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Grape Production Diagnosis in the Highlands Region of the State of Espírito Santo, Brazil

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Abstract

Espírito Santo was the eighth largest Brazilian grape producing state and the sixth largest exporter. The objective of this study was to carry out a grape production diagnosis in the highlands region of Espírito Santo. The methodology consisted of field research in rural farms. The municipalities with the greatest participation in state grape production were selected. Field research was conducted in 2019 and 2020 in rural properties in the municipalities of Santa Teresa, Domingos Martins, Venda Nova do Imigrante, Alfredo Chaves and Vargem Alta, which are representative in production. Were interviewed 86 vinegrowers and this sample represented 13.7% of the number of grape producing centers in the State. The need to improve management practices, yield and grape quality was identified, with a focus on sustainability, reducing the use of pesticides, in addition to certification for organic/biodynamic grape production, increasing the quality of the material. It is necessary that Technical Assistance and Rural Extension (ATER) works also concentrate efforts to develop production systems with lower implementation and production costs, mainly related to the supporting structure of the vines and the development of cultivars more resistant and/or tolerant to pests and diseases, mainly vine downy mildew (*Plasmopara viticola*), which will consequently reduce production costs for the winegrower.

Keywords: *Vitis vinifera* L., grape, vinegrowers, family farms, production chains

1. Introduction

The main tropical viticulture centers in Brazil are the Vale do Submédio São Francisco, the northwest of São Paulo and Northern Minas Gerais. In recent years, tropical viticulture has expanded to other states, such as Espírito Santo, Mato Grosso do Sul, Mato Grosso, Goiás, Rondônia, Ceará and Piauí (Camargo et al., 2011).

Grape production is in many family farms the main source of income. However, Neto et al. (2022), for example, observed that in the north of Portugal, the producer is willing to apply more pesticides to guarantee the quantity and quality required for grape processing. However, vineyard family farmers do not always register their practices and are rarely subject to any controls. In the agroindustrialization of grapes, product quality control is a very important process. Oliveira et al. (2019) showed that grape juice, for example, is a product with high commercial value, making it a source of various types of fraud, such as the addition of other juices, such as apple juice, to whole grape juice.

In Espírito Santo, vine cultivation is important, mainly due to its characteristic of family production; furthermore, it is a product with high added value. Among the strategic guidelines outlined for the production chain, increasing and improving production quality are shown to be priorities. The path defined for advancing these guidelines involves: (i) increasing yield, the number of producers and the area planted with grapes, mainly to increase the raw material supply for agro-industrialization; (ii) Ensure production that meets market standards with sensory quality and is safe for consumers; (iii) Promote the socio-environmental adequacy of rural properties and increase the adoption of low-carbon agricultural techniques; (iv) Strengthen the relationship

between the links in production chains, and encouraging associations and cooperativism to expand external relations; (v) Foster public policies, ensuring family succession in grape production and agro-industrialization; (vi) Develop traceability, strengthen geographical indications and develop strategies to access more demanding markets and, finally, (vii) encourage consumption and expand participation in domestic and foreign markets (SEAG, 2023).

Espírito Santo was the eighth largest Brazilian grape producing state and the sixth largest exporting state. In Brazil, among the largest grape producers, the State of Rio Grande do Sul stands out, with a production of 734,982 tons in 2022, followed by Pernambuco and São Paulo, with 338,206 tons and 164,131 tons, respectively. In 2022, Brazil produced 1,450.8 thousand tons of grapes in a total area of 74,798 hectares, with an average yield of 19,396 kg/ha (IBGE-PAM, 2022a, Brasil-Comexstat, 2022).

Of the total national grape production in 2022, only 52,593 tons were destined for the foreign market. Although Rio Grande do Sul is the largest national grape producer, the largest exporting state is Pernambuco, having been responsible for 67.8% of the exported volume. Espírito Santo was the sixth largest grape exporting state, having exported 9.1 tons of grapes in 2022, with the Marshall Islands, Panama and Hong Kong as its main destinations (Brasil-Comexstat, 2022).

Present in 37.1% of Espírito Santo's municipalities, grape is a fruit with great social importance, with the majority of production sold in the domestic market. The Central Serrana, Litoral Sul and Southwest Serrano microregions concentrate the majority of production, with a predominance, respectively, of cultivars from the Isabel, Bordô and Violeta subgroups. The municipalities of Santa Teresa and Alfredo Chaves, for example, were the largest producers in 2022. Grape production is regionalized, with production systems and grape types being different in each municipality.

The objective of this work was to carry out the diagnosis and understand the social and economic impact of viticulture in the highlands region of Espírito Santo.

1.1 Importance of the Grape Production Chain in Espírito Santo

The diversity of edaphoclimatic environments present in Espírito Santo provides fruit growers with options for diversifying production, resulting in added value, improved economic gains, production of healthy foods, in addition to contributing to the food and nutritional security of their family and consumers (Souza et al., 2024b). Vine cultivation for the production of grapes and wine in Espírito Santo, were initially backyard activities, practiced by Portuguese and Italian immigrants who settled in Espírito Santo. The first vine branches arrived in Espírito Santo skewered on potatoes, to avoid dehydration. There were excellent conditions for commercial cultivation, whether for fresh consumption or for wine manufacture, mainly in artisanal form (Costa et al., 2009). At IBGE, there is an official record of grape production only from 1974 onwards, when a production of 366 tons was recorded in 79 hectares.

In 1953, the first wine was produced in Espírito Santo, using appropriate oenological standards. The raw material used was the 'Isabel' grape. In 1954, a "Pilot Cantina" was installed at the State Experimental Viticulture Station and began operating, encouraging the implementation of vine cultivation and, at the same time, producing wine and evaluating its quality, based on oenological protocols (Pinho, 1985).

Transforming Espírito Santo into a diversified fruit production hub was one of the mobilizing goals included in the Government's Action Plan for Agriculture. This decision was made considering the excellent natural conditions and potential presented by the State in specific micro-regions (Costa et al., 2009).

In 2004, the Table Grape and Wine Hub was established in Espírito Santo (Costa et al., 2009). The actions were primarily developed in the municipalities of Santa Teresa, Santa Maria de Jetibá, Santa Leopoldina, Domingos Martins, Marechal Floriano, Venda Nova do Imigrante, Conceição do Castelo and Alfredo Chaves.

Santa Teresa has become a reference in viticulture in the State and has received numerous excursions and technical visits, with a view to exchanging experiences regarding crop implementation, training and production pruning, fertilization, pest and disease control and other practices that would enable satisfactory production (Costa et al., 1992; Ventura et al., 1988). Furthermore, through Emater-ES and its Extensionists, various rural extension methods such as meetings, field days, demonstrations of methods, demonstration of results, visits, among others, have occurred. These actions enabled winemaking in Espírito Santo to move from backyard orchards to a noble activity, generating opportunities and quality of life for vinegrowers.

The main grape producing municipality in Espírito Santo continues to be Santa Teresa. In addition to its proximity to the metropolitan area of the capital, Vitória, the region is privileged by a landscape with interesting natural beauty, which has led, through official programs, to the organization and development of regional

tourism. In this context, grapes, wine and other derivatives such as grape juice, sparkling wine and gastronomy are the main attractions. The growing direct sales to tourists, associated with the opportunities for marketing products in greater Vitória, has stimulated wine growing resumption in recent years, both for the sale of fresh fruit and for the production of wines and grape juice (Protas & Camargo, 2011).

The 2017 Census counted 627 rural properties in Espírito Santo producing table grapes and another 136 producing grapes for wine and juice. Of this amount, 278 properties have more than 50 feet. The municipality of Santa Teresa stands out for its pioneering spirit in grape cultivation and its significant planted area, being the largest producer, with 33.6% of state production. In addition to Santa Teresa, Santa Maria de Jetibá, Santa Leopoldina, Domingos Martins, Marechal Floriano, Venda Nova do Imigrante, Conceição do Castelo and Alfredo Chaves can also be highlighted (Incaper, 2020).

Grape production in Espírito Santo went from 1,600 tons in 2010 to 3,200 in 2022 (Figure 1), with 2,710 tons being destined for the commercialization of table fruits and 495 tons for the production of wine and juice. The gross value of grape production corresponded to around 21.492 million Reais in 2022.

