Risk analysis in the arabica coffee cultivation in the state of Espírito Santo considering manual and semi-mecanized harvesting[1]

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Submissão: 02/04/2020 - Aprovação: 28/04/2020

Abstract - The Coffee culture is the most important agricultural activity when it comes to social and economic aspects in Espírito Santo. The state is Brazil's second largest producer including arabica and conilon coffee, with a production of 13.7 million bags, which represents 22.3% of the Bazillian coffee. The objective of this study was to evaluate the risk in arabica coffee cultivation comparing manual and semi-mechanized harvesting to different productivity levels. For the feasibility analysis, the techniques of Net Present Value and Internal Rate of Return were used and the sensitivity analysis was used for the risk assessment. The risk statistics evaluated by the standard deviation and coefficient of variation indicate that it is less risky to produce at the productivity levels of 50 bags per hectare in manual harvesting and over 40 bags per hectare in semi-mechanized harvesting.

Keywords: Coffee. Risk. Investment. Modernization.

Análise de risco na cafeicultura de arábica no estado do Espírito Santo considerando colheita manual e semimecanizada

Resumo - A cafeicultura é a principal atividade agrícola do Espírito Santo tanto no âmbito social quanto econômico. O Estado é o segundo maior produtor do Brasil envolvendo os cafés arábica e conilon, com uma produção de 13,7 milhões de sacas, que representa cerca de 22,3% do café brasileiro. Este trabalho teve como objetivo avaliar o risco na cafeicultura de arábica considerando a colheita manual e semimecanizada para diferentes níveis de produtividade. Para a análise de viabilidade, foram utilizadas as técnicas de Valor Presente Líquido e Taxa Interna de Retorno e para a avaliação de risco foi utilizada a análise de sensibilidade. As estatísticas de risco avaliadas pelo desvio padrão e coeficiente de variação indicam que é menos arriscado produzir nos níveis de produtividade de 50 sacas por hectare na colheita manual e acima de 40 sacas por hectare na colheita semimecanizada.

Palavras-chave: Café. Risco. Investimento. Modernização

INTRODUCTION

The coffee culture is the most important agricultural activity in the social and economic levels in Espírito Santo. The state is Brazil's second largest producer, including arabica and conilon coffee (2019). Arabica alone stood for a production of 13.7 million bags in 2018, which represented 22.3% of all the Brazilian coffee produced that year (CONAB, 2020).

The coffee activity is very dynamic and coffee producers must always be careful to make decisions about their crops and seek yield and profitability, since coffee is already considered a biennial culture, that is, it produces more in a year and less the following year.

The analysis of the risk of the coffee activity can occur at three different levels: i) conjectural economic analysis, such as: market, supply and demand, prices, interest, exchange and government agricultural policy, that is, variables off-farm and which coffee growers have very little chance of acting to change them; ii) analysis of property, such as: aptitude, infrastructure, administration, labor, etc.., which the good coffee grower can always change in such a way that it does not become an effective risk; iii) analysis of crop management, such as: technology used, control of pests and diseases, use of irrigation. These are present risks within the activity and, if decision making is not rapid, the losses may be significant (MATIELLO et al., 2016).

In the specific case of the mountain coffee culture of the state of Espírito Santo, produced in the mountains and Caparao region, or even in the mountain coffee culture of the Mata Mineira region, the mountains of Rio de Janeiro and south of Minas Gerais, it is important to mention the risk of the disease called phoma spot caused by the fungus *Phoma spp*. because when it attacks during the pre- and post-flowering period and with favorable climatic conditions (high humidity, winds and low temperature),it causes significant losses in the coffee production of the following year due to the attack of the disease on the leaves, branches, flowers and fruits, causing the premature fall of leaves, flowers and fruits in the grain filling phase.

