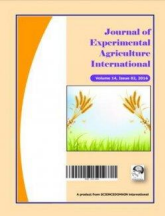

Journal of Experimental Agriculture International

37(6): 1-7, 2019; Article no.JEAI.49047
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Analysis of the Production Components in the Soybean Crop in the Last Two Decades in the State of Parana and Brazil

Norma Schlickmann Lazaretti[1], Patrícia Clemente Abraão[1*], Tatiane Calandrino da Mata[1], Kerolém Prícila Sousa Cardoso[1], Noélle Khristinne Cordeiro[1], Dablieny Hellen Garcia Souza[1], Daiane Bernardi[1], and Eurides Kuster Macedo Júnior[1]

[1]State University of Western Paraná, Marechal Cândido Rondon, Paraná State, Brazil.

Authors' contributions

This work was carried out in collaboration among all authors. Authors NSL, KPSC, PCA, TCM and EKMJ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NKC and DHGS managed the analyses of the study. Author DB managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2019/v37i630284
Editor(s):
(1) Dr. Ismail Seven, Assistant Professor, Department of Plantal and Animal Production, Vocation School of Sivrice, University of Firat, Turkey.
(2) Dr. Lanzhuang Chen, Professor, Laboratory of Plant Biotechnology, Faculty of Environment and Horticulture, Minami Kyushu University, Miyazaki, Japan.
(3) Dr. Slawomir Borek, Professor, Department of Plant Physiology, Adam Mickiewicz University, Poland.
(4) Dr. Daniele De Wrachien, Professor, State University of Milan, Italy.
Reviewers:
(1) Schirley Costalonga, Universidade Federal do Espírito Santo, Brazil.
(2) F. J. Owuna, Usmanu Danfodiyo University, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/49047

Short Research Article

Received 26 March 2019
Accepted 12 June 2019
Published 21 June 2019

ABSTRACT

Introduction: Soy is an agricultural crop that has great economic importance. The analysis considering the cultivated area, the production and the yield of grains contributes to research and transfer of technology to the producers.
Aims: To adjust the mathematical model using simple linear regression analysis and correlation between the variables of planted area, production and productivity, in the state of Paraná and Brazil, in the last two decades.

**Corresponding author: E-mail: patriciaabraao@gmail.com;*

Study Design: Data collection and research of information on the cultivation of soybeans in the state of Paraná and in Brazil on official websites
Place and Duration of Study: State University of Western Paraná, Post-Graduation in Agronomy, between July 2018 and December 2018.
Methodology: Data were obtained from the Portal of the Brazilian Institute of Geography and Statistics between 1997 and 2017. Simple linear regression analysis and Pearson correlation analysis were used.
Results: By analyzing the results, it is possible to observe significant increases in soybean production in both Paraná and Brazil over this 20-year period. Paraná achieved a 205% increase in planted area, 290% in production and 141% in average yield.
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.

Keywords: Production; yield; area planted; glycine max.

1. INTRODUCTION

The soybean (*Glycine max* (L.) Merrill) is a crop of great economic 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 [2,3].

In a context marked by the growth of animal protein consumption and concern for health and the development of new energy matrices, soybean has become the main agricultural commodity, supported by different segments, such as meat production, 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 develop 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 in the variables of planted area, production and productivity of the soybean crop in the state of Paraná between 1997 and 2017.

2. MATERIALS 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, is defined as follows:

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

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.

Next, the linear regression model was used to verify the fit of the data by the following expression:

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

which describes a line with slope β_1 and Yi intercept β_0. 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:

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

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

Using the Microsoft Excel software, analysis of variance was performed (ANOVA) and generated scatter plots to demonstrate the fit of the linear model between the variables.

3. RESULTS AND DISCUSSION

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

Based on the results of the cultivated area with soybean crop in Brazil, between the years of 1997 to 2017, it is observed that there was an increase of 295.44%, corresponding to an increase of more than 20 million hectares (Fig.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 (Fig. 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].

