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Analysis of the Technological Evolution of Coffee Production in Brazil

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Abstract

Coffee is one of the most important crops in the Brazilian agricultural sector. In order to position itself as the largest producer and exporter of grains, since to maintain levels, the sector has been associating and introducing concepts of new technologies in the field, processing, as well as in the introduction of increasingly modern equipment. The objective of this work was to verify if the increase in technology provides an increase in production and productivity. Thus, its development started based on data collections from the National Institute of Industrial Property (INPI) in relation to the evolution of new technologies in the Brazilian coffee sector, raising information on patent deposits carried out between the years 1977 and 2017. to collect and classify according to the classification of the IPC (International Classification of Patents), separating according to its technological level and in its area of operation (field, processing and industrial equipment). Performed from the data survey, a verification by the Pearson correlation between the variables. Observing that even with the reduction of areas destined to the culture cultivation, it was possible to identify an increase in production. Evidence that can be associated with the development and application of efficient management, implementation and structuring of technological concepts. In addition to the acceptance of the insertion of new tools and the qualification of labor by the producers, given the need to ensure productive values and guarantee a quality product for the final consumer.

Keywords: Coffee growing, technological development, patent, innovation and technology

1. Introduction

Coffee is a crop of the *Rubiaceae* family, historically originated in Ethiopia (*Coffea arabica*

L.), with the predominance of cultivation and development in tropical and subtropical regions. Brazil is currently the largest producer and exporter of coffee, in addition to having the second largest coffee consumer market in the world. In Brazil, coffee cultivation started in the 18th century, ensuring great prominence for the Brazilian economy and agriculture (Wikström; Bremer; Rydin, 2020; Winter, 2020). Its cultivation spread to several states, mainly due to the favorable edaphoclimatic conditions in Brazil, initially establishing itself more effectively in the states of Rio de Janeiro and São Paulo. The cultivation of coffee changed the country and its economic cycle, with the insertion of immigrant labor, construction of railways for transport, in addition to the generation of wealth that stimulated the growth of industries, trade and services (Tosi & Faleiros, 2011; Mapa, 2018).

In the scenario of world coffee exports, in the 2018/2019 harvest, Brazilian coffee represented 25.5%, followed by Vietnam, with 20.4%, and Colombia with 9.5% (Conab, 2020; Copetti; Coronel, 2020). In 2020, the production of 63.08 million bags processed reflected a positive biennium and represented an increase of 27.9% compared to the 2019 harvest. In relation to the Brazilian trade balance, in 2020, coffee represented the fifth product with the highest volume handled, with R$ 29.4 billion, with a significant increase of 37.9% compared to previous years (Mapa, 2020). In the period from February 2019 to January 2020 alone, coffee production generated US$ 5.122 billion in exports, 3.3% more than in the previous period (Ico, 2020).

In this sense, the rural environment begins to integrate the digital revolution. Thus, Agriculture 4.0 brought with it significant changes in the field of agriculture and livestock, with a strong influence on the use of Information and Communication Technology (ICT), Precision Agriculture and Digital Agriculture, opening paths and showing the contribution to the expansion of Brazilian agricultural products (Simões, Soler and Py, 2017).

The use of sensors, cameras, GPS and intelligent algorithms, according to Simões, Soler and Py (2017), allow the handling of agricultural machines remotely, and simultaneously the application of mathematical models by the farmer to identify and analyze the need for natural resources, such as the need for water, and monitoring the impact of the crop on the environment. All this technology brings with it the possibility for the farmer to have greater control over his property, production, and productivity, allowing him to go further and guarantee a sustainable product, an essential issue nowadays and demanded by the market.

Identifying that the introduction of technology concepts in the sector can provide benefits in development and ensure both an increase in production and quality, this work aims to verify whether the increase in technology provides an increase in production and productivity.

2. Material and Methods

Information on the number of patents in the Brazilian coffee sector, from 1977 to 2017, were collected in the database of the Brazilian National Institute of Industrial Property (INPI).

The patents were classified according to the area of operation, as follows: Field, Processing and Equipment, according to the code of the International Patent Classification (IPC), held during the application for patent registration at the INPI, described in Table 1.