[1] A version of this article was presented at the X Symposium on Research of Brazilian Coffees in October 2018.
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Studies carried out in these regions showed increases in production between 75% and 148%, when coffee plants were sprayed preventively to control this disease. In regions such as Alto Paranaíba (MG), the losses recorded were between 30% and 50% of reduction in production in years of higher occurrence of the disease (MATIELLO et al., 2016). That is to say, in mountain regions, as in the case of arabica coffee cultivation in the state of Espírito Santo, it is important to prevent this disease in pre- and -lowering coffee, when climatic conditions are favorable for the occurrence of this disease.

Another risk condition for arabica coffee cultivation in the mountains of Espírito Santo is during Indian Summer (*veranicos*) period that sometimes occurs from December to March, which coincides with the filling and granulation phase of the coffee fruits. This is the period when the greatest water and nutrient requirements for the coffee trees occur (MATIELLO et al., 2016).

In two reproductive coffee stages, drought is detrimental: in flowering, causing fewer flowers to bloom, and in the granulation of the fruits, when the lack of water increases the presence of dull and poorly grained fruits (DAMATTA et al., 2007).

It is important to remember that the technology used in agriculture in recent times has caused the economic risk of the agricultural activity to be divided into two variables: variability of production and prices. The use of irrigation reduces or even eliminates the losses caused by water deficit, but the economic risks and risk losses due to excessive rainfall, especially during the harvest period, still remain (FILHO; GONZAGA, 1991). As there are many factors to consider, and the investment is long-term, risk analysis generally takes into account the records observed.

The objective of this study was to evaluate the risk in arabica coffee growing comparing manual and semi-mechanized harvesting to different productivity levels.

MATERIALS AND METHODS

From the data presented in Galeano and Krohling (2019), production costs were calculated for two more scenarios to compose the risk analysis.

For the financial analysis, economic viability indicators were considered (GITMAN, 2010; ASSAF NETO; LIMA, 2014): Net Present Value (NPV) and Internal Rate of Return (IRR).

$$NPV = \sum_{t=1}^{n} \frac{R_t - C_t}{(1+i)^t} - I_0 \quad (1)$$

$$O = \sum_{t=1}^{n} \frac{R_t - C_t}{(1+IRR)^t} - I_0 \quad (2)$$

In equations1 and 2, NPV = net present value, R$ (Brazilian real); Rt = revenue in each month, R$ (Brazilian real); Ct = cost in each month; I_0 = initial investment; n = time of project analysis in years; i = minimum attractive rate of return (MARR); IRR = internal rate of return.

For the investment to be considered viable, the NPV should be positive, and the higher the NPV, the more attractive the investment. The IRR should be higher than the cost of capital or opportunity cost.

For the risk analysis, the sensitivity analysis was considered, a risk assessment methodology that reveals how much the economic result of the NPV of an investment will change due to changes in study variables (ASSAF NETO; LIMA, 2014). The analysis was performed considering three scenarios.

The scenarios considered were: Scenario 1 - the first scenario considered was the one presented initially, which considers the potential production of the crop; Scenario 2 - for the optimistic scenario, the average production growth rates has been calculated considering the years for which positive growth rates were expected (biennially positive) and these actually occurred; Scenario 3 - similarly, the average of the productivity variation of the pessimistic scenario was calculated, but for the purpose of calculation, the years for which negative rates were considered (biennially negative) and these actually occurred.

For the calculation of the historical average and the probability of occurrence of each scenario, the data of the average production of the arabica coffee from Espírito Santo from 2002 to 2018 were collected. The historical series of production data were obtained from the IBGE and CONAB and historical price data were obtained from the Capixaba Institute for Research, Technical Assistance and Rural Extension - INCAPER. For the risk assessment, mean, standard deviation and coefficient of variation statistics are also presented, as described in equations 3, 4 and 5.

$$E(IRR) = \sum_{t=1}^{n} P\ x\ IRR \quad (3)$$

$$\sigma = \sqrt{\sum_{t=1}^{n} P\ x\ (IRR - E(IRR))^2} \quad (4)$$

$$CV = \frac{\sigma}{E(IRR)} \quad (5)$$

In equations 3, 4 and 5, *E* represents the mean, *P* the probability, σ the standard deviation and *CV* the coefficient of variation. The higher the standard deviation and the coefficient of variation, the greater the risk.