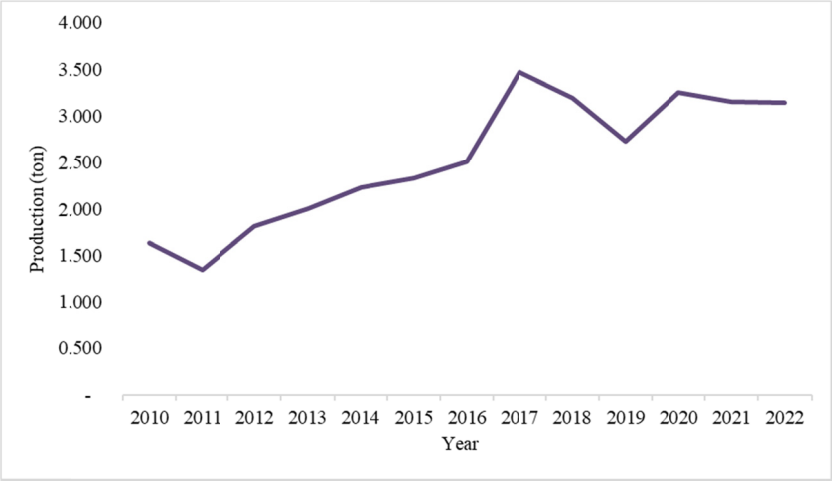

Figure 1. Grape production in Espírito Santo

Source: Prepared by the authors based on IBGE-PAM-Sidra, 2010 to 2022.

Besides its proximity to the metropolitan area of the capital, Vitória, the Santa Teresa region is privileged by a landscape with interesting natural beauty, which has led, through official programs, to the organization and development of regional tourism. In this context, grapes, wine and other derivatives such as grape juice, sparkling wine and gastronomy are the main attractions. In recent years, the growing direct sales to tourists, associated with opportunities to sell products in greater Vitória, has stimulated wine growing resumption, both for the sale of fresh fruit and for the production of wines and grape juice. As a reflection of this fact, producers in Santa Teresa created the Santa Teresa Wine Growers Association, APROVITI (Protas & Camargo, 2011).

Vine cultivation can be important in the interaction between urban and rural ways of life (Otani et al., 2013). In addition to contributing to the conservation of the vegetation that forms part of the landscape, viticulture is an activity capable of providing a better quality of life for the rural population, attracting new consumers with the production of artisanal products and allowing the exploration of agritourism.

2. Material and Methods

In preparing this study, quantitative (Triola, 2005) and qualitative research techniques and procedures were adopted based on the methodological approach of production chains, also called: agro-industrial complexes, agri-food system, agribusiness, sectoral innovation systems (Dalcomuni et al., 2000; Nogueira et al., 2013). The methodological approach to production chains serves as an analytical tool for carrying out diagnoses and strategic simulations of each product in focus (Dalcomuni et al., 2000; Nogueira et al., 2013).

This research was carried out through the application of semi-structured interviews and questionnaires containing objective questions about the winegrower and their property, production data, phytosanitary aspects, production financing and information about marketing. This type of research is quite common in socioeconomic

analyzes of agricultural production. Neto et al. (2022), for example, applied a checklist-type questionnaire to a sample of family farmers in the northern region of Portugal to understand the decision-making processes regarding grape production.

Producers from the most representative municipalities in grape production in the highlands region of Espírito Santo were interviewed, who responded to semi-structured interviews, in order to have access to data and information relevant to the diagnosis of the chain and inferences about the product marketing trends. The questionnaire model applied is available in Galeano et al. (2022).

A sample was defined in order to qualitatively and quantitatively support the design of the insertion of viticulture activities in the food and beverage production chain. Sampling was calculated according to Triola (2005).

To define the number of questionnaires applied to vinegrowers, the municipalities with the greatest participation in state production were selected. The selection of sampling municipalities was based on the 2017 Agricultural Census.

The number of questionnaires was calculated for each municipality included in the research (Table 1). The questionnaires sought to cover all stages of the production chain, from the acquisition of inputs to the final consumer, in order to obtain the necessary information for the proposed diagnosis.

Table 1. Scope of application of grape production questionnaires on rural properties in the main producing municipalities of Espírito Santo

Municipality	**Production (Tons)**	**Agricultural properties (Nº)**	**Questionnaires (nº)**	
			Goal	**Applied**
Santa Teresa	975	76	45	35
Domingos Martins	172	90	21	15
Venda Nova do Imigrante	210	8	6	5
Alfredo Chaves	284	23	20	20
Vargem Alta	202	12	11	11
Total	1,843	209	103	86
% in relation to the State's total	57.3%	33.3%	16.4%	13.7%

Source: Prepared based on data from the 2017 Agricultural Census and PAM-IBGE, 2020.

The interviews occurred in 2019 and 2020. A total of 86 vinegrowers were interviewed in Santa Teresa, Alfredo Chaves, Domingos Martins, Vargem Alta and Venda Nova do Imigrante. Grape production in these municipalities represented 57.3% of the state's total. These municipalities represent 33.3% of grape producing sites. Sampling represented 13.7% of the total number of grape producing properties in the state.

3. Results and Discussion

3.1 Results

Regarding socioeconomic characterization, the research results indicated that the majority of vinegrowers had low educational background, with 31.8% having incomplete primary education and only 17% having completed higher education. Four of the vinegrowers interviewed have higher education related to the agricultural area (Figures 2 and 3).

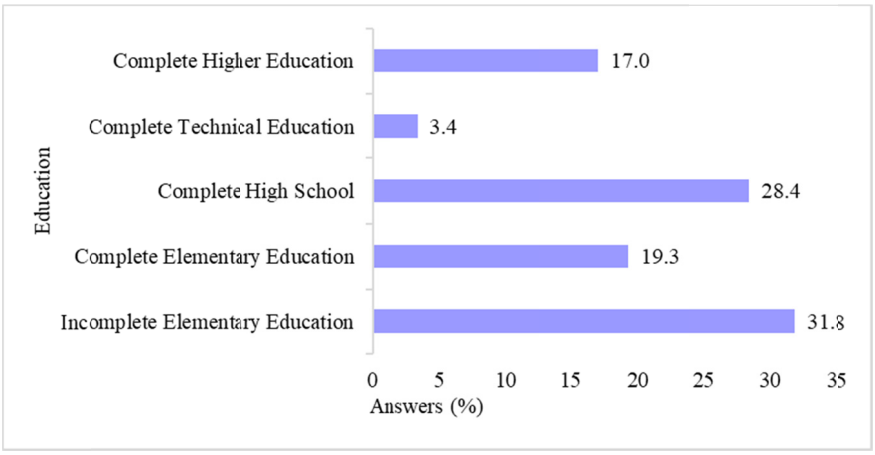

Figure 2. Educational background of the vinegrowers interviewed

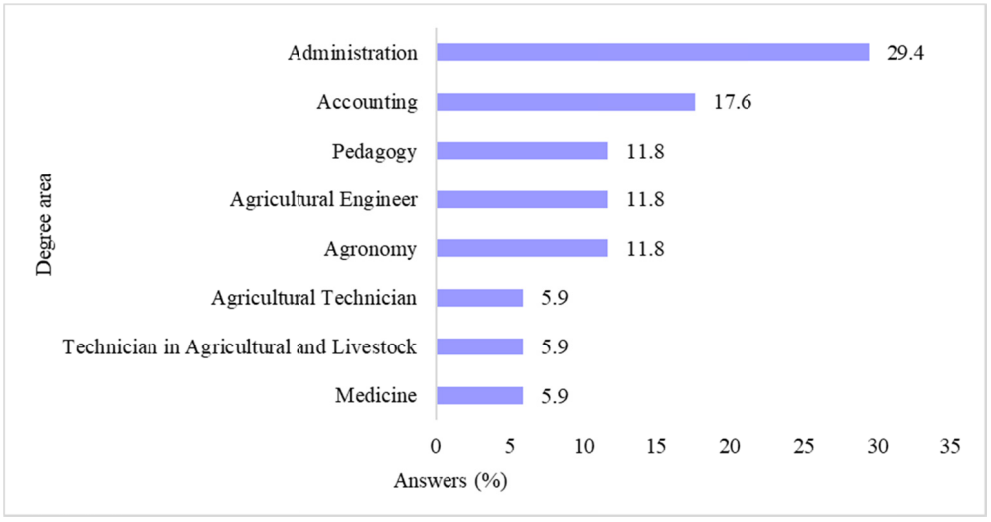

Figure 3. Background of vinegrowers with higher education

As for technical assistance, when asked if the property currently has access to this service, the majority, 69.3%, responded that it does. It was also asked whether the winegrower used technical assistance in the last year and 71.6% responded yes. For vinegrowers who received technical assistance, when asked about the institution that provided assistance, Incaper appears with 39.7%, while 47.1% used private technical assistance. There is also the participation of cooperatives, associations, city hall and agricultural stores (Figure 4).