Table 1. Categorization/Classification of patent documents related to the different areas of activity of the coffee sector according to the IPC.

Area	Class/Category	IPC
Field	Harvesting fruits, vegetables, hops or similar; mechanical shakers to disturb coffee trees or bushes (mechanical harvesting of the beans)	A01D 46/06
Processing	Food or food products; food processing, not covered by other classes - coffee; tea; coffee substitutes; manufacture, preparation, or infusion thereof- Coffee; coffee substitutes; preparation with basis of coffee (extracts, essences or concentrates of coffee)	A23F 5/*
Equipament	Furniture; household articles or appliances; coffee mills; spice mills; vacuum cleaners in general - kitchen equipment; coffee grinders; spice grinders; apparatus for making beverage; coffee grinders; spice grinders.	A47J 42/* A47J 31/*

(*) indicates that all subgroups of lower hierarchical levels are considered. Source: prepared by the authors.

In order to verify the impact on the number of patents applications in the activity of coffee sector in Brazil, data in the period between 1961 and 2017 on Brazilian coffee production, planted area and coffee yield were also collected in the database from Statistical Division of the Food and Agriculture Organization of the United Nations (FAOSTAT). Pearson's correlation analysis was performed between the studied variables, using MINITAB® *software*. All graphs and regression curves were elaborated by the SigmaPlot® *software*.

3. Results and Discussion

A total of 1,046 patent applications were registered for the coffee sector activity in Brazil in the period between 1977 and 2017, being arranged in three distinct classes according to the IPC. Thus, it was verified a total of 257 patent applications in the Field area, 419 patents in the coffee Processing area and 370 patent applications related to Equipment area, representing around 24.6%, 40.1% and, 35.4%, respectively.

In recent years, the three areas have shown an increasing trend in the number of patent registrations (Figure 1). The fluctuations between the three areas over the evaluated period may be associated with the development of new technologies to solve problems verified with the implementation of previous patents.

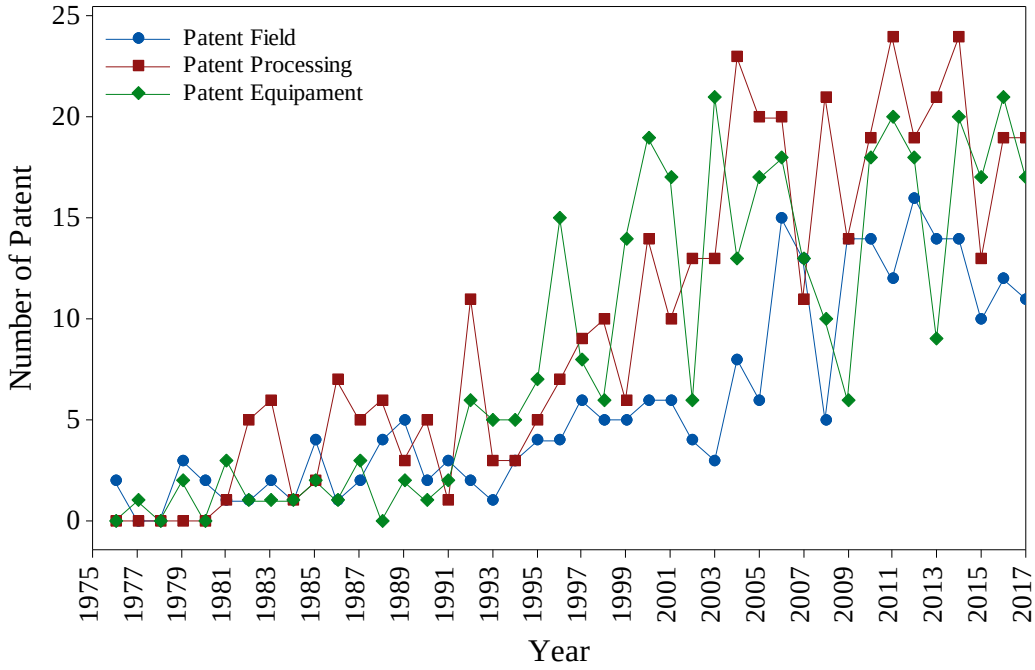

Figure 1. Number of patent registrations in the coffee sector according to the IPC classification by area between 1977 and 2017

There was an increase in the number of patent deposits in the period analyzed, with a significant growth from the 1990s onwards, which went from 89 patent filings, so far, to 159 patents in 2000, representing a growth of 78% in the period.