RESULTS AND DISCUSSION

Considering that the economic risk of agricultural activity is mainly divided into the following variables: "production variability" and "prices", the risk analysis will be focused on these two variables.

The average production of arabica coffee in the state of Espírito Santo is around 22.1 bags per hectare, which is below the national average (24.3 bags per hectare) (CONAB, 2018). The risk analysis will consider three possible production scenarios taking into account variations in production and prices.

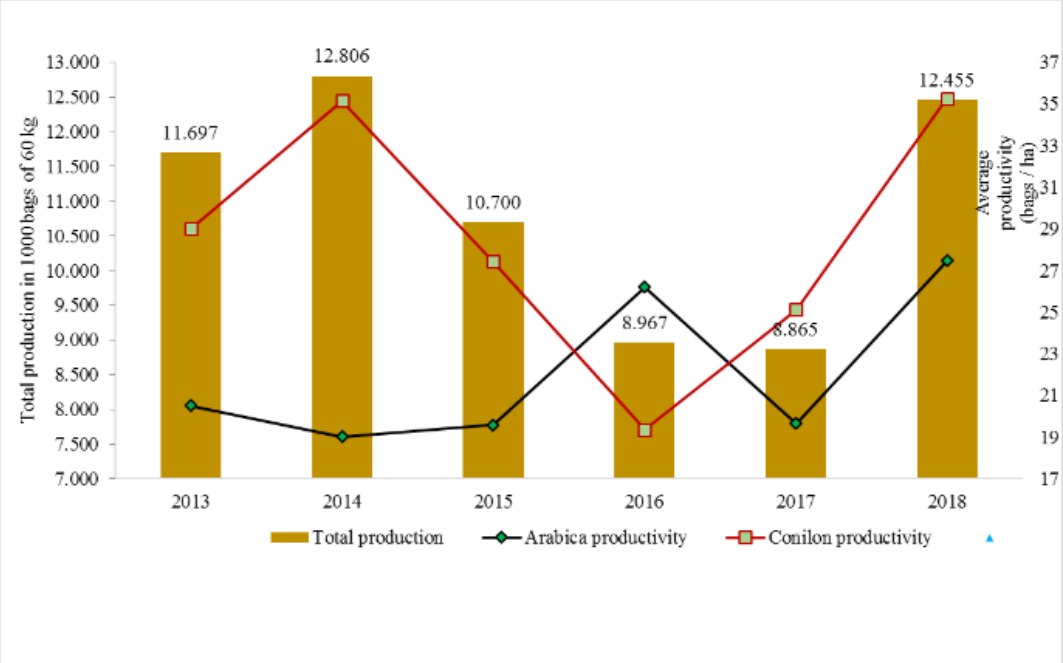

Figure 1. Historical production levels and average coffee productivity in Espírito Santo.
Source: Prepared from CONAB (2011-2018).

