of great socioeconomic importance, occupying one of the largest areas planted in Brazil. In the harvest of 2017/2018 production amounted to 119.80 million tons, in a planted area of 35.10 million hectares [1]. The state of Paraná is the second largest national producer, with a planted area of 5.44 million hectare producing approximately 19.07 million tons [2].

In a context marked by the growth in consumption of animal protein and the concern with the health and the development of new energetic matrices, the soybean became the main commodities, sustained by different segments, such as production of meat, soy-based drinks, manufacture of oils [4]. Additionally, another factor that stimulated the increase of the demand for soybeans was the extension of the use of biofuels in the world to replace petroleum derivatives [5].

The analysis of the dynamics of the cultivated area, production and yield of grains are important, since it allows to join actions of research and technology transfer to producers of

soybeans. Furthermore, it enables the development of technologies and the generation of knowledge aimed to maximize productivity [6].

Thus, it is crucial to know the history of the production, considering that culture is of great economic and social importance for the country. The objective of this work was to use simple linear regression analysis and correlation with information onproductionofplanted area, production and yield of soybean cropproduction in the state of Paraná, between 1997and 2017 seasons.

2. MATERIAL AND METHODS

The study was conducted with data obtained from the Portal of the Brazilian Institute of Geography and Statistics. We used information from the planted area, quantity produced and soybean yield in the state of Paraná and in Brazil, between the years of 1997 to 2017.

The Pearson correlation coefficient was used to measure the existence and degree of intensity between each of the considered variables, calculated from the following formula 1:

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

The correlation coefficient (r) for a sample of *n* pairs of values can demonstrate that X and Y are positively correlated, or are negatively correlated, or even, that there is no correlation.

In the following we used linear regression model to check the adjustment of the data byformula 2:

$$Yi = \beta_0 + \beta_1 X_i + \mu_i$$

Where β_0 represents the linear coefficient of the straight; β_1 is the angular coefficient of the straight and μ_i the error. The calculation of the estimate of trend was applied by F test (H0: $\beta = 0$; H1: $\beta \neq 0$). The coefficient of determination (r^2) was considered for the regression analysis, which is the amount of variation in Y explained by the regression line ($0 \leq r^2 \leq 1$), obtained by formula3:

$$r^2 = \frac{SQRegressão}{SQTotal} = \frac{\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

The coefficient of determination (r^2) is a descriptive measure of the quality of the adjustment is obtained.

Thus, with the use of a Microsoft Excel software, the analysis of variance (ANOVA) was performed and the dispersion graphs were generated, to demonstrate the adjustment of the linear model between the variablesconsidered.

3 RESULTS AND DISCUSSION.

The analysis of variance of linear regression ofcultivated area, quantity produced and soybean yield showed 1% of probability and observed by the correlation coefficient of Person (Table 1).

Table 1. Analysis of variance (ANOVA) to evaluate numerically the quality of fit for soybean production components between 1997 and 2017 in the state of Paraná.

Variables analyzed	R^2	F
Plantedarea	0.95	344.19**
Production in the state of Paraná	0.85	107.64**
Average production	0.62	34.21**

Rejects the hypothesis H0: β = 0, and whether to accept the alternative hypothesis H1: β ≠ 0

Based on the results of the cultivatedarea with soybean crop in Brazil, between the years of 1997 to 2017, it is observedthat there was an increase of 295.44%, corresponding to an increase of more than 20 million hectares (Figure 1).

Similarly,the state of Paraná shows an increase of area planted with soy in 204.97% when comparing the years 1997 to 2017, including more than 2 million hectares in these 20 years (Figure 1). However, both for the state and for the country there were fluctuations over the period averages of planted area.

The analysis shows the increase in the growth of soybean cultivation in Brazil. Increase as a result, almost exclusively, the incorporation of new areas in the production process rather than by an increase of the average yield of culture, especially in the last 20 years [3].