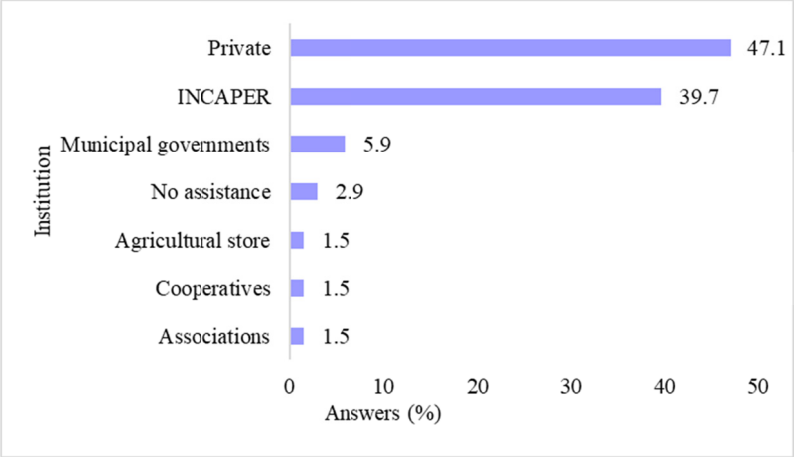

Figure 4. Institutions that provided technical assistance to vinegrowers in Espírito Santo

The technical assistance provided by Incaper in fruit growing activities includes assistance at local offices, visits to rural properties, group activities such as method demonstrations, meetings, project development, excursions and courses (Incaper, 2018).

Regarding family size in the property, it was identified that 56.8% is made up of just 3 to 4 members (Appendix A, Figure A1). Regarding the number of people working on the property, 55.7% of those interviewed reported that the work is done by one or two people (Appendix A, Figure A2). The families who live on the properties have, in most cases, one to six members. Families with more than 6 members are not very significant.

Regarding the total area of grape producing properties, it was found that 46.6% have up to 10 hectares, while 1.1% have between 50.1 and 60 hectares. However, the grape growing area is relatively smaller, with 70.9% of the grape producers interviewed using up to 0.5 hectares to grow the fruit and 23.3% between 0.5 and 1.5 hectares (Figure 5).

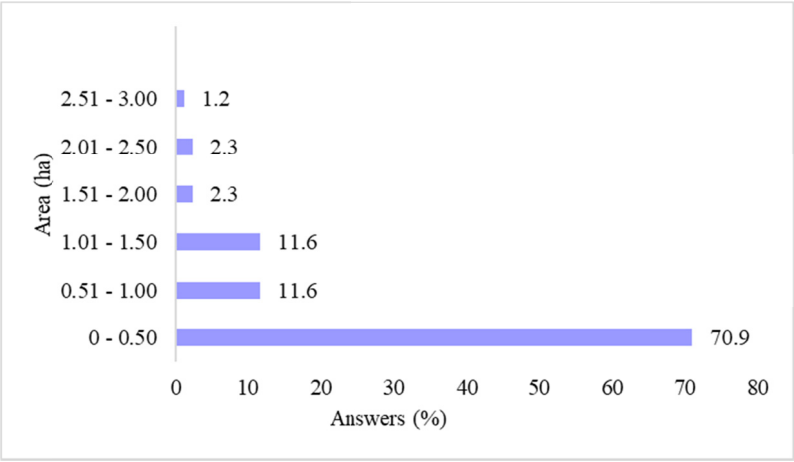

Figure 5. Area with grape cultivation in rural properties in the State of Espírito Santo

Grape production intensified from 2006 when the grape cluster in the State was delimited. By the year 2000, only 34.1% of those interviewed had started planting (Appendix A, Figure A3). The majority of vinegrowers (88.2%) use selected varieties in their planting. 87.5% of properties use soil analysis as a tool to assist in planting and managing vine fertilization.

Most producers (60.3%) use seedlings from nurseries when planting and 25.6% use their own seedlings (Figure 6). According to research data, 67.6% come from another state and the rest are purchased in the state itself.

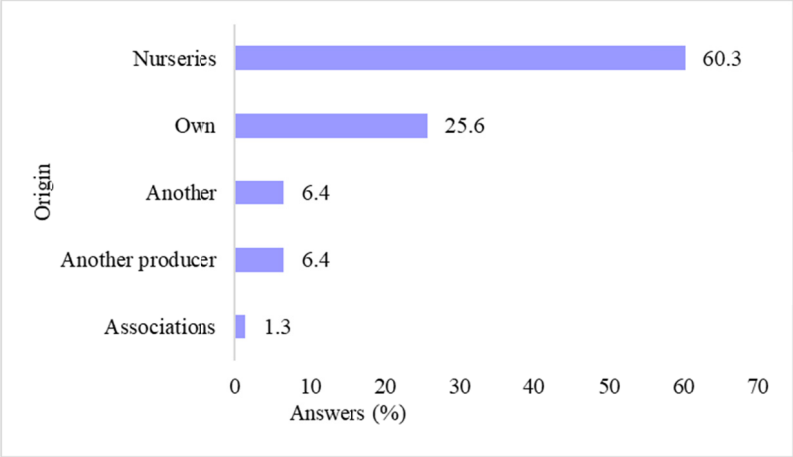

Figure 6. Origin of propagative material for grape cultivation in Espírito Santo

Grape producers have innovated with the introduction of new cultivars such as 'Niágara Rosada' and 'BRS Clara', for fresh consumption and 'Isabel Precoce', 'BRS Cora', 'BRS Violeta', 'BRS Lorena' and 'Moscato Embrapa', for the production of juice and wines, including sparkling wines (Protas & Camargo, 2011).

In this research, the quantity sampled from the 86 vinegrowers interviewed was 696 tons, which represented 21.6% of production and the average grape yield was 16,930 kg/ha, consistent with the average yield of the state production. 'Niágara Rosada' was the cultivar most cited by the interviewed producers and represented 35.37% of the sampled production volume (Table 2).

Table 2. Cultivars, number of producers per cultivar, area, production, yield and production per sampling plant

Cultivar	Vinegrowers (No)	Area (ha)	Production (t)	Yield (kg/ha)	Production (kg/plant)
Niagara Rosada	62	17.9	246.2	13,792	7.40
Isabel	55	7.8	188.8	24,174	10.99
Isabel precoce	13	2.9	41.6	14,169	6.69
Carmen	10	2.0	36.5	18,713	9.57
Vitória	23	2.7	33.1	12,070	6.94
Bordo	12	2.3	30.4	13,497	6.34
Violeta	7	0.9	19.5	21,739	11.68
Isis	8	1.3	17.8	14,016	8.09
Cabernet Sauvignon	3	0.7	14.9	20,272	9.61
Moscatel	5	1.1	14.3	13,408	6.01
Lorena	1	0.2	4.5	20,000	6.00
Tannat	1	0.0	0.9	20,000	6.00
Others	6	1.3	47.4	35,820	10.75
Total		**41.1**	**696.0**	**16,930**	**8.37**

The average yield of 'Niágara Rosada' was 13.792 kg ha^{-1}. However, 'Isabel', which was the second most cited cultivar (27.12%), presented an average yield of 24.174 kg ha^{-1}, a value well above the average yield of 'Niágara Rosada' (Table 2). This difference between the average yield of 'Niágara Rosada' and 'Isabel' may be associated with the different management practices and technologies adopted by vinegrowers. Both cultivars are grapes of American origin (*Vitis labrusca*) and have similar characteristics. The plants of both cultivars have medium vigor, are tolerant to pests and diseases, are very productive, with medium-sized, conical and compact clusters, presenting low resistance to transportation and storage. The berries are medium-sized, oval-shaped, juicy and covered with pruine, with a foxado flavor, much appreciated by the Brazilian palate (Moura et al., 2021).

As for the most common spacing used, in the cultivation of 'Niágara Rosada', the 3 × 2 m spacing predominated and, in the cultivation of Isabel, the 2 × 2.5 m spacing predominated (Appendix A, Figures A4 and A5).

Regarding the planting calendar, the research identified that grapes can be planted throughout the year. However, most producers plant from August to December. Although it can be harvested at any time of the year, most producers tend to concentrate on the months of January to March. According to Camargo et al. (2011), with the use of appropriate technology, it is possible to obtain two or more harvests per year, in the same vineyard and schedule the harvest for any day of the year. The research also collected data on personnel working on grape farms. It is more common to find two people employed on grape crops (48.9% of cases), but this number can also vary on a smaller scale from three to six people (Figure 7). The labor force that predominates in harvest is that of the owner's own family (85.3%). Temporary employees, sharecroppers and permanent employees are also used (Figure 8). The number of people employed in the 86 properties interviewed was 180, which represents an average of 2.1 workers per property.