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
Planted area	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

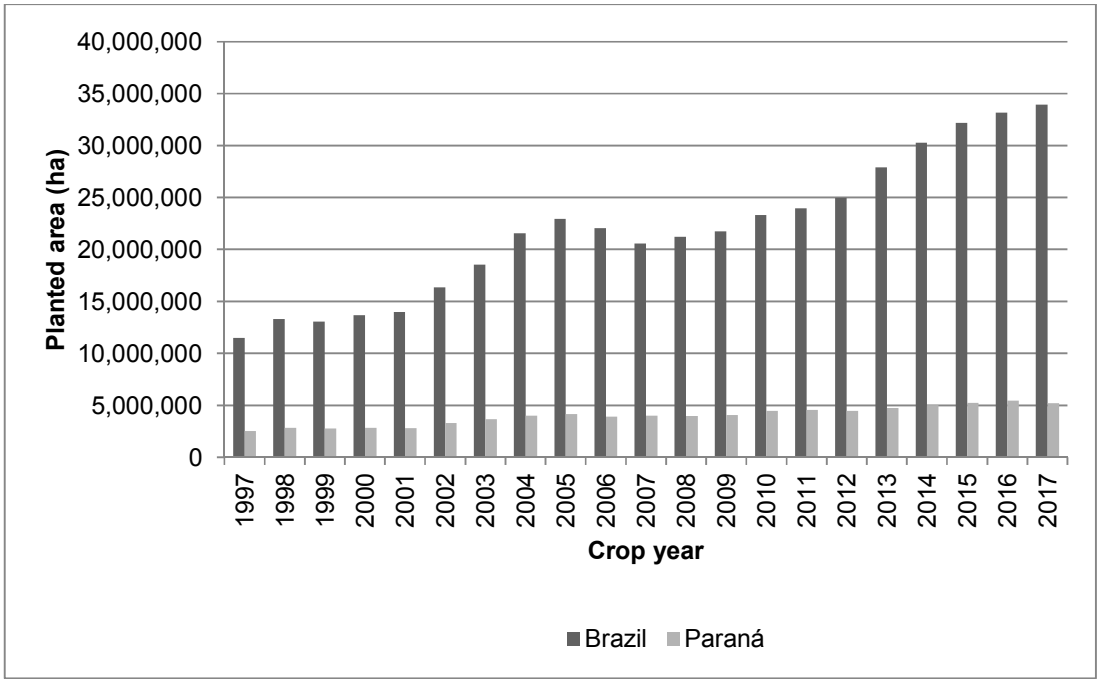

Fig. 1. Area planted with soybean cultivation in the state of Parana and Brazil in the period from 1997 to 2017

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 soybeans understood at the time of the harvest of 1997/98 to 2016/17 in Brazil shows growth with oscillations (Fig. 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.

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 Brazil exported 49.6 million tons of soybeans. Of this total, 75% went to China, Spain was the destination for 3.3% of the total exported, Thailand 3%, Holland 2.9% and Iran 2.4%.

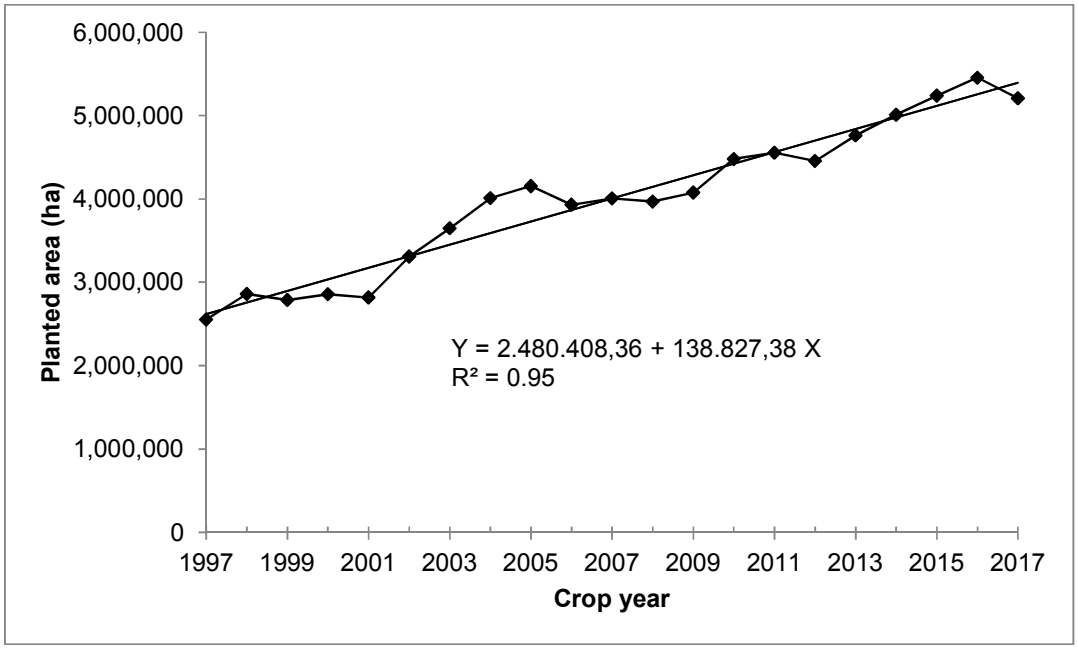

Fig. 2. Graph of the linear regression of cultivated area with soybean from 1997 to 2017 in the state of Paraná

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 (Fig. 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 in 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 around 289.82%, it went from and 6.58 million tons in 1997 to 19.07 million tons, representing 17.2% of the national total in the harvest of 2017.