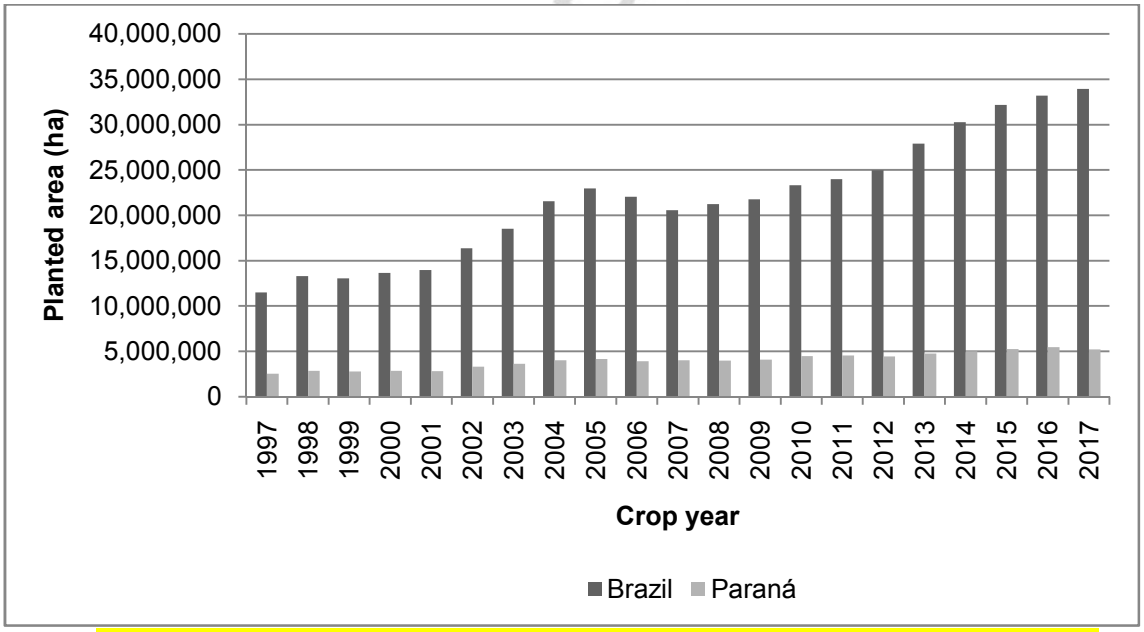

Fig. 1. Area planted with soybean cultivation in the state of Parana and Brazil in the period from 1997 to 2017.

The Paraná stood out over the years, however presented instability, being possibly related to climatic adversities [7]. Although there were fluctuations in the course of 20 years, it is observed that the increase in the planted area, both for Brazil and for the state of Paraná, possibly due to the degree of performance and availability of key factors of production and the technological advancement in the state and in the country [8].

In addition to this, the data showed that possibly the adoption and implementation of public policies, based on the incentive for research, development and innovation, in a public-private partnership model, may allow the increase of national production and state of the cultivation of soy due to a significant evolution of the planted area [9].

The area planted with soybeansunderstood at the time of the harvest of 1997/98 to 2016/17 in Brazil shows growth with oscillations (Figure 2). In the period between 2006 to 2009, there was a decrease in the planted area, when compared to the period of 2001 to 2006, but, from the year 2011 until the end of 2017 Brazil reached 5.45 million hectares.