Similarly, the growth in the number of patent registrations in the following 10 years is remarkable, totaling 391 registrations between the years 2001 and 2010, meaning an increase of 150% in the 10 years. In turn, between 2010 and 2017, 350 patents were deposited to the coffee sector in Brazil. Corroborating the finding of an increase in patent filing requests between 2011 and 2017, Santos et al. (2021) state that this increase occurred in an important evolution scenario for the agricultural sector, with the search for connected machines and the "Internet of Things".

Until 1990, patents in the Field area totaled 30 deposits, with the first deposit occurring in 1976. While in the Processing and Equipment sectors there were a total of 41 and 18 deposits until the beginning of the 1990s, respectively. The Machinery and Equipment sector recorded a 383% growth in the period between 1991 and 2000, totaling 87 patent deposits in a 10-year period, against 39 in the Field area and 69 in the Processing sector.

In the period analyzed, between 1961 and 2017, Brazil had its area devoted to coffee cultivation reduced by more than 589%, from 4.38 to 1.80 million hectares (Figure 2). However, production grew 51.8% in the same period compared to the average measured of 1.76 million tons, reaching 2.68 million tons in 2017. An overview of Figure 2 reveals that there has been a sharp increase in the Brazilian coffee bean production although there was a decrease in the planted area. This trend indicates a gain in coffee productivity, as shown in the Figure 3, and corresponds to the beginning of the growth of patent applications from the

1990s and investment in the coffee sector in Brazil.

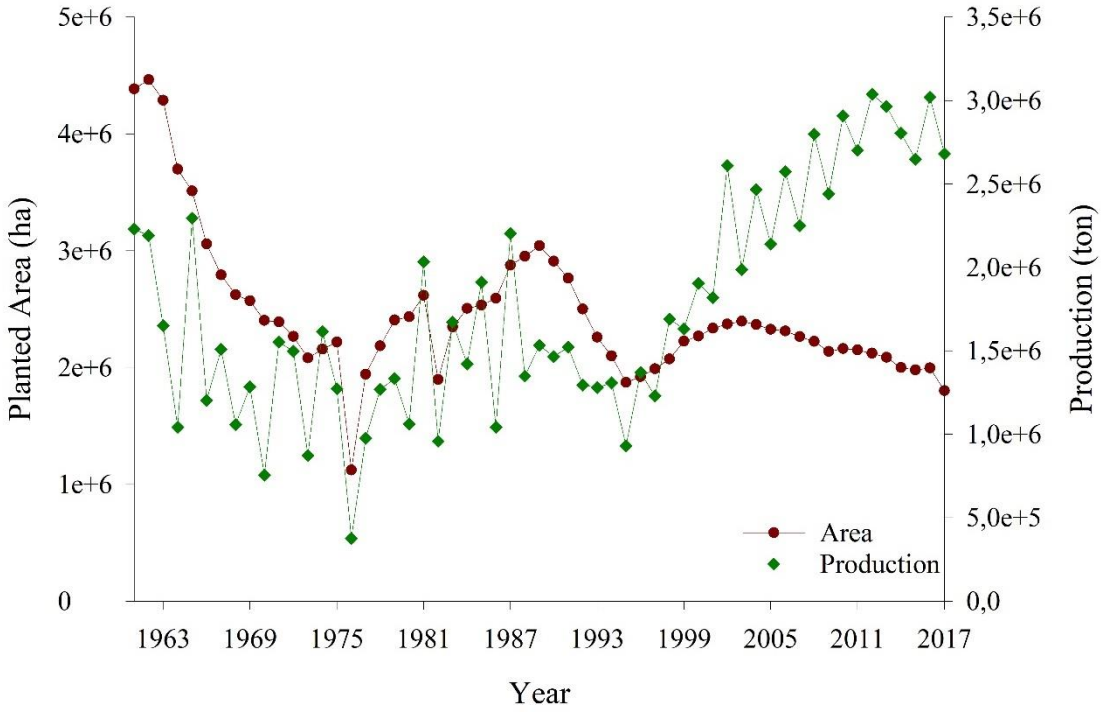

Figure 2. Planted area and coffee bean production in Brazil between 1961 and 2017