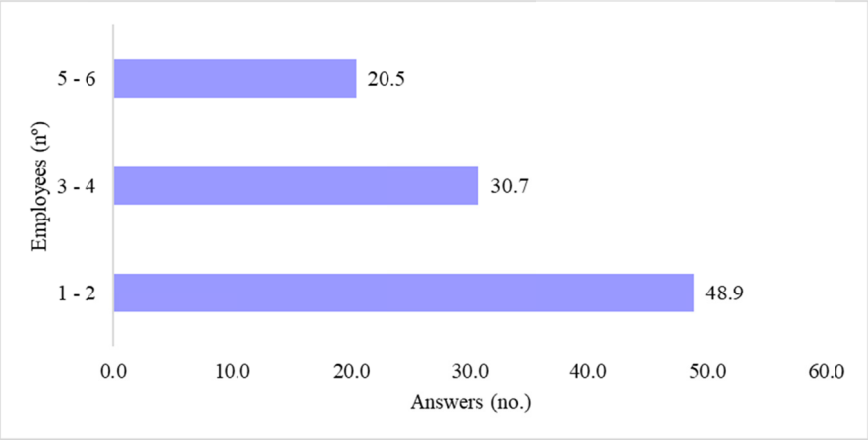

Figure 7. Number of people employed in grape producing properties in Espírito Santo

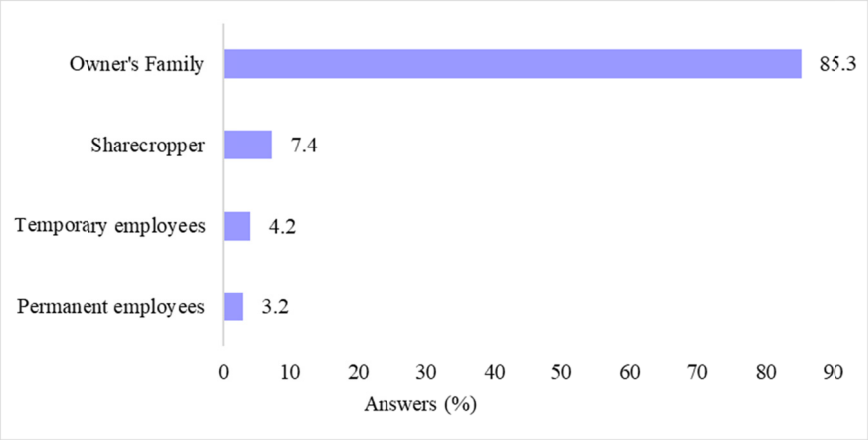

Figure 8. Type of labor used in grape harvesting in Espírito Santo

As for the number of family members who help with harvest, two people per property predominate in 70.2% of cases, but the number varies from 3 to 4 in 21.4% of cases. There are few properties that use 5 to 6 family members for harvest (Appendix A, Figure A6). In properties where there are temporary employees, the cases that have up to two workers on the harvest represent 65.2%. Cases of properties where the number of workers varies from three to four represent 17.4% (Appendix A, Figure A7). On properties where the type of labor is sharecroppers, cases that generally have just one worker represent 44.4% (Appendix A, Figure A8). Regarding the cost of employees, when the worker is temporary and receives daily wages, the daily value varies on average between R$60.00 and R$80.00[1] Reais.

Regarding the grape cultivation area, according to those interviewed, 63.6% intend to maintain their planting area and 22.7% intend to expand their crops. However, 8% have plans to reduce planting, and 5.7% want to eliminate their planting areas (Figure 9).

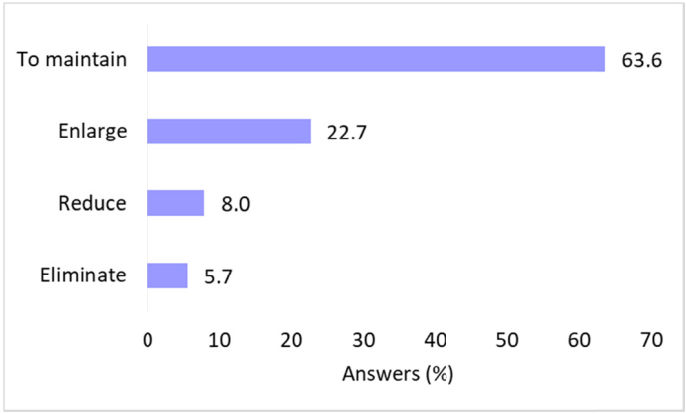

Figure 9. Perspective regarding grape planting and production in Espírito Santo

The majority of interviewees (85.2%) use an irrigation system. Those who carry out irrigation prefer dripping (41.9%), but there are also properties that use micro-sprinklers (37.8%), sprinklers (17.6%), manual and hose irrigation (Figure 10). The water used to irrigate grape crops comes from a dam for 54.8% of the cases that use irrigation (Appendix A, Figure A9).

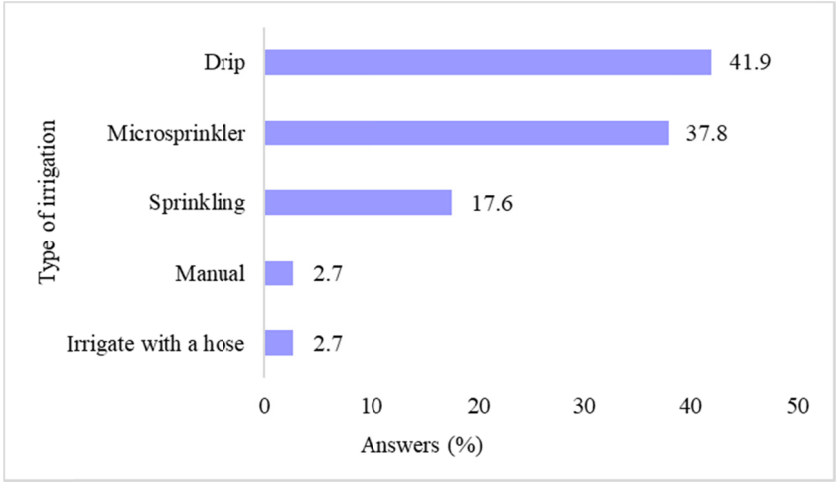

Figure 10. Type of irrigation system used in grape production properties in Espírito Santo

The main problem cited in grape production was pest and disease control (39.3%). High production costs were the second most cited problem (29.2%), followed by low grape prices (11.2%) (Figure 11).

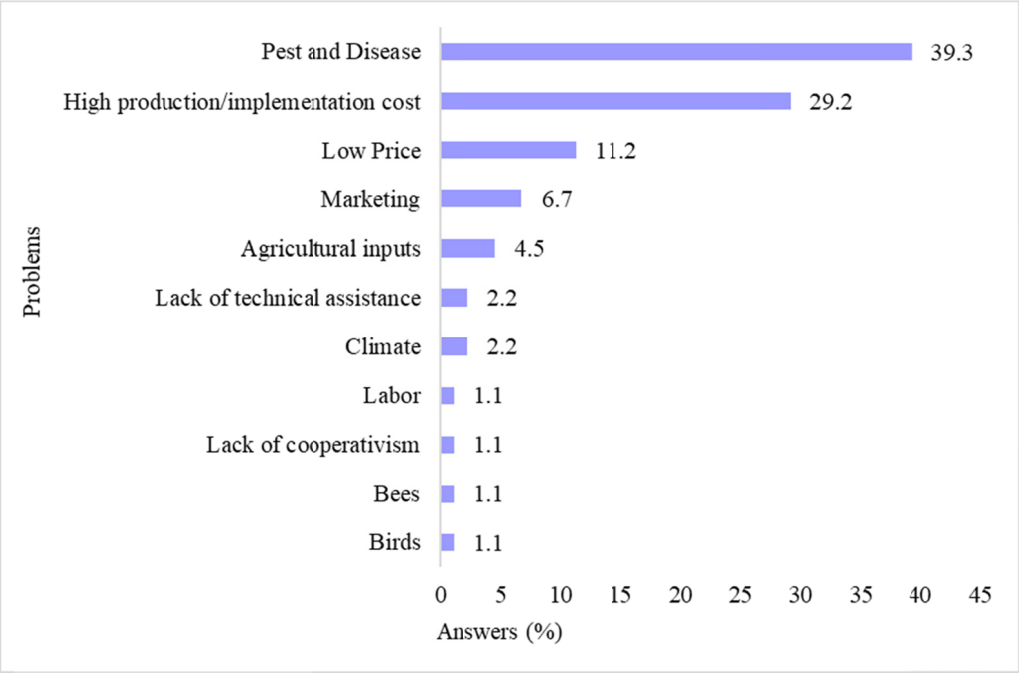

Figure 11. Main problems in grape production in the State of Espírito Santo

Among the main phytosanitary problems cited by the producers interviewed, downy mildew (*Plasmopara viticola*) (42.3%), powdery mildew (*Uncinula necator*) (21.2%) stands out first, followed by 9.6%. anthracnose (*Elsinoe ampelina*) (Figure 12). These diseases have been reported to be responsible for significant losses in fruit production (Appendix A, Figures A10, A11 and A12). For 43.3% of interviewed vinegrowers who reported the occurrence of downy mildew, losses were up to 5% of production and 18.9% reported losses ranging from 5.1 to 10%. Losses due to the occurrence of powdery mildew range from 3.1 to 5% for 41.7% of cases. Losses due to the occurrence of anthracnose vary from 3.1 to 5% for 42.9% of cases.