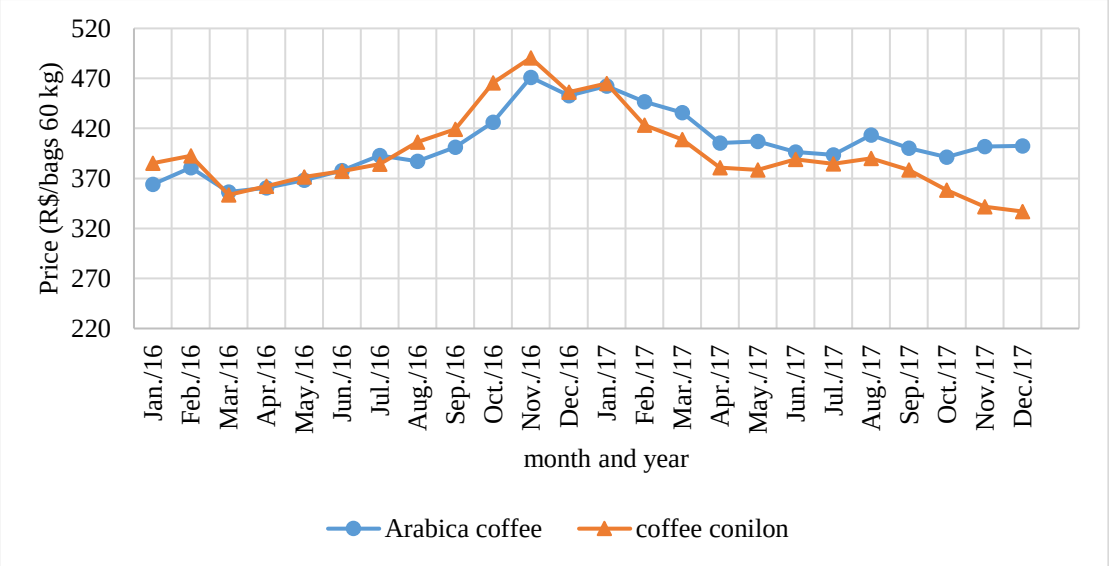

Figure 2. Prices received by coffee producers in Espírito Santo.
Source: Prepared from the price survey of Incaper, 2018.
Note: Values corrected by Dec. 2017, by IGP-M-FGV.

Coffee prices increased in 2016, reflecting lower production. The average price received by the arabica coffee producer reached a peak of R$ 475.43 in November 2016 and decreased to R$ 402.43 in December 2017 (INCAPER, 2017). In March 2018, the price received by the arabica coffee producer was around R$ 380.00 per bag, reflecting the expectation of a larger production.

The evaluation of the average production costs of arabica coffee in the state is important in order to better guide the producer regarding his decision making. Galeano and Krohling (2019) evaluated the costs and viability of the arabica coffee production in Espírito Santo. Table 1 shows the costs of the third year of activity for the various levels of productivity and manual and semi-mechanized harvesting. From the data collected by the authors, we have evidence that the activity is only viable at the level of 50 bags per hectare, both for manual harvesting and for semi-mechanized harvesting. In manual harvesting, the IRR is 8.3% and is very close to the opportunity cost adopted. In the semi-mechanized harvest, the IRR is 16% and the net present value is R$ 21,411.12, which represents a net profit of R$ 428.22 per bag during the crop cycle.

Table 1. Production costs and revenues (3rd year) of 1 ha of arabica coffee at different yield levels and indicators of economic viability (during the whole production life cycle)

Specification / Productivity levels (bags / ha)	Manual harvesting					Semi-mechanized harvesting		
	15	**20**	**30**	**40**	**50**	**30**	**40**	**50**
Inputs	1,726.92	2,012.92	2,185.30	2,988.78	2,897.22	4,007.88	3,857.53	3,765.97
Labor	4,255.75	4,205.00	7,017.50	8,756.00	10,164.50	5,877.50	6,866.00	7,524.50
Total direct costs	5,982.67	6,217.92	9,202.80	11,744.78	13,061.72	9,885.38	10,723.53	11,290.47
Crop depreciation	545.93	578.14	796.81	945.91	1,187.16	796.71	945.91	1,187.16
Machinery depreciation	353.76	360.39	373.47	386.35	399.22	373.47	386.35	399.22
Cost of land	486.59	486.59	486.59	486.59	486.59	486.59	486.59	486.59
Opportunity cost	844.38	890.33	1,232.39	1,466.15	1,842.48	1,232.25	1,466.15	1,842.48
Total cost	8,213.34	8,533.37	12,092.06	15,029.78	16,977.18	12,774.40	14,008.53	15,205.93
Total revenue	6,127.50	8,170.00	12,255.00	16,340.00	20,425.00	12,255.00	16,340.00	20,425.00
Net revenue	-2,085.84	-363.37	162.94	1,310.22	3,447.82	-519.40	2,331.47	5,219.07
NPV (8%)	-33,762.81	-18,630.70	-19,291.53	-15,348.21	763.23	-13,424.80	-1,716.72	21,411.12
IRR	-	-	-	-	8.3%	-	7.1%	16.0%

Source: Galeano and Krohling (2019).