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 increase of 141,43% when one compares the average yield over the last 20 years in Paraná, (Fig. 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.

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.

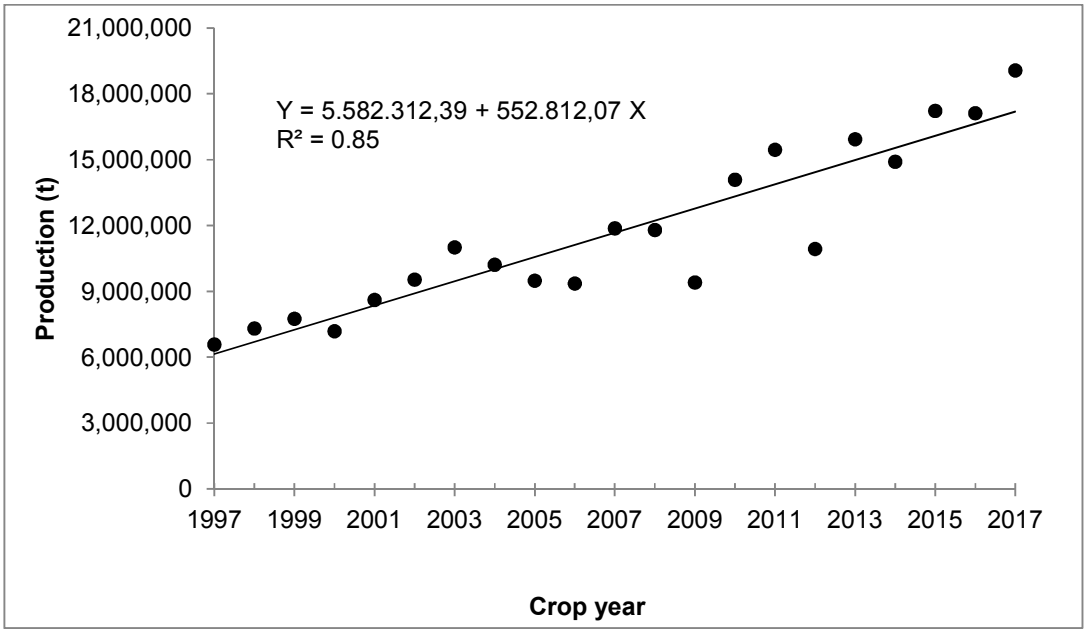

Fig. 3. Graph of the linear regression of soybean production (t) from 1997 to 2017 in the state of Paraná

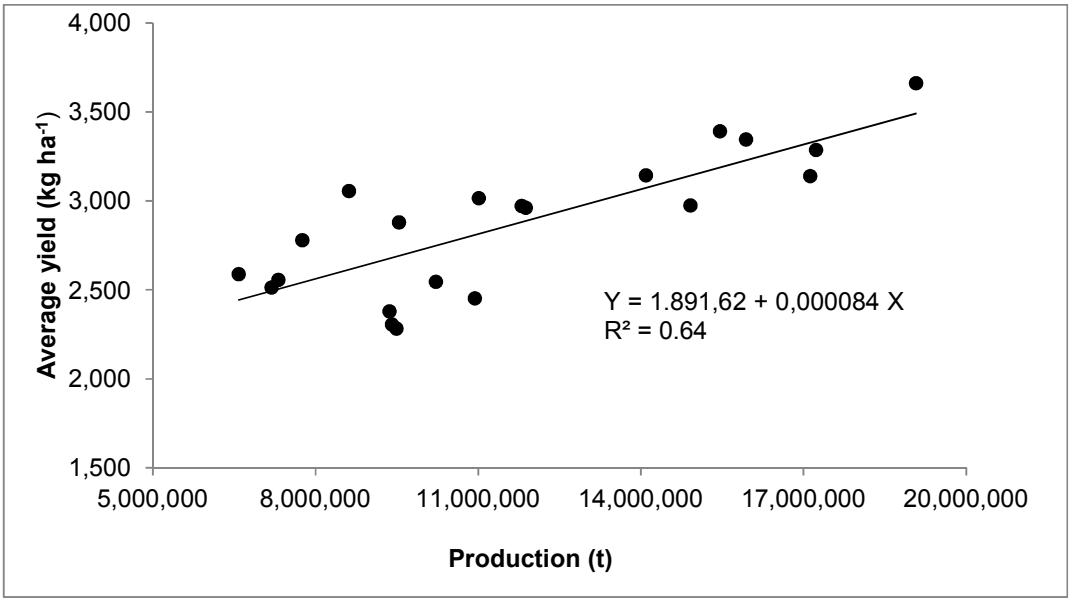

Fig. 4. Graph of the linear regression of soybean average yield (kg ha^{-1}) and production from 1997 to 2017 in the state of Paraná

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.