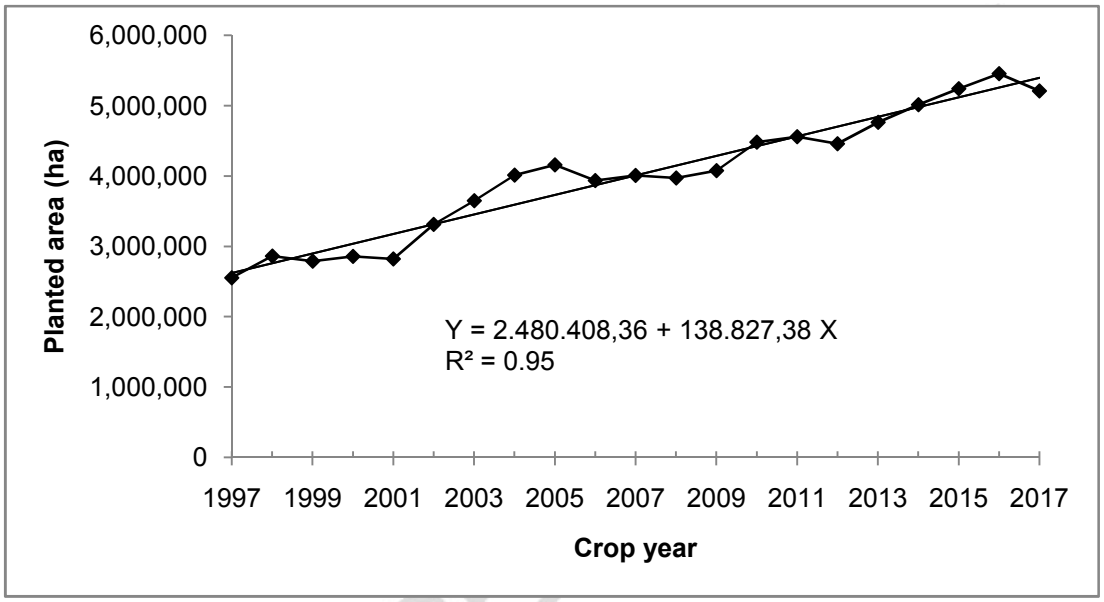

Fig. 2. Graph of the linear regression of cultivated area with soybean from 1997 to 2017 in the state of Paraná

The lack of regular rains, coupled with the currency appreciation in real and the low prices of agricultural products in the international market led to a fall of 15.1% in nominal value of production of the agricultural harvest in 2006 compared to 2005, reducing the value of production in 5.2% of the planted area of the harvest 2006 in relation to 2005, interrupting the sequence of growth since 2001 [10].

Over the years, it is possible to observe a strong correlation of growth in the area planted (R^2 0.95) which represents an increase of 48.4 %. In addition, investments in agrochemicals contributed to increase the productivity of soybean crop, as well as the researches of new genetic varieties more resistant. Also joined the innovative techniques of crop rotation and soil management [11]. This evolution has contributed to preventing hair loss of productivity and quality losses caused by climatic problems and also plant protection.

According to the Department of Rural Economy [12] In addition to the increase in area, the productivity of crops in Paraná favors the gradual increase in the production state, driven by exports of culture. In 2016 Brazilexported 49.6 million tons of soybeans.Of this total, 75% went to China, Spain was the destination for 3.3% of the totalexported, Thailand 3%, Holland 2.9% and Iran 2.4%.

The growth of planted area is directly proportional to the amount harvested over the years. Thus, the adjusted regression model of the amount of soybean produced as a function of years is expressed by equation Y = 5.582.312,39 + 552.812,07 X(Figure 3).

The model showed a coefficient of determination (R^2) of 0.85 and the correlation coefficient (R) of 0.92, indicating a strong relationship between the production and harvestsin the period considered. Similar results were observed by [13], in a study where he performed the analysis of correlation and regression of the Brazilian production of soy and maize, in the harvests of 1976/77 to 2015/2016.

In the last twenty years the production of soybeans in the state of Paraná increased by around289.82%, it went fromand 6.58 million tons in 1997 to 19.07 million tons, representing 17.2% of the national total in the harvest of 2017.

