# Production and yield of soybean in the state of Paraná for two decades


## ABSTRACT

**Aim:** The present study aims to evaluate the production and yield of soybean in the state of Paraná, in the last two decades
**Study design:** The study was conducted with data obtained from the Portal of the Brazilian Institute of Geography and Statistics (IBGE/cider). The study 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.
**Place and Duration of Study:** the State University of Western Paraná, Post-Graduation in Agronomy, between July 2018 and December 2018.
**Results:** The results obtained, it was possible to observe significant increases in soybean production in Paraná in 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. The regression analysis and the correlation demonstrated the influence between the production components planted area, quantity produced and soybean yield evaluated in the period which fostered the prospect of increased grain production chain in Brazil and in the state of Paraná, evidencing that the technological standard, the basket of inputs.
**Conclusion:** There was a linear correlation between the production components demonstrating increased during the period examined in the components of the soy production.



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


## 1. INTRODUCTION

The soybean (*Glycine max* (L.) Merrill) is high socio-economically important crop, occupying one of the largest areas planted in Brazil. In the harvest of 2017/2018 production amounted to 119.80 million tonnes, 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 5.444 million hectares producing approximately 19.070 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, soybean has become one of the major commodities in the market, sustained by different segments, such as the 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 cultivated area dynamics, production and yield of grains are important since it allows to align 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 production data planted area, production and yield of soybean production in the state of Paraná, between 1996 and 2017 seasons.

## 2. MATERIAL AND METHODS

The study was conducted with data obtained from the Portal of the Brazilian Institute of Geography and Statistics (IBGE/cider). 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.

Pearson's correlation coefficient was performed to measure the existence and degree of intensity between each of the variables considered by means of the following expression by equation 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 equation, we used a linear regression model to check the adjustment of the data

$$Yi = \propto + \beta Xi + \mu i$$

Where α represents the linear coefficient of the straight; β is the angular coefficient of the straight and μ the error. The calculation of the estimate of the trend was applied by the F test (H0: β = 0; H1: β ≠ 0). The coefficient of determination (r2) was considered for the regression analysis, which is the amount of variation in Y explained by the regression line ($0 \leq r2 \leq 1$), obtained by equation 3:

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

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

Result data were normalized and analysis of variance (ANOVA) was performed and the dispersion graphs were generated, to demonstrate the adjustment of the linear model between the variables.

## 3 RESULTS AND DISCUSSION.

The analysis of variance of linear regression for the planted area, quantity produced and soybean yield showed 5% of probability and observed by the correlation coefficient of Person (Table 1).

**Table 1. Analysis of variance of simple linear regression and correlation of components of production in the years 1997 to 2017 for the state of Paraná**

| Variables analyzed | R2 | F |
|---|---|---|
| The planted area and years | 0.94 | 344, 19** |
| Quantity produced and years | 0.84 | 107, 64** |
| Quantity produced and income | 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 area planted with soy in Brazil, between the years of 1997 to 2017, it is observed that there was an increase of 195.44%, corresponding to an increase of more than 20 million hectares (Figure 1).

Similarly, state of Paraná shows an increase of area planted with soy in 104.97% 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 the planted area.

This analysis was done to realize the tremendous growth of the cultivation of soybeans 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].