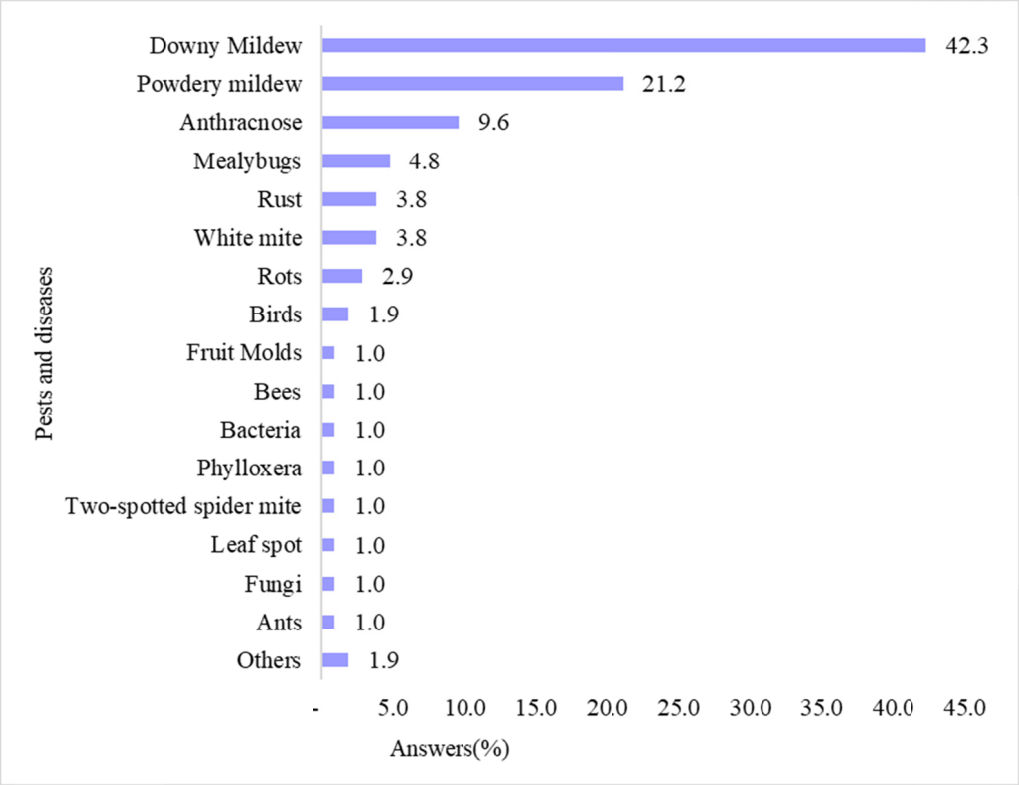

Figure 12. Main pests and diseases that affect grape crops in the State of Espírito Santo

To control pests and diseases, grape producers have used chemical control (insecticides and fungicides) as their main method, which was reported by 87.5% of respondents, followed by biological (12,5%) control strategies. In cases of biological control, 36.4% use baits.

Around 79.4% of vinegrowers declare that they carry out post-harvest treatment. The main type in 50.5% is the elimination of berries with insect/bird bites and the rest of the interviewees declare that they eliminate sour grapes.

The main financial resource used for planting grapes in properties is 90.1% of own origin. The survey shows that 96.6% of producers did not take out loans to grow grapes in the year prior to the survey. Producers who used the bank loan used the resources mainly to pay various expenses.

When selling grapes, 81.3% of producers declared that the main expense was fuel and 18.8% said that the main expense was freight. Regarding the type of packaging used for transportation, 43.6% of respondents stated that they use plastic boxes and 29.5% use cardboard boxes (Appendix A, Figure A13).

As for marketing problems, prices below expectations, price fluctuations and production volume were the main problems cited (Figure 13). Producers have difficulty transporting production so that it reaches the market at the desired time. The total production volume also influences grape price fluctuations. Unpaved and unmaintained roads are included in infrastructure. When the total supply of the product on the market increases, the price received by the producer falls, damaging its revenue forecast.

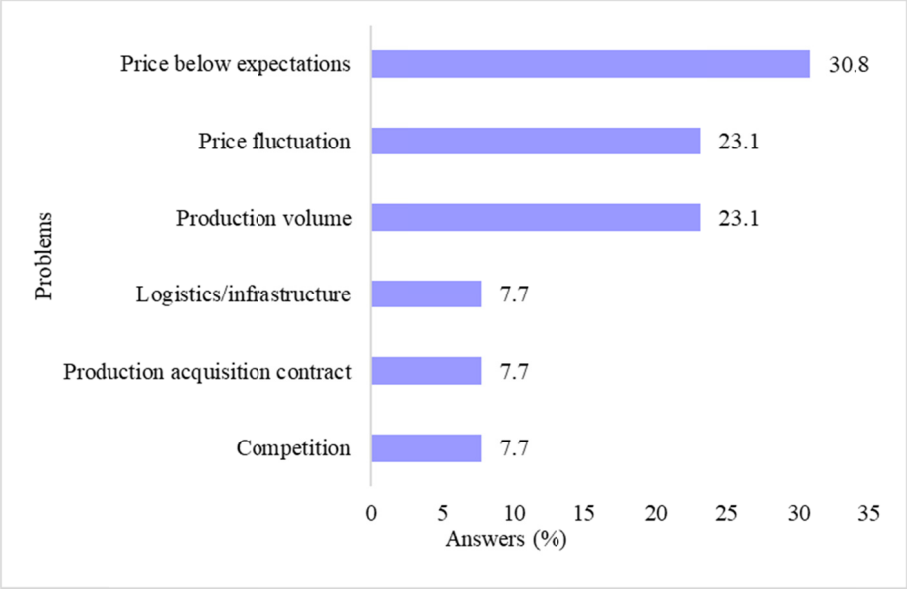

Figure 13. Main problems related to grape marketing

3.2 Discussion

Organic fresh grapes and organic grape juice are considered to have a higher market value due to the benefits offered to health by not using pesticides and chemical fertilizers, in addition to preserving the environment (Junges et al., 2022). The chemical constitution of grape juice depends on several factors, such as the grape variety used, climate, harvest, geographic origin, state of maturation and cultivation process (Sen &Tokatli, 2016; Jégou et al., 2017). Following the environmental footprint (EF) methodology proposed by the EU, Litskas et al. (2020) showed that on the Mediterranean island of Cyprus, machinery, fuel, and sulfur production and use were identified as EF hotspots for organic grapes. Fertilizer production and use were identified as EF hotspots for high-input grape production. The EF impact category values for low-input grapes showed similarities with organic production. Organic and low-input viticulture could mitigate the environmental impact of viticulture (Litskas et al., 2020).

Grape production in Santa Teresa and its associated businesses were very important instruments for the consolidation of rural tourism in the highlands Region of Espírito Santo. However, the viticulture in the highlands region of Espírito Santo, especially in Santa Teresa, a significant use of pesticides was observed. Therefore, in 2022, a working group was formed with the main institutional actors in the production chain to jointly seek improvements and solutions to the main existing problems and bottlenecks. The objective of this initiative is to improve management practices, grape yield and quality, focusing on the sustainability of the activity and certification for organic/biodynamic grape production, increasing the quality of the raw material, as well as associated products (juices, wines, sparkling wines and others), favoring consumers, diversification and adding value to beverages.

Currently, something that also concerns actors in the grape production chain in Espírito Santo is related to the costs of implementing and producing grapes. Producers have been working with narrow margins, competing with grapes produced in other units of the federation at much lower costs, such as in the São Francisco Valley, a semi-arid region in Brazil. In this sense, it is necessary for Research and Technical Assistance and Rural Extension (ATER) work to concentrate efforts to develop production systems with lower implementation and production costs, mainly related to the support structure of the vines and the development of cultivars that are more resistant and/or tolerant to pests and diseases, mainly vine downy mildew (*Plasmopara viticola*), which will consequently reduce production costs for the vinegrowers.

Grape production in Espírito Santo meets only 2% of the state's demand. Thus, there is still a vast field to be explored in winemaking by producers. However, the reality of wine growing in the state shows that there is a need for producers to improve cultivation techniques aiming to make better use of the area, reduce production costs, increase profitability, making them more competitive and encouraging them to invest in the activity and remain in rural areas (Rassele et al., 2022).

