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3 **Overview of the components of soy production**

4 **in the state of Paraná and in two decades**

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9 **ABSTRACT**

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**Aims:** The aim of this work was by means of the simple linear regression analysis and correlation to evaluate the panorama of production, the planted area and the production and yield of soybean production in the state of Paraná, in the last two decades

**Study design:** The 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 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 and linear correlation.

**Results:** The results obtained, it was possible to observe significant increases of soybean production in Paraná in comparison to Brazil 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

**Conclusion:** There was a linear correlation between the production components demonstrating increased during the period examined in the components of the soy production.

11

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

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15 **1. INTRODUCTION**

16

17 The soybean (*Glycine max* (L.) Merrill) is a crop of great socio-economic importance, 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 hectare producing approximately 19.070 million tons [2].

22

23 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, soy has become one of the major commodities markets, 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].

29

30 The analysis of the dynamics of the cultivated area, production and yield of grains are important, since it allows one 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].

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35 Thus, it is crucial to know the history of the production, considering that culture is of great  
36 economic and social importance for the country. The objective of this work was to use simple  
37 linear regression analysis and correlation with production data (planted area, production and  
38 yield of soybean production in the state of Paraná, between 1996 and 2017 seasons.

39

## 40 2. MATERIAL AND METHODS

41

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

46

47 Pearson's correlation coefficient was performed to measure the existence and degree of  
48 intensity between each of the variables considered by means of the following expression by  
49 equation 1:

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

50

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

53

54 In the following we used linear regression model to check the adjustment of the data by  
55 equation 2:

56

$$Y_i = \alpha + \beta X_i + \mu_i$$

57

58 Where  $\alpha$  represents the linear coefficient of the straight;  $\beta$  is the angular coefficient of the  
59 straight and  $\mu$  the error. The calculation of the estimate of trend was applied by F test ( $H_0: \beta$   
60 = 0;  $H_1: \beta \neq 0$ ). The coefficient of determination ( $r^2$ ) was considered for the regression  
61 analysis, which is the amount of variation in Y explained by the regression line ( $0 \leq r^2 \leq 1$ ),  
62 obtained by equation 3:

63

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

64

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

67

68 Thus, with the use of a spreadsheet Microsoft Excel, the analysis of variance (ANOVA) was  
69 performed and the dispersion graphs were generated, to demonstrate the adjustment of the  
70 linear model between the variables studied

71

## 72 3 RESULTS AND DISCUSSION.

73

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

77

78 **Table 1. Analysis of variance of simple linear**  
 79 **regression and correlation of components of production in the years 1997 to 2017 for**  
 80 **the state of Paraná.**  
 81

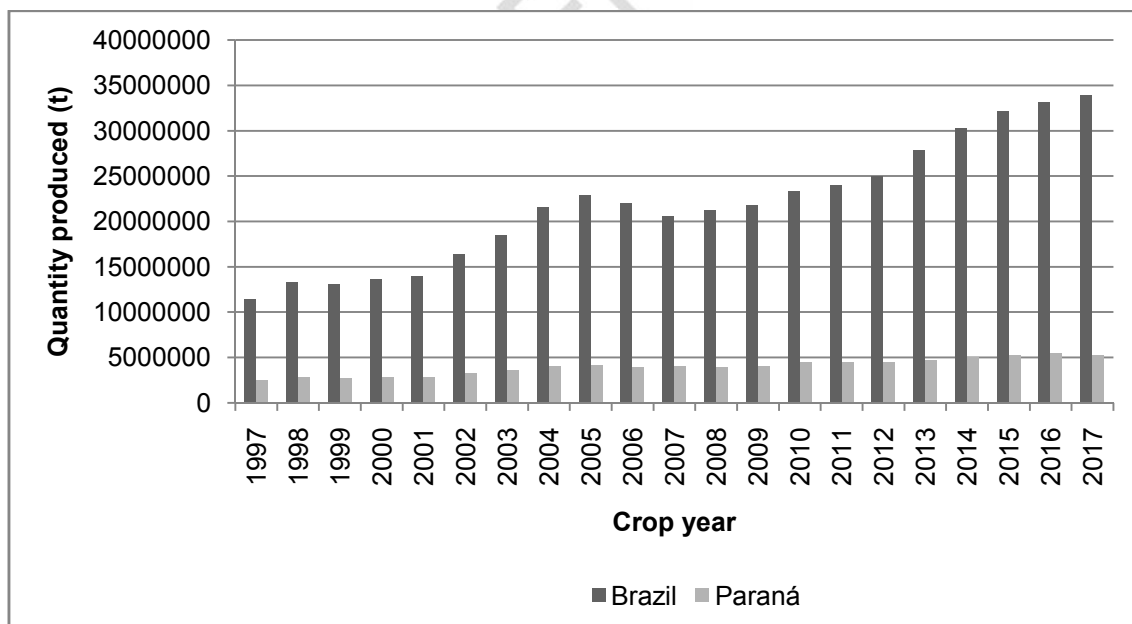
Variables analyzed	R2	F
The planted area and years	0.94	344, 19**
Quantity produced and years	0.84	107, 64**
Quantity produced and income	0.62	34, 21**