Figure 3 represents the evolution of profit or loss accumulated during the crop cycle. The accumulated loss is relatively higher for lower productivity levels. Producers should be aware of how much they have been losing, that is, if they have been decapitalizing over the years for insisting on maintaining a crop with low yield levels.

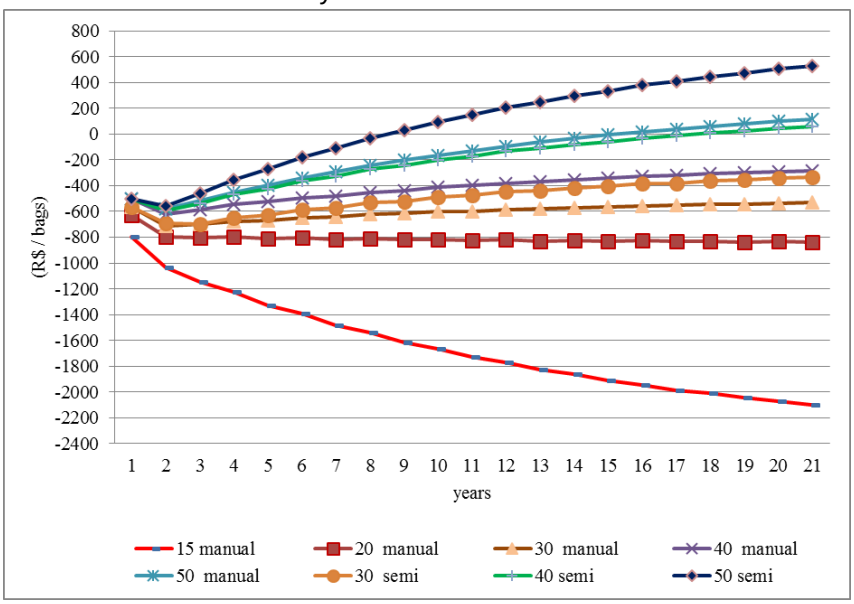

Figure 3. Present value of the accumulated profit per bag during 20 years of production for different productivity levels and type of harvest.

Some producers are able to produce high quality coffee and get a higher price for their production, which makes the activity viable. However, most producers end up selling their product at the average market price and can barely pay for the costs.

For the risk analysis, the sensitivity analysis was considered as presented in the methodology. Three scenarios were considered in the risk assessment. The first scenario was the one presented initially in Table 1, Galeano and Krohling (2019), which considers the potential production of the crop. A probability of 41.1% was attributed to the occurrence of the potential production situation.

The average rate of productivity growth for the optimistic scenario was 17.5%, as described in the methodology, and the average price was constant. The probability of occurrence of the optimistic scenario was 32.4%. The average fall in productivity in the pessimistic scenario was 3.4% and the average increase in the price level was 1.4%. The probability of occurrence of the pessimistic scenario was 26.5%. The data presented in Table 2 consider the positive scenario and the data presented in Table 3 consider the negative scenario. Finally, Table 4 shows the statistics for the average of the three scenarios.

Table 2. Production costs and revenues (3rd year) of 1 ha of arabica coffee at different productivity levels and indicators of economic viability - positive biennial scenario