It's increasingly important to know the effects of climate change on crops. The study of Macedo and Carvalho (2022) aimed to determine the bioclimatic indices for the main wine-growing areas of Madeira Island, for the current period and for two simulated climate scenarios to understand the potential and limits that will be imposed on the development of vine culture. In a climate changing scenario, the winegrower also needs to be prepared to grow the vine at even higher temperatures and, mainly, in an atmosphere with higher CO_2 concentrations. This applies to all crops. Nonetheless, in the case of viticulture in particular, very high temperatures can make cultivation unfeasible. It is an issue that needs to be resolved. Otherwise, serious economic and social problems created by the rural exodus could be accentuated, such as the expansion of peripheral areas, the formation of demographic voids in the countryside, a reduction in agricultural production, an increase in unemployment rates, a reduction in food supply, a lack of labor work in agriculture and several other problems (Souza et al., 2024a; Souza et al., 2024c).

To maintain a growing path of sustainability and technological impact provided by wine growing, it is necessary to continue training vinegrowers, offering ATER services and public research. In addition to increasing yield, it is necessary to explore new market niches, verticalize production systems through agro-industries, interconnect productive activities and increase interaction with the urban environment, such as rural tourism, which can function as a food sovereignty strategy, connecting rural and urban communities through a shared appreciation of environmentally sustainable and socially fair foods (Souza et al., 2024a). Similarly to the observations of Silva et al. (2012), in Espírito Santo, there is also an imminent need to strengthen the institutional environment for the continuity of winegrowing. This can be accomplished through specific public policies for the activity, such as rural credit lines that meet the demands of producers, the maintenance of research and ATER services and the permanent participation of an institutional agent that coordinates activities/actions, promoting the product, generating trust in related institutional agents, through greater coordination and involvement between them.

A viable opportunity for expanding grape production in Espírito Santo would be cultivation in other regions of the State. Viticulture developed in temperate conditions generally follows the same procedures used in traditional countries for vine cultivation. In hot climate regions, management techniques were adapted to each specific situation (Costa et al., 2012).

Considering the parameters average annual temperature and water index, Klippel et al. (2011) concluded that the climatic potential for exploring vine cultivation in Espírito Santo was fully suitable in 0.14% of the state territory, 90.10% with thermal suitability and restriction by water index and 9.76% unsuitable for cultivation. All municipalities that make up the coastal strip, according to the study, are located in the area that has thermal suitability for the cultivation of the species, but water deficit is a limitation. This leads to the inference that, in these municipalities, *a priori*, with water supply via irrigation, there may be viability for growing vines. The authors (Costa et al, 2012; Camargo et al., 2011; Klippel et al., 2011; Pommer et al., 2009; Viana et al., 2008; Maia et al., 2007) showed promising results regarding vine cultivation in regions with a hot climate. From an energetic point of view, viticulture in hot climate regions also presented positive impacts (Souza et al., 2024b).

4. Conclusion

Grape cultivation in the State represents a great opportunity for diversification and added value for rural producers. However, there are still several challenges to be overcome, requiring a greater supply of Research, Technical Assistance and Rural Extension (ATER) services to overcome the problems highlighted in the research.

The need to improve management practices, yield and grape quality was identified, with a focus on sustainability, reducing the use of pesticides, and certification for organic/biodynamic grape production, increasing quality. It is necessary that Research and Technical Assistance and Rural Extension work also concentrate efforts to develop production systems with lower implementation and production costs, mainly related to the support structure of the vines and the development of cultivars that are more resistant and/or tolerant to pests and diseases, mainly vine downy mildew (*Plasmopara viticola*), which will consequently reduce production costs for the vinegrowers.

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Notes

Note 1. Monetary values for 2020.

Appendix A

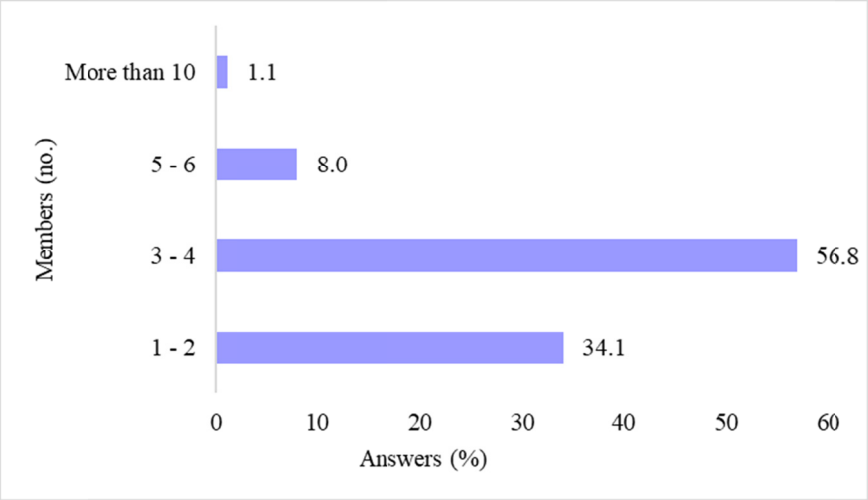

Figure A1. Family size in rural grape-producing farms in Espírito Santo

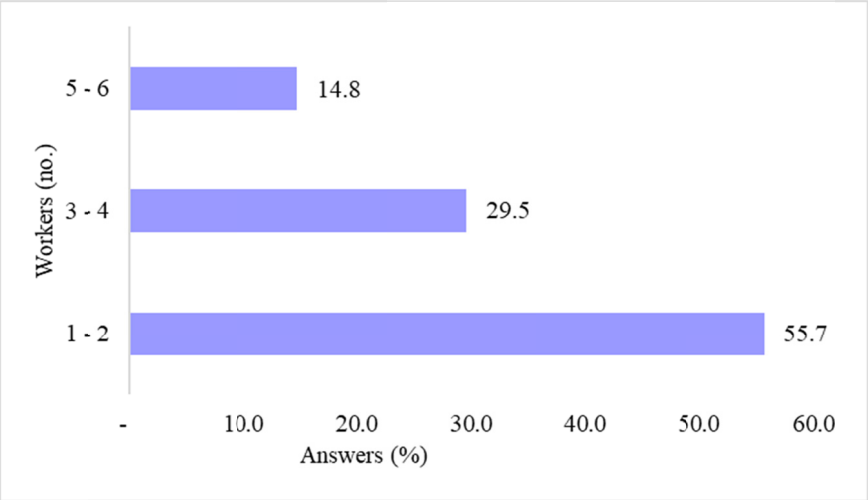

Figure A2. People working in grape producing properties in Espírito Santo

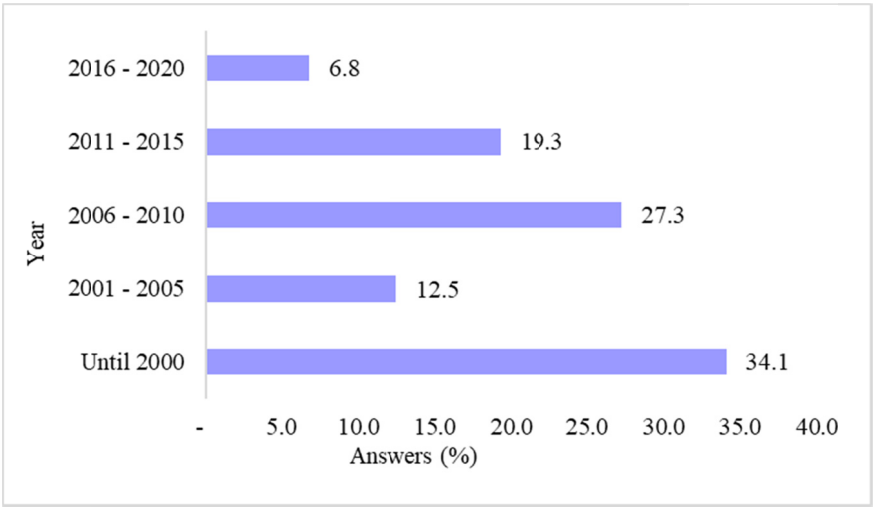

Figure A3. Year in which grape cultivation began on the rural properties included in this study