These numbers reflect the advance of science around new techniques, products and equipment to increase crop productivity, such as dense planting, reducing space between coffee crops. This technique allows to increase grain productivity and reduce labor costs and inputs, in addition to reducing time for return on investment in farming, production and development of new cultivars (Pereira et al., 2011; Prezotti & Rocha, 2004). Investments in management and cultural traits, improvement of machinery in the field, increase the level of technological innovation in the coffee activity (Simões, 2010). These new techniques are disseminated by the scientific community through publications in specialized periodicals, extension projects and specialization courses, resulting in the technology transfer process arising from research results (Simões, 2010).

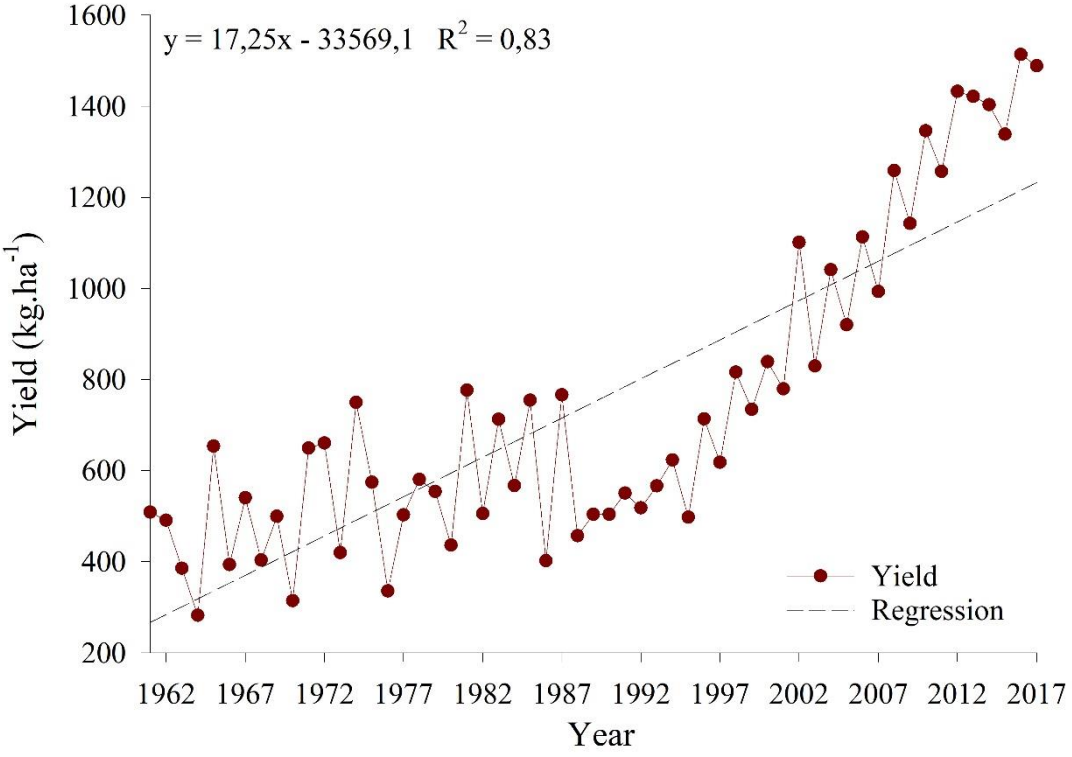

Figure 3. Coffee productivity in Brazil between the years 1961 and 2017

The increase in coffee productivity is a reflection of the adoption of new technologies in the activity, making it increasingly profitable from a financial point of view, with improvements for both coffee species the Coffea arabica L. and C. canephora, also known as Arabica and Conilon or Robusta, respectively. In addition to the incorporation of mechanization in the coffee activity and the use of new inputs, the increase in productivity results from improvements in the production process, such as the implementation of an irrigation system in the crop (Conab, 2017; Bardawil, 2018).