Specification / Productivity levels (bags / ha)	Manual harvesting					Semi-mechanized harvesting		
	15	**20**	**30**	**40**	**50**	**30**	**40**	**50**
Inputs	1,765.51	2,064.37	2,262.47	3,091.68	3,046.85	4,253.05	3,960.43	3,915.60
Labor	4,559.86	4,610.48	7,625.71	9,566.95	11,178.19	6,118.21	7,178.20	7,908.19
Total direct costs	6,325.37	6,674.85	9,888.19	12,658.63	14,225.04	10,371.26	11,138.63	11,823.79
Depreciation of crop	545.93	578.14	796.81	945.91	1,187.16	796.71	945.91	1,187.16
Machinery depreciation	353.76	360.39	373.47	386.35	399.22	373.47	386.35	399.22
Cost of land	486.59	486.59	486.59	486.59	486.59	486.59	486.59	486.59
Opportunity cost	844.38	890.33	1,232.39	1,466.15	1,842.48	1,232.25	1,466.15	1,842.48
Total cost	8,556.03	8,990.30	12,777.45	15,943.63	18,140.49	13,260.29	14,423.63	15,739.24
Total revenue	6,127.50	9,599.75	14,399.63	19,199.50	23,999.38	14,399.63	19,199.50	23,999.38
Net revenue	-2,428.53	609.45	1,622.18	3,255.87	5,858.88	1,139.34	4,775.87	8,260.13
NPV (8%)	-27,049.69	-11,250.40	-5,858.80	2,641.47	23,123.14	3,233.06	20,870.00	49,595.93
IRR	-	-	4.3%	9.3%	16.5%	9.8%	17.4%	25.0%

Considering that, on average, there would be a 17.5% increase in productivity levels, costs and revenues were adjusted taking into account this scenario (Table 3). In this case, it would be feasible to produce from 40 bags per hectare with manual harvesting and over 30 bags per hectare in semi-mechanized harvesting.

Considering that, on average, there would be a fall of 3.4% in productivity levels and a 1.4% increase in the price of coffee bags, costs and revenues were adjusted taking into account this scenario (Table 4). In this case, the production at the level of 40 bags per hectare becomes unfeasible. It would be feasible to produce from 50 bags per hectare with manual harvesting and over 45 bags per hectare in the semi-mechanized harvesting.

Considering that the producer can experience in practice the various situations above and obtain an average income from these scenarios, the statistics that represent the risk around the rates of return presented are shown below.

Table 3. Production costs and revenues (3rd year) of 1 ha of arabica coffee at different productivity levels and indicators of economic viability - negative biennial scenario

Specification / Productivity levels (bags / ha)	Manual harvesting					Semi-mechanized harvesting		
	15	**20**	**30**	**40**	**50**	**30**	**40**	**50**
Inputs	1,719.43	2,002.93	2,170.31	2,968.79	2,868.15	3,960.24	3,837.54	3,736.90
Labor	4,196.67	4,126.22	6,899.33	8,598.44	9,967.56	5,830.73	6,805.34	7,449.96
Total direct costs	5,916.09	6,129.15	9,069.64	11,567.23	12,835.71	9,790.97	10,642.88	11,186.86
Depreciation of crop	545.93	578.53	796.81	945.91	1,187.16	796.71	945.91	1,187.16
Machinery depreciation	353.76	360.39	373.47	386.35	399.22	373.47	386.35	399.22
Cost of land	486.59	486.59	486.59	486.59	486.59	486.59	486.59	486.59
Opportunity cost	844.38	890.33	1,232.39	1,466.15	1,842.48	1,232.25	1,466.15	1,842.48
Total cost	8,146.76	8,445.00	11,958.90	14,852.24	16,751.16	12,680.00	13,927.89	15,102.31
Total revenue	6,127.50	7,892.22	11,838.33	15,784.44	19,730.55	11,838.33	15,784.44	19,730.55
Net revenue	-2,019.26	-552.78	-120.57	932.20	2,979.39	-841.67	1,856.55	4,628,24
NPV (8%)	-34,880.43	-19,833.84	-17,681.15	-18,343.54	3,499.81	-12,441.02	-5,605.18	23,016.00
IRR	-	-	-7.4%	-4.7%	9.4%	-0.8%	4.9%	16.6%