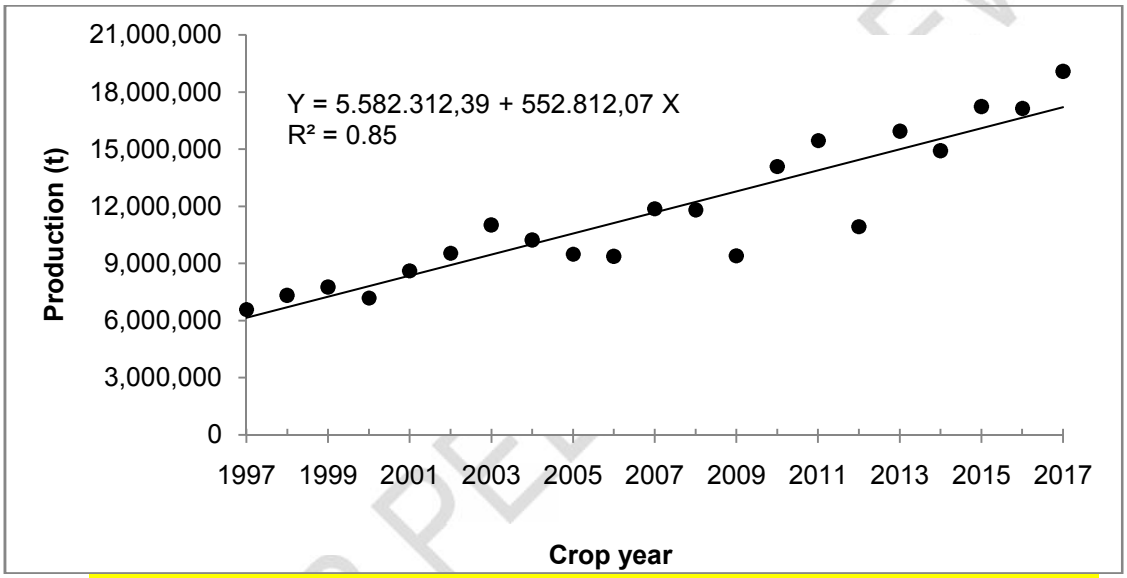

Fig. 3. Graph of the linear regression of soybeanproduction(t) from 1997 to 2017 in the state of Paraná.

The average production is an important factor for the analysis of economic performance because it is related to the existing technological levels and production[3].

The Paraná presents excellent yield, since production increased from 6.58 million tons of soy in 1997, with average yield of 2,590 kg ha^{-1} to 19.07 million tons, with average yield of 3,663 kg ha^{-1} in 2017. There is an increaseof141,43% when one compares the average yield over the last 20 years in Paraná, (Figure 4).

The mathematical model adjusted between the average yield of soybeans in the state of Paraná as a function of production is expressed by equation Y = 1.891,62 + 0,000084 X.

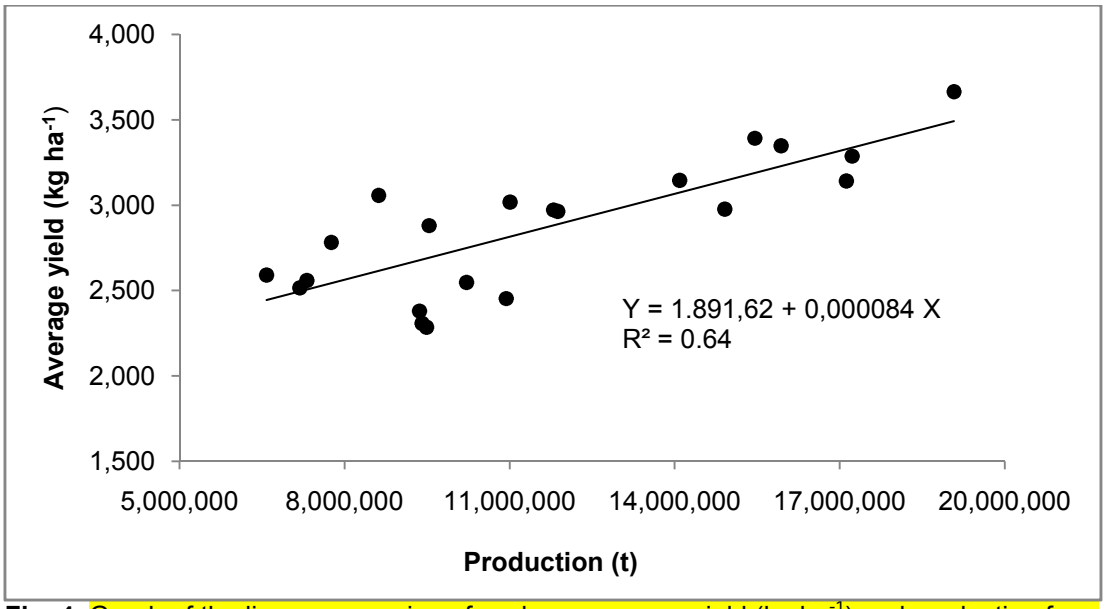

Fig. 4. Graph of the linear regression of soybean average yield (kg ha^{-1}) and production from 1997 to 2017 in the state of Paraná.

The average yield of soybeans reached this yield, due to the performance, technological level and availability of the main economically viable factors of production [3].

The average yield of soybean production in the state of Paraná in 2017 was above the national average of 3,377 kg ha^{-1}. Investments in technology, management practices and soil conservation contribute to the Parana being second in national production [14].

The level of technology, financing, technical development, agricultural inputs and natural resources together contribute to raising the average of productive income[3]. However, it is necessary to constantly seek technological innovation in the production process to achieve higher levels of production with the soybean crop

4. CONCLUSION

The simple linear regression and correlation analysis showed an adjustment between the cultivated area, the production and the average productivity in the soybean crop in the period from 1997 to 2017.These statistical techniques were efficient to describe the relations between the production components in the soybean crop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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