82 Rejects the hypothesis  $H_0: \beta = 0$ , and whether to accept the alternative hypothesis  $H_1: \beta \neq$   
 83 0  
 84

85 Based on the results of the area planted with soy in Brazil, between the years of 1997 to  
 86 2017, it is possible to observe that there was an increase of 195.44%, corresponding  
 87 to an increase of more than 20 million hectares (Figure 1).  
 88

89 Similarly, the state of Paraná shows an increase of area planted with soy in 104.97% when  
 90 comparing the years 1997 to 2017, including more than 2 million hectares in these  
 91 20 years (Figure 1). However, both for the state and for the country there were fluctuations  
 92 over the period averages of planted area.  
 93

94 This analysis to realize the tremendous growth of the cultivation of soybeans in Brazil.  
 95 Increase as a result, almost exclusively, the incorporation of new areas in the production  
 96 process rather than by an increase of the average yield of culture, especially in the  
 97 last 20 years [3].  
 98



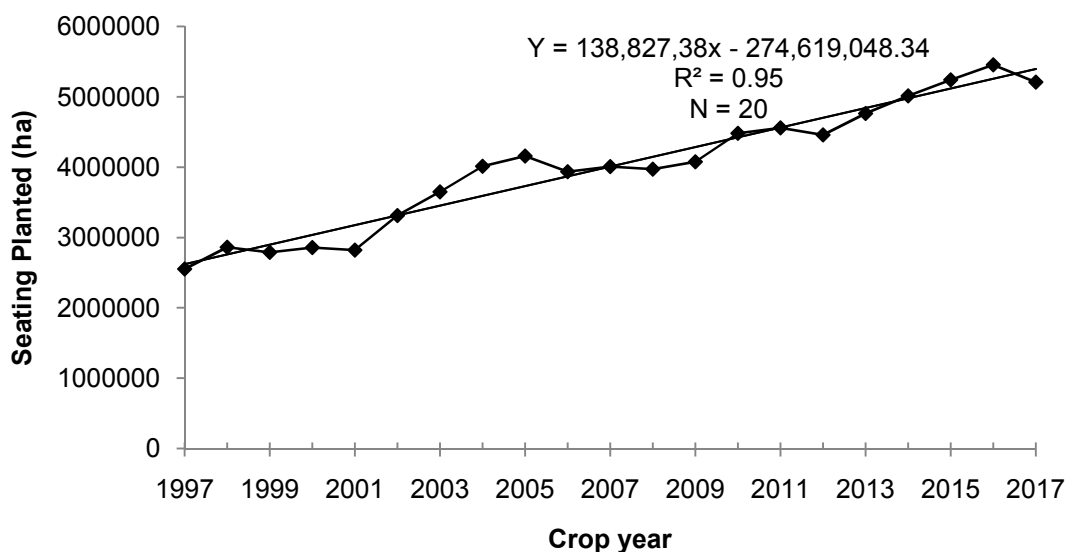
99  
 100 **Fig. 1. Soybean planted area in hectares in the state of Paraná and in Brazil in the**  
 101 **years 1997 to 2017. Source: IBGE**  
 102

103 The Paraná stood out over the years, however presented instability, being possibly related to  
 104 climatic adversities [7]. Although there were fluctuations in the course of 20 years, it is  
 105 observed that the increase in the planted area, both for Brazil and for the state of

106 Paraná, possibly due to the degree of performance and availability of key  
107 factors of production and the technological advancement in the state and in the country [8].

108  
109 In addition to this, the data showed that possibly the adoption and implementation of public  
110 policies, based on the incentive for research, development and innovation, in a public-  
111 private partnership model, may allow the increase of national production and state of  
112 the cultivation of soy due to a significant evolution of the planted area [9].