The increase in Brazilian coffee productivity also reflects studies in science and technology to reduce the effects of biennial behaviors in coffee production, innovating in planting techniques, and combining different nutrients for fertilization. As demonstrated by Valadares et al. (2013), correct fertilization management reduced the biennial effects and increased the potential for recovery of coffee productivity.

Thus, the correlations existing between the performance of the coffee activity in Brazil and the increase in the level of technological innovation in the sector are remarkable. These correlations are exemplified by Table 2, and show that the increase in production, even with the reduction of areas destined to coffee cultivation, and therefore the increase in productivity, are positively correlated with the number of patents throughout the coffee sector, which may explain and be related to the high performance.

Table 2. Pearson correlation for Patent deposits in coffee activity by sector and coffee activity parameters

	Pat. Field	Pat. Proc.	Pat. Equip.	Area	Production
Pat. Proc.	0,855				
Pat. Equip.	0,791	0,856			
Area	-0,383	-0,371	-0,395		
Production	0,748	0,768	0,666	-	
Yield	0,862	0,866	0,787	0,383	0,905

Pat. Field = Patent in Field sector; Pat. Proc. = Patent in Processing sector; Pat. Equip. = Patent in Equipment sector; Area = planted area (1000 ha); Production = coffee production (1000 Mg); Yield = coffee bean yield (kg ha-1). Values present statistical significance at $p \leq 0.01$.

The introduction of new technologies in the coffee production chain involves processes ranging from the production of the coffee seedling to the beverage in the cup. Thus, it is possible to observe the insertion of new technologies in order to add value to the product from the packaging process, with the insertion of coffee roasting companies, or the diversification in beverages, such as coffee blends (Medeiros & Rodrigues, 2017).

Agriculture 4.0 and Information and Communication Technologies (ICT) together are enabling innovation to effectively reach rural areas. The use of equipment and connected machines linked to the use of the Internet of Things, provides an increase in the efficiency of the use of inputs, the quality of work, and thereby providing increased productivity and reduction of environmental impacts. Thus, it is currently possible to have the rural environment connected, and at the same time producing sustainably (Santos et al., 2021).

According to Silva and Winck (2019), there was an increase in the production of coffee beans, from 68.0 to 186.9 million tons, in the period from 1993 to 2013. The authors state that this increase in production was directly related to the increase the use of machinery and equipment.

The 2020 Export Performance Report carried out by the Brazilian Instant Coffee Industry Association (ABICS), shows a significant increase of 9.9% in soluble coffee exports in 2020 compared to 2018, and an increase of 2.4% compared to 2019. The United States were the biggest buyers of Brazilian soluble coffee, followed by Russia, Argentina and Japan. According to ABICS, in 2019 Brazil set the record for the exported volume of soluble coffee, with 4 million 60kg bags of coffee, equivalent to 91,963 ton destined for 106 countries (Abics, 2021b).

In 2019, ABICS and the Brazilian Trade and Investment Promotion Agency (Apex-Brasil) launched the institutional identity brand for soluble coffee in Brazil, called "Explore & Enjoy - Brazilian Instant Coffee!". The goal is to strengthen the brand and had a great partnership with Nestlé in Brazil, which currently has the largest industrial park for soluble coffee in the country (Abics, 2021a).

Another factor that allowed the increase in the purchase of Brazilian soluble coffee by the USA was the increase in the tariff on Mexican products (Vegro, 2019). Afterwards, the COVID-19 pandemic scenario did not cause a negative impact, on the contrary, there was an increase in the consumption of soluble coffee in exports and in the country's domestic consumption in 2020 (Cavaton & Ferreia, 2020).

It is noteworthy that a large portion of coffee cultivation in Brazil is carried out by family farmers. Thus, to maintain the levels and promising results of the sector, financing programs, such as BNDES's Rural Credit Program, and the "National Program for Strengthening Family Agriculture" (PRONAF), were essential to assist and ensure the development of the coffee sector (Gomes & Mello, 2020; Soares et al. al., 2020).