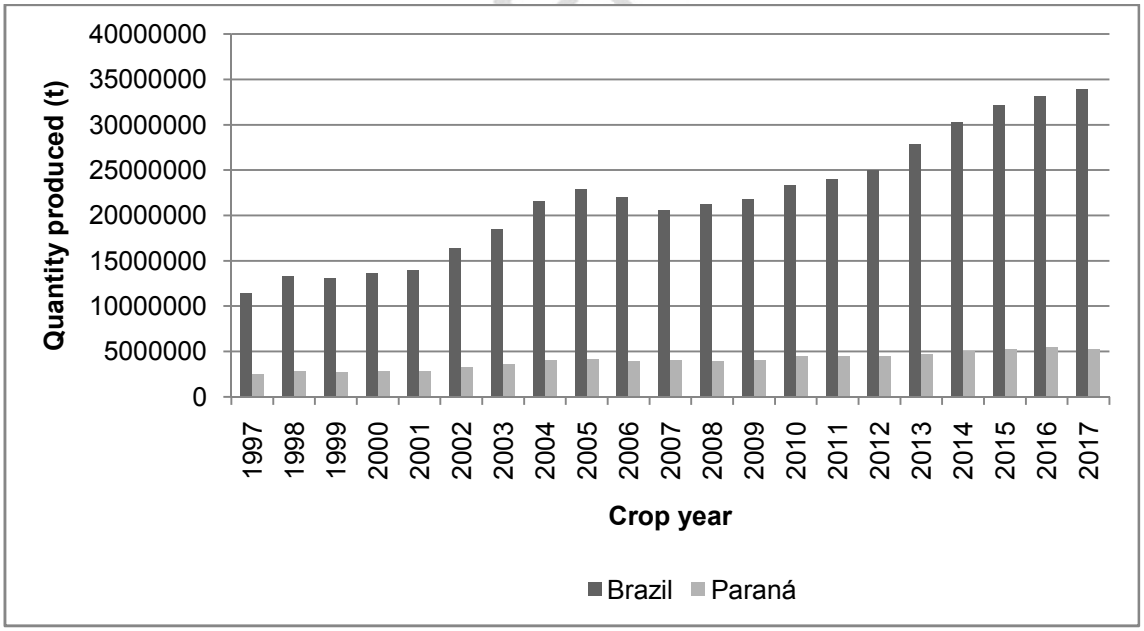


**Fig. 1. Soybean planted area in hectares in the state of Paraná and in Brazil in the years 1997 to 2017. Source: IBGE**

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 soybean plantation area during harvest time of 1997/98 to 2016/17 showed growth with oscillations (Figure 2) in Brazil. 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.

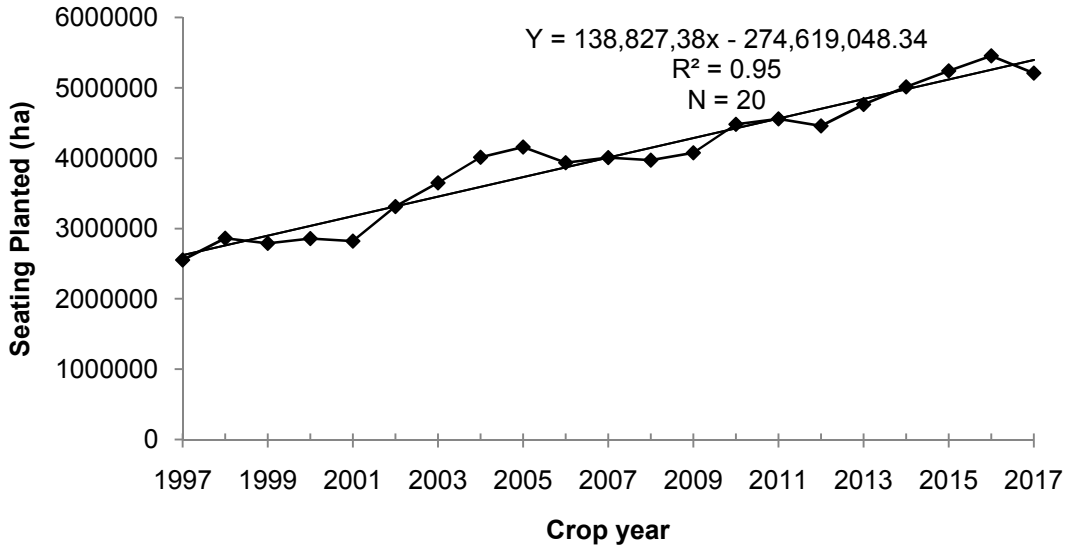


**Fig. 2. Correlation between the area planted with soybeans (ha) and the years of 1997 to 2017 in the state of Paraná. Source: IBGE**