113  
114 The area **planted to soybeans** understood at the time of the harvest of 1997/98 to 2016/17  
115 in Brazil shows growth with oscillations (Figure 2). In the period between 2006 to 2009, there  
116 was a decrease in the planted area, when compared to the period of 2001 to 2006,  
117 but, from the year 2011 until the end of 2017 Brazil reached 5.45 million hectares.



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

140  
141 The lack of regular rains, coupled with the currency appreciation in real and the low  
142 prices of agricultural products in the international market led to a fall of 15.1% in nominal  
143 value of production of the agricultural harvest in 2006 compared to 2005, reducing the value  
144 of production in 5.2% of the planted area of the harvest 2006 in relation to  
145 2005, interrupting the sequence of growth since 2001 [10].

146  
147 Over the years, it is possible to observe a strong correlation of growth in the area  
148 planted ( $R^2$  0.95) which represents an increase of 48.4 %. Furthermore, the investments in  
149 the agrochemicals contributed in the increase of **productivity**, as well  
150 as the researches of new genetic varieties more resistant. Also joined the innovative  
151 techniques of crop rotation and soil management [11]. This  
152 evolution has contributed to preventing hair loss of productivity and quality losses caused by  
153 climatic problems and also plant protection.

154  
155 According to the Department of Rural Economy [12] In addition to the increase in area, the  
156 productivity of crops in Paraná favors the gradual increase in the production state, driven by  
157 exports of culture. In 2016 Brazil exported 49.6 million tons of soybeans. Of this total,

158 75% had as a destination to China, Spain was the destination for 3.3% of the total export to  
159 Thailand 3%, the Netherlands with 2.9% and 2.4% Iran around.

160

161 The growth of the planted area is directly proportional to the quantity harvested  
162 over the years. In this way, the adjusted model of regression of quantity produced of soy is  
163 function of years is expressed by the equation  $y = 552,812,07x - 1,097,830,584.77$   
164 (Figure 3).

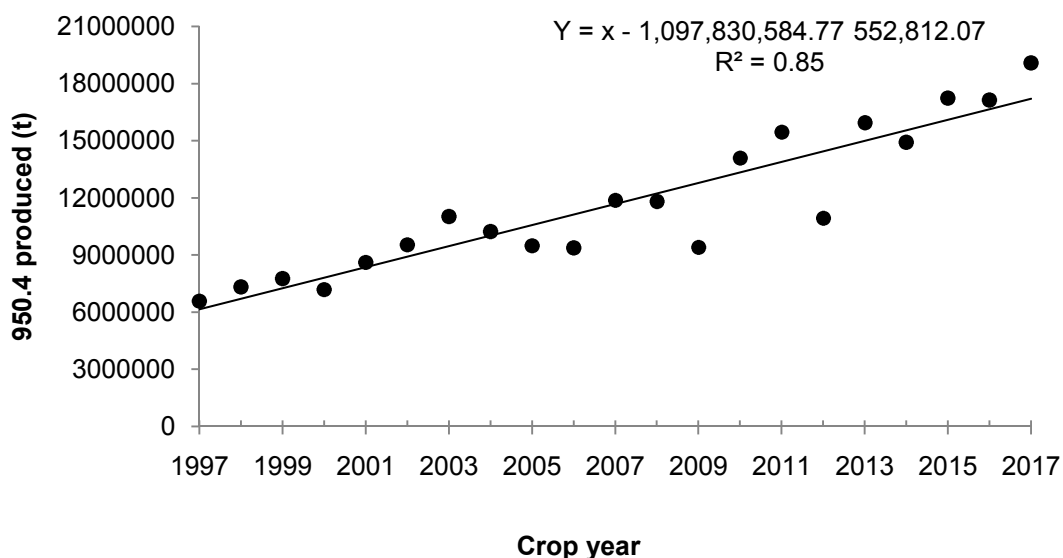
165

166 The model showed a coefficient of determination ( $R^2$ ) of 0.85 and the correlation  
167 coefficient (R) of 0.92, indicating a strong relationship between the production and  
168 harvests over the years. Similar results were observed by [13], in a study where he  
169 performed the analysis of correlation and regression of the Brazilian  
170 production of soya and maize, in the harvests of 1976/77 to 2015/2016.