Thus, in the coffee culture there is an evident increase in productivity, thus allowing for greater competitiveness for the Brazilian product. Therefore, mechanization, new technologies, strengthening of the agro-industrial coffee chain and State incentives contribute to the advancement of productivity in the national coffee industry.

4. Conclusion

It can identify that the growth of coffee production and productivity is related to the introduction of precise and effective tools, which denotes the increasing introduction of science and technology concepts. In addition to the development of qualified labor, in which the qualification of specialized companies has been intensified, as well as Startups that aim to bring workers closer to the tools available in the field.

References

Abics. Associação Brasileira de Café Solúvel (2021a). *Relatório do Café Solúvel do Brasil*: Análise de Desempenho, São Paulo.

Abics. Associação Brasileira de Café Solúvel (2021b). *Desempenho das Exportações*. São Paulo..https://www.abics.com.br/noticia.php?noticia=244&desempenho_das_exportacoes_de_cafe_do_brasil_2020

Bardawil, O. (2018).*Tecnologia aumenta a produtividade e a rentabilidade do café no Brasil*: segundo estudo, o café arábica e o conilon tornaram-se cultura mais. Brasília: Agência Brasil. https://agenciabrasil.ebc.com.br/pesquisa-e-inovacao/noticia/2018-01/tecnologia-aumenta-produtividade-e-rentabilidade-do-cafe-no

Cavaton, T., & Ferreira, L. T. (2020). Exportações de café solúvel do Brasil mantém crescimento apesar da pandemia de COVID-2019. *Estudos Socioeconômicos e Ambientais*, EMBRAPA. Disponível em: https://www.embrapa.br/busca-de-noticias/-/noticia/53048005/exportacoes-de-cafe-soluvel-d

o-brasil-mantem-crescimento-apesar-da-pandemia-de-covid-19

Conab. Companhia Nacional de Abastecimento (2017). *A cultura do café:* análise dos custos de produção e da rentabilidade nos anos-safra 2008 a 2017. Brasília: Conab, 12(1).

Conab. Companhia Nacional de Abastecimento (2019). *Acompanhamento da safra brasileira de café*. Brasília: Conab, 5(4).

Conab. Companhia Nacional de Abastecimento (2020a). *Acompanhamento da safra brasileira de café*. Brasília: Conab, 6(3).

Conab. Companhia Nacional de Abastecimento (2020b). *Análise Mensal:* Café. Brasília: Conab.

Conab. Companhia Nacional de Abastecimento (2020c). *Acompanhamento da Safra Brasileira:* Café, Brasília, DF, 6(4): 1- 45. Quarto levantamento. www.conab.org.br

Copetti, L. S. & Coronel, D. A. (2020). Transmissão da variação da taxa de câmbio para os preços de exportação brasileiros do café robusta: um estudo comparativo do dólar e do euro. *Revista Capital Científico*, 18(1): 24-44. https://revistas.unicentro.br/index.php/capitalcientifico/article/view/5982/html

Ferrão, R. G. et al. (2007). *Café Conilon*. Vitória: INCAPER, 702p.

Gomes, I. N. & Mello, S. P. T. (2020). The effects of credit granting in southern Brazil under the "Programa Nacional de Fortalecimento da Agricultura Familiar–PRONAF". *Research, Society and Development*, 9(7): 1-20. https://doi.org/10.33448/rsd-v9i7.4628

Ico. Internacional Coffe Organization (2020). *Relatório sobre o mercado de café.* Londres.

Mapa. Ministério da Agricultura Pecuária e Abastecimento (2018). *Café no Brasil*. Brasília: Ministério da Agricultura, Pecuária e Abastecimento.

Mapa. Ministério da Agricultura Pecuária e Abastecimento (2020). *Valor Bruto da Produção - VBP*. Brasília: Ministério da Agricultura, Pecuária e Abastecimento.