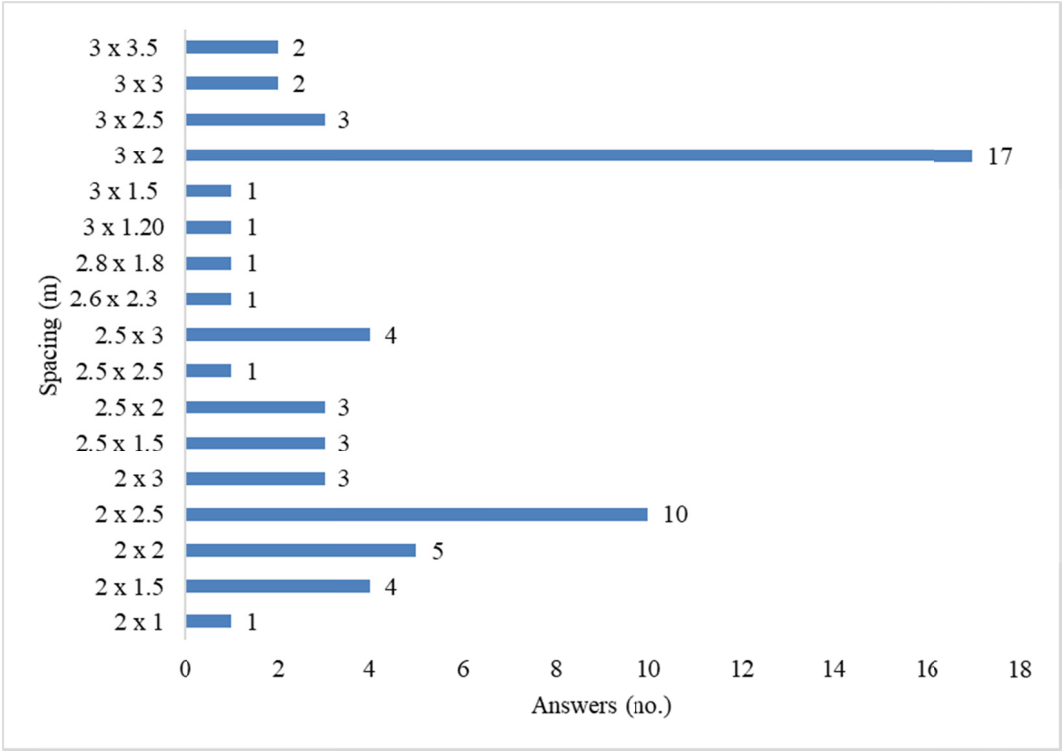

Figure A4. Main spacing used for planting ‘Niagara Rosada’ grapes in Espírito Santo

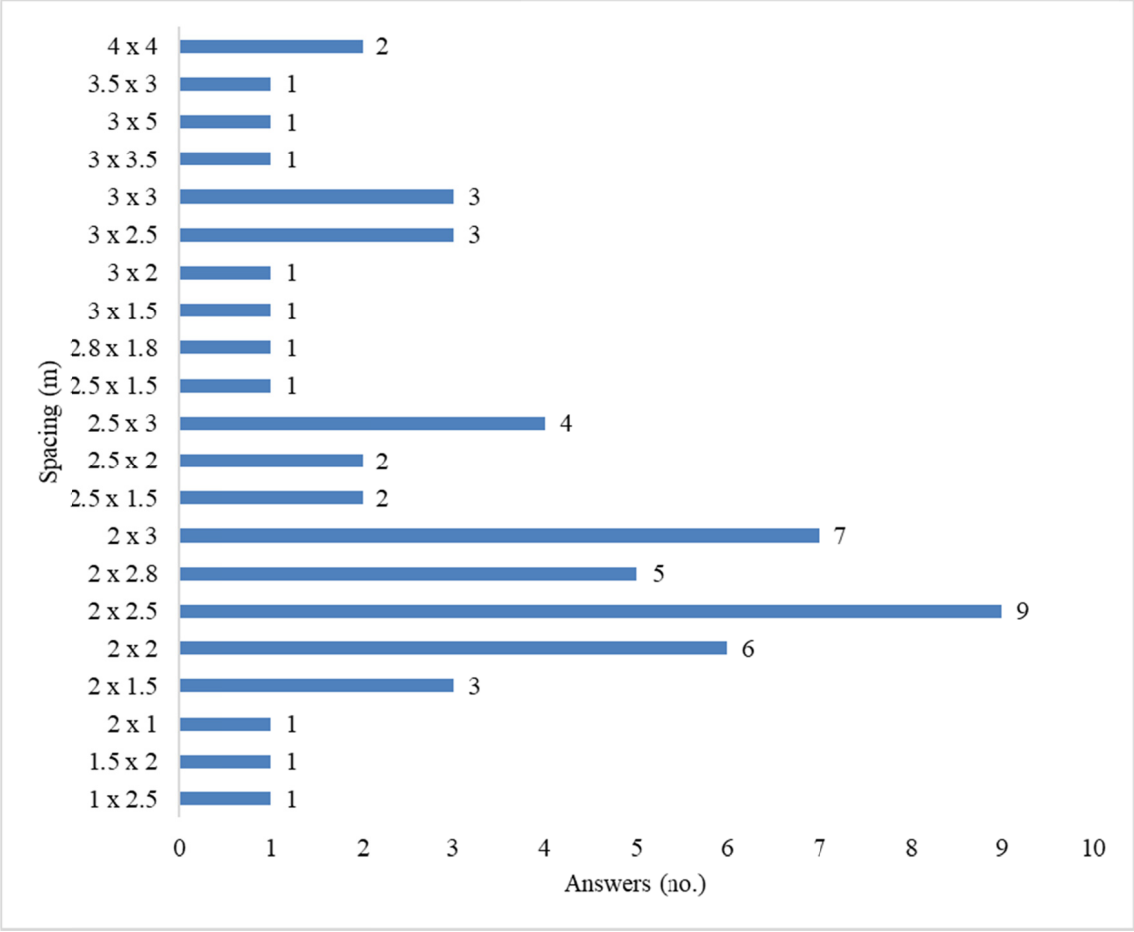

Figure A5. Main spacing used for planting 'Isabel' grapes in Espírito Santo

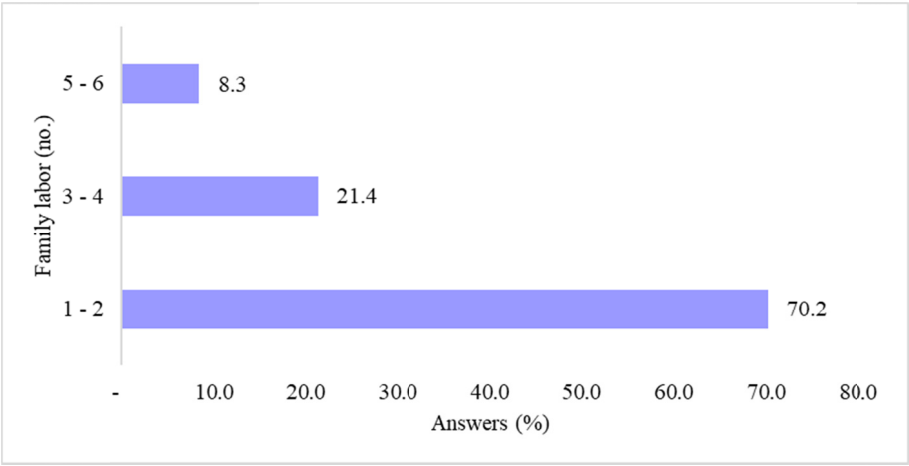

Figure A6. Number of family members working on grape harvest in Espírito Santo properties

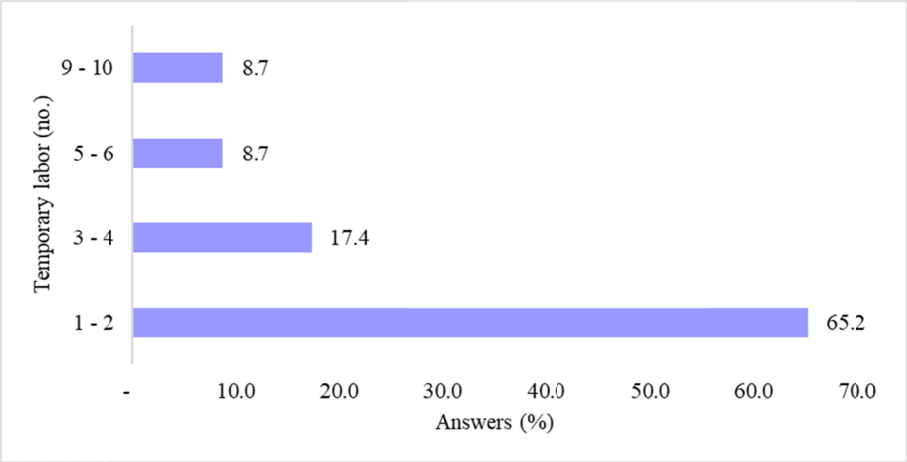

Figure A7. Number of temporary employees working on grape harvest in properties in Espírito Santo