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 (R2 0.95) which represents an increase of 48.4 %. Furthermore, the investments in the agrochemicals contributed to the increase of production, 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 favours the gradual increase in the production state, driven by exports of culture. In 2016 Brazil exported 49.6 million tons of soybeans. Of this total,

75% had as a destination to China, Spain was the destination for 3.3% of the total export to Thailand 3%, the Netherlands with 2.9% and 2.4% Iran around.

The growth of the planted area is directly proportional to the quantity harvested over the years. In this way, the adjusted model of regression of quantity produced of soybean is a function of years is expressed by the equation y = 552,812,07x - 1,097,830,584.77 (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 harvests over the study period. Similar results were observed by [13], in a study where he performed the analysis of correlation and regression of the Brazilian production of soya and maize, in the harvests of 1976/77 to 2015/2016.

In the last twenty years of soybean production in Paraná increased 189.82%, i.e., passed and 6.58 million tonnes in 1997 to 19.07 million tons, representing 17.2% of the national total in the harvest of 2017.

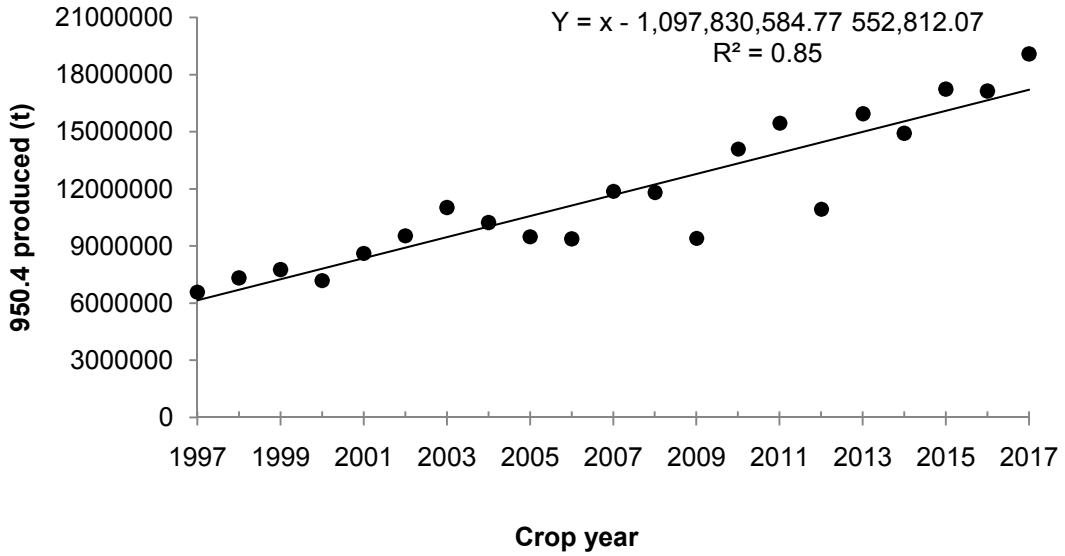


**Fig. 3. Correlation between the production of soybean (t ha-1) and the years of 1997 to 2017 in the state of Paraná. Source: IBGE**

The average yield represents a central aspect and fundamental for the analysis of the economic performance of culture in the field, in virtue of the income be a coefficient that measures the optimization obtained from the optimal application of factors of production, given the existing technological levels [3].

Figure 4 shows the Paraná presents excellent yield, since production increased from 6.58 million tons of soy in 1997, with an average yield of 2,590 kg ha-1 to 19.07 million tons, with an average yield of 3,663 kg ha-1 in 2017. There is an evaluation of 59.95% when one compares the average yield over the last 20 years in Paraná.