Medeiros, R. V. V., & Rodrigues, P. M. A. (2017). A Economia Cafeeira no Brasil e a Importância das Inovações para essa Cadeia. *A Economia em Revista*, 25(1): 1-12. https://doi.org/10.4025/aere.v25i1.35511

Oliveira, G. M., & Zylbersztajn, D. (2018). Make or buy: the case of harvesting mechanization in coffee crop in Brazil. *International Food and Agribusiness Management Review*, 21(7): 895- 913. https://doi.org/10.22434/IFAMR2017.0085

Pereira, S. P. et al. (2011). Crescimento, Produtividade e bienalidade do cafeeiro em função do espaçamento de cultivo. *Pesquisa Agropecuária Brasileira*, Brasília, 46(2): 152-160. https://doi.org/10.1590/S0100-204X2011000200006

Prezotti, L. C., & Rocha, A. C. (2004). Nutrição do cafeeiro arábica em função da densidade de plantas e da fertilização com NPK. *Bragantia*, 63(1): 239-251. https://doi.org/10.1590/S0006-87052004000200009

Rufino, J. L. S. (2006). *Programa Nacional de Pesquisa e Desenvolvimento do Café*:

antecedentes, criação e evolução. Embrapa Café, Brasília, DF: Embrapa Informação Tecnológica, 348p.

Santos, C. A. S. A. et al. (2021). Mapeamento Patentário do Tema Máquinas Conectadas a Máquinas (M2M) e os Desafios Brasileiros da Agricultura 4.0. *Cadernos de Prospecção*, Salvador, 14(1): 153-168. http://dx.doi.org/10.9771/cp.v14i1.33052

Silva, B. A., & Winck, C. A. (2019). Evolução da quantidade máquinas e implementos agrícolas nas propriedades rurais brasileiras (1960-2017). *Revista Visão: Gestão Organizacional*, Santa Catarina, 8(1): 174-188. https://doi.org/10.33362/visao.v8i1.1934

Simões, J. C. (2010). *Diagnóstico da cafeicultura mineira - regiões tradicionais:* Sul/Sudoeste de Minas, Zona da Mata, Triângulo Mineiro/Alto Paranaíba. Belo Horizonte: EPAMIG, 1(46).

Simões, M.; Soler, L. S., & Py, H. (2017). Tecnologias a serviço da sustentabilidade e da agricultura. *Boletim Informativo da SBCS*, 1(1): 49-53. https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1080538/tecnologias-a-servico-da-sustentabilidade-e-da-agricultura

Soares, W. O. et al. (2020). Influência das mudanças climáticas na produção cafeeira segundo a percepção das cafeicultoras. *Revista Formação (ONLINE)*, 27(5): 77-100. https://doi.org/10.33081/formacao.v27i52.6728

Tosi, P. G., & Faleiros, R. N. (2011). Domínios do café: ferrovias, exportação e mercado interno em São Paulo (1888-1917). *Economia e Sociedade*, Campinas, 20(2): 417-442. https://doi.org/10.1590/S0104-06182011000200008

Valadares, S. V. et al. (2013). Produtividade e bienalidade da produção de cafezais adensados, sob diferentes doses de N e K. *Pesquisa Agropecuária Brasileira*, Brasília, 48(3): 296-303. https://doi.org/10.1590/S0100-204X2013000300008

Vegro, C. L. R. (2019). Reflexos da Majoração Tarifária Estadunidense sobre as Importações de Café Solúvel Mexicano. *Análise e Indicadores do Agronegócio*, IEA, São Paulo, 14(6): 1-4. http://www.iea.sp.gov.br/ftpiea/AIA/AIA-43-2019.pdf

Wikström, N.; Bremer, B. & Rydin, C. (2020). Conflicting phylogenetic signals in genomic dataof the coffee family (Rubiaceae). *Journal of Systematics and Evolution*, 58(4): 440–460. https://doi.org/10.1111/jse.12566

Winter, E. et al. (2020). Evaluating the Sustainability Performance of Typical Conventional and Certified Coffee Production Systems in Brazil and Ethiopia Based on Expert Judgements. *Frontiers in Sustainable Food Systems*, 4(1): 1-18. https://doi.org/10.3389/fsufs.2020.00049

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