171

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

175



176

177 **Fig. 3. Correlation between the production of soybean (t ha-1) and the years of 1997 to**  
178 **2017 in the state of Paraná. Source: IBGE**

179

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

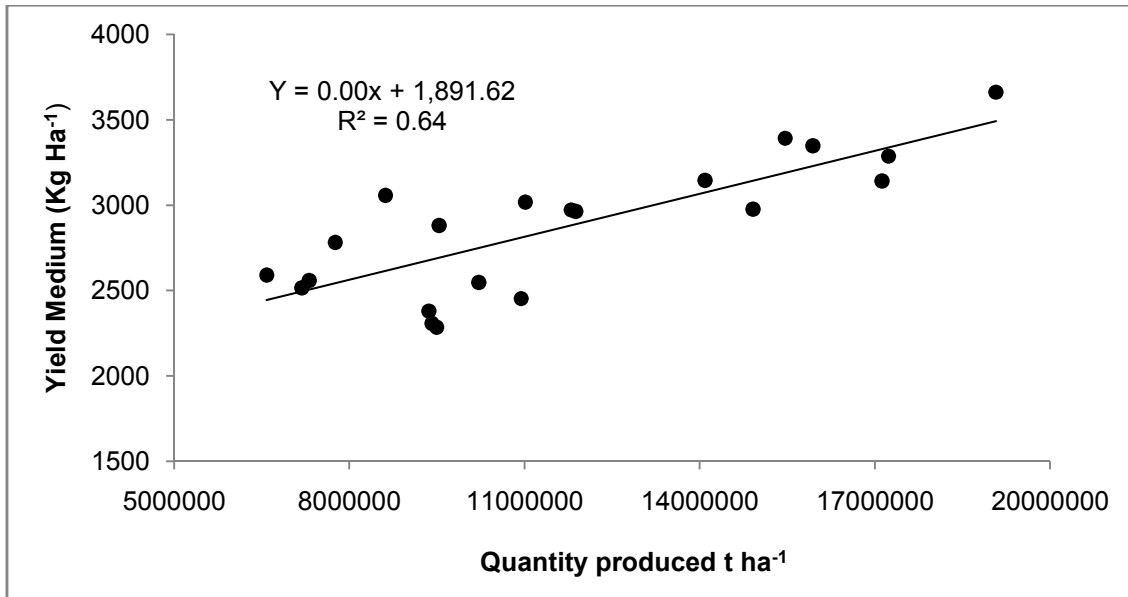
184

185 In Figure 4, the Paraná presents excellent yield, since production increased from  
186 6.58 million tons of soy in 1997, with average yield of 2,590 kg ha-1 to 19.07 million tons,  
187 with average yield of 3,663 kg ha-1 in 2017. There is an evolution  
188 59.95% when one compares the average yield over the last 20 years in Paraná.

189

190 The mathematical model adjusted by regression on the average yield of soybean  
191 production in the state of Paraná in the production function is expressed by the equation  $y =$   
192  $0.00x + 1,891,6$ .

193



194 Fig. 4. Correlation between the production (t ha<sup>-1</sup>) and the average yield (kg ha<sup>-1</sup>) of  
 195 soybeans in the years 1997 to 2017 in the state of Paraná. Source: IBGE  
 196  
 197

198 The average productivity of soybean reached a level of productive balance, in which the  
 199 average yield is optimized, given the degree of performance and availability of key  
 200 factors of production and also given the level of accessible technology, widespread  
 201 commercially and economically viable [3].  
 202

203 The average yield of soybean production in the state of Paraná is  
 204 above the national who was in 2017 of 3,377 kg ha<sup>-1</sup>. Investments in technology, the  
 205 adoption of practices for the conservation and management of the soil,  
 206 which mitigate the risk inherent in the activity, makes the Paraná is evident in the second  
 207 position among the producing states [14].  
 208

209 Therefore, the transformation of raw material into product reflects the level of applied  
 210 technology, the degree of investment bank employee, the  
 211 pattern of development and technical progress, added to the productive inputs, the  
 212 use of natural resources so great, finally, maximizing the average yield results from  
 213 the application of this entire set of variables of great way [3]. On the other hand, it is  
 214 necessary to the constant pursuit of change in production, by means of technological  
 215 innovation, is, of inputs or in the productive process, because the cultivation of soy can  
 216 achieve higher levels of income.  
 217

#### 218 4. CONCLUSÃO

219  
 220 The regression analysis and the correlation demonstrated the influence between the  
 221 production components planted area, quantity produced and soybean yield evaluated in the  
 222 period from 1997 to 2017, which fostered the prospect of increased grain production chain in  
 223 Brazil and in the state of Paraná, evidencing that the technological standard, the basket of  
 224 inputs, production techniques, among other factors relevant for the production of soya,  
 225 disseminated and commercially available in the major centers producers can provide results  
 226 that achieve higher levels of productivity.  
 227  
 228

229 **COMPETING INTERESTS**

230

231 Authors have declared that no competing interests exist.

232

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