REFERENCES

1. USDA - United States Department of Agriculture. World Agricultural Production. [Accessed 30 October 2018] Available:https://www.fas.usda.gov/data/world-agricultural-production
2. CONAB. National Supply Company. Monitoring of the Brazilian harvest of grain -season 2017/2018. Brasilia: Embrapa. 2018;1:178.
3. CONAB-National Supply Company. The yield of soybean: Analysis and perspectives; 2017. [Accessed 31 October 2018] Available:https://www.conab.gov.br/uploads/arquivos/17_08_02_14_27_28_10_compendio_de_estudos_conab__a_produtividade_da_soja_-_analise_e_perspectivas_-_volume_10_2017.pdf
4. Rigo AA, Dahmer AM, Steffens C, Steffens J, Carrão-Panizzi MC. Characterization of soybean genetically improved cultivars for human consumption. International Journal of Food Engineering. 2015;1:7. Available:https://www.alice.cnptia.embrapa.br/alice/bitstream/doc/1018826/1/2015IJFEv1n1p1.pdf
5. Solano L, Yamashita OM. Soybean cultivation in different spacing between lines. Varies Scientia Agrarias. 2011;35: 47. [Accessed 31 October 2018] Available:http://e-revista.unioeste.br/index.php/variascientiaagraria/article/view/5382/5043
6. Room AAB, Hirakuri MH, Franchini JC, Debiasi H, Ribeiro RH. Analysis of the area, production and yield of soybean in Brazil in two decades (1997-2016). Londrina: Embrapa. 2017;21. [Accessed 31 October 2018] Available:https://ainfo.cnptia.embrapa.br/digital/bitstream/item/156652/1/Boletim-de-PD-11.pdf
7. Barbosa MZ, Sampaio RM. Soybeans: High productivity and technology. Analyzes and indicators of agribusiness, São Paulo; 2017. [Accessed 31 October 2018]

Available:http://www.iea.sp.gov.br/ftpiea/AIA/AIA-28-2017.pdf
8. OECD - Organization for Economic Cooperation and Development. Crop production (indicator). France: OECD; 2018.
DOI: 10.1787/49a4e677
[Accessed 30 October 2018]
Available: www.oecd.org
9. Guimarães TA. The dynamics of soybean crop in the state of Paraná: The role of the Embrapa between 1989 and 2002. Showcase of the Conjuncture, Curitiba; 2011.
[Accessed 30 October 2018]
Available:https://img.fae.edu/galeria/getImage/1/2496584274915073.pdf
10. Farid OJ. Estadão de São Paulo. Portuguese.
[Accessed 31 October 2018]
Available:https://economia.estadao.com.br/noticias/geral,valor-da-safra-agricola-de-2006-teve-queda-de-15-1,22423
11. IEAG-Institute for the Study of agri-business. The Future of the national soy - socioeconomic impacts of the Asian rust in soybeans in the next ten years; 2015.
[Accessed 20 October 2018]
Available:http://www.abag.com.br/media/images/0-futuro-da-soja-nacional---ieag---abag.pdf
12. Federal-Department of Rural Economy. Soybean - Analysis of the agricultural situation PARANÁ - season 2016/17; 2016.
[Accessed 20 October 2018]
Available:http://www.agricultura.pr.gov.br/arquivos/File/deral/Prognosticos/2017/Soja_2016_17.pdf
13. Egewarth VA, Mattei, Chiapetti T, Macedo Junior EK, Egewarth JF, Bartzen BT. Analysis of correlation and regression of the Brazilian production of soya and maize. Journal of Sciences, Umuarama seeds. 2017;134:140.
[Accessed 20 October 2018]
Available:http://www.dca.uem.br/V6N1/14.pdf
14. Demarchi M. Analysis of the agricultural situation, safra 2011/2012. Paraná: Seab. 2011;14.
[Accessed 31 October 2018]
Available:https://www.fag.edu.br/upload/revista/cultivando_o_saber/54eb1d17c9e96.pdf

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/49047