The mathematical model adjusted by regression on the average yield of soybean production in the state of Paraná in the production function is expressed by the equation y = 0.00x + 1,891,6.

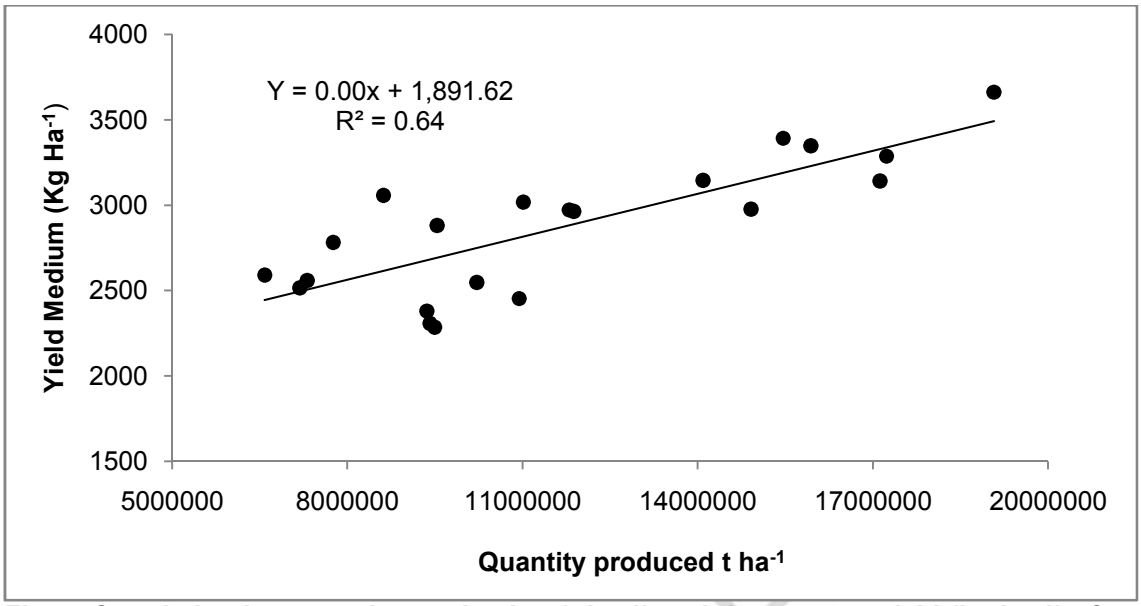


**Fig. 4. Correlation between the production (t ha-1) and the average yield (kg ha-1) of soybeans in the years 1997 to 2017 in the state of Paraná. Source: IBGE**

The average production of soybean reached a level of productive balance, in which the average yield is optimized, given the degree of performance and availability of key factors of production and also given the level of accessible technology, widespread commercially and economically viable [3].

The average yield of soybean production in the state of Paraná is above the nation which was in 2017 of 3,377 kg ha-1. Investments in technology, the adoption of practices for the conservation and management of the soil, which mitigate the risk inherent in the activity, makes the Paraná is evident in the second position among the producing states [14].

Therefore, the transformation of raw material into product reflects the level of applied technology, the degree of investment bank employee, the pattern of development and technical progress, added to the productive inputs, the use of natural resources so great, finally, maximizing the average yield results from the application of this entire set of variables of great way [3]. On the other hand, it is necessary to the constant pursuit of change in production, by means of technological innovation, is, of inputs or in the productive process, because the cultivation of soy can achieve higher levels of income.

## 4. CONCLUSION

The regression analysis and the correlation demonstrated the influence between the production components planted area, quantity produced and soybean yield evaluated in the period from 1997 to 2017, which fostered the prospect of increased grain production chain in Brazil and in the state of Paraná, evidencing that the technological standard, the inputs, production techniques, among other factors relevant for the production of soya, disseminated and commercially available in the major centres producers can provide results that achieve higher levels of productivity.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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