Table 4. Risk analysis considering the three scenarios

		Productivity levels (bags/ha) and IRR					
		Manual harvesting			Semi-mechanized harvesting		
Probability.		**30**	**40**	**50**	**30**	**40**	**50**
41.1%	Scenario 1 - Potential	-10.6	-1.8	8.3	-1.7	7.1	16.0
32.4%	Scenário 2 - Optimistic	4.3	9.3	16.5	9.8	17.4	25.0
26.5%	Scenário 3 - Pessimistic -	-7.4	-4.7	9.4	-0.8	4.9	16.6
	Average	-4.9	1.0	11.3	2.3	9.9	19.1
	Standard deviation	6.5	5.9	3.7	5.2	5.3	4.1
	Coefficient of variation	-1.32	5.67	0.33	2.29	0.54	0.22

The average rates of return for 30 and 40 bags per hectare in manual harvesting and the level of 40 bags per hectare in semi-mechanized harvesting are less than 8% and, therefore, are not economically viable. The average rate of return for production at the level of 50 bags per hectare with manual harvesting was 11.3% and the semi-mechanized harvesting at the level of 40 and 50 bags per hectare was 9.9% and 19.1%, respectively (Table 4). The higher the standard deviation and the coefficient of variation, the greater the risk, since they indicate greater deviation from the mean.

ACKNOWLEDGEMENTS

The authors would like to thank the Espírito Santo Research and Innovation Support Foundation - FAPES and the Brazilian Agricultural Research Corporation – EMBRAPA.

CONCLUSION

The risk statistics evaluated by the standard deviation and coefficient of variation indicate that it is less risky to produce at the productivity levels of 50 bags per hectare in manual harvesting and over 40 bags per hectare in semi-mechanized harvesting.

REFERENCES

ASSAF NETO, A; LIMA, F. G. *Curso de Administração Financeira*.3. ed. São Paulo: Atlas, 2014.

COMPANHIA NACIONAL DE ABASTECIMENTO. *Série histórica das safras*. Disponível em: <https://www.conab.gov.br/info-agro/safras/serie-historica-das-safras> Acesso em: 15/01/2018.

DAMATTA, F. M. et al. Ecophysiology of coffee growth and production. *Brazilian Journal of Plant Physiology*, v. 19, n. 04, p. 485-510, 2007.

FERRRÃO, R. G.; FONSECA, A. F. A da.; FERRÃO, M. A. G.; DE MUNER, L. H. de. *Conilon Coffee*: The *Coffee canephora* produced in Brasil. 3. ed. Vitória, ES: Incaper. 2019.973 p.

FILHO, J. P.; GONZAGA, M. L. Análise de custos de lavouras irrigadas. In: *Curso de Agricultura Irrigada*. Piracicaba: ESALQ/Depto. de Agricultura, 1991. p.27-57.

GALEANO, E. A. V.; KROHLING C. A. Comparative analysis of production costs and economic viability of arabica coffee in the state of Espírito Santo considering manual and semi-mechanized harvest. *Coffee Science*, Lavras, v. 14, n. 2, 2019.

GITMAN, L. J. *Princípios de administração financeira.* 10. ed. São Paulo: Pearson Addison Wesley, 2010. 800p.

IBGE. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. Grupo de Coordenação de Estatísticas Agropecuárias - GCEA/IBGE, Diretoria de Pesquisas, Coordenação de Agropecuária, *Levantamento Sistemático da Produção Agrícola*, Vitória-ES, dezembro de 2018. Relatório de pesquisa.

IBGE. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. *Produção Agrícola Municipal* – PAM. Sistema IBGE de Recuperação Automática de dados – SIDRA, IBGE-PAM, 2000 a 2017 Disponível em: < http://www2.sidra.ibge.gov.br/bda/acervo/acervo9.asp?e=c&p=PA&z=t&o=11>. Acesso em: 29/03/2018.

INCAPER. Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural. *Acompanhamento semanal de preços recebidos pelos produtores em 2016 e 2017*. Vitória, ES: Incaper, 2016. Disponível em: <https://incaper.es.gov.br/sispreco>. Acesso em: maio 2018

MATIELLO, J. B.; SANTIAGO, R.; ALMEIDA, S. R.; GARCIA, A. W. R. *Cultura do café no Brasil: manual de recomendações*. São Paulo: Faturama Editora, 2016.