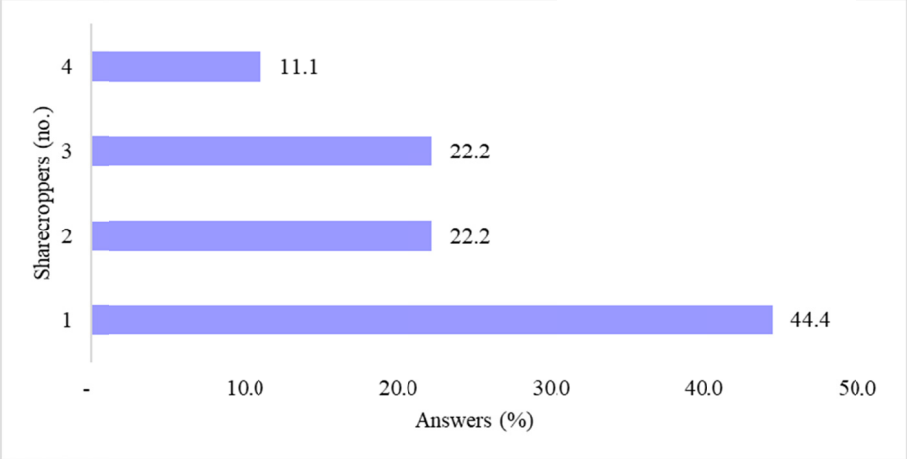

Figure A8. Number of sharecroppers working on grape harvest in properties in Espírito Santo

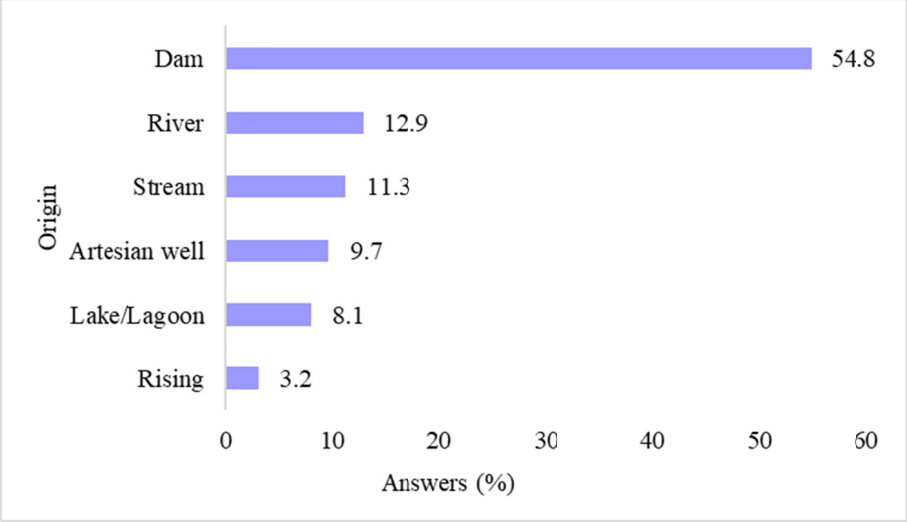

Figure A9. Origin of water used in irrigation in grape production properties in Espírito Santo

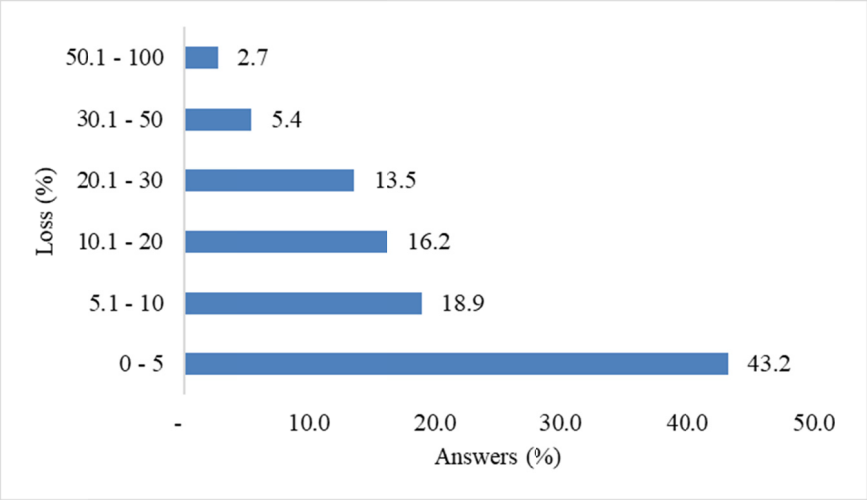

Figure A10. Losses reported by vinegrowers related to vine downy mildew

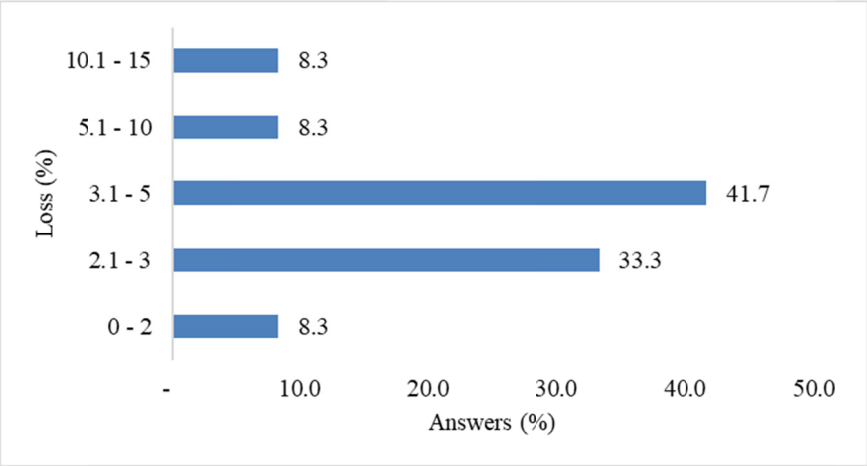

Figure A11. Losses reported by vinegrowers related to vine powdery mildew

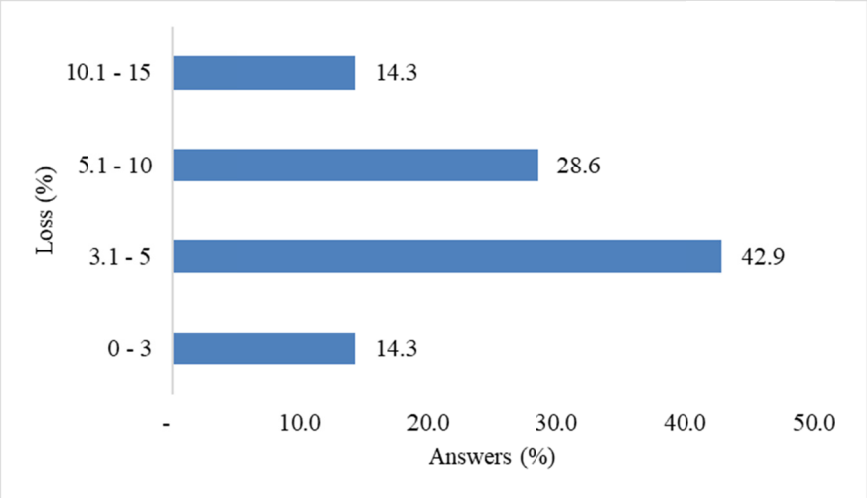

Figure A12. Losses reported by vinegrowers related to fruit anthracnose

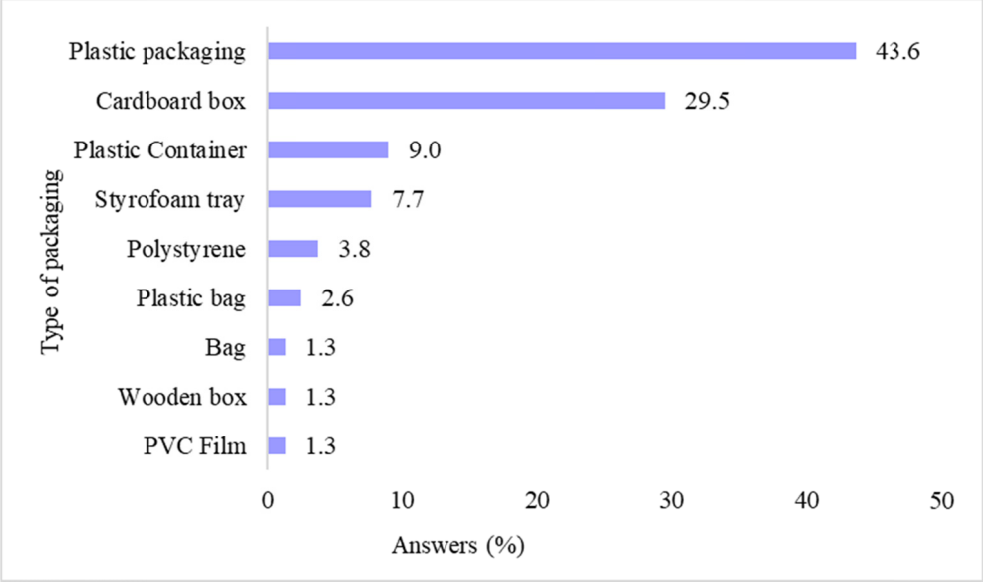

Figure A13. Packaging used to transport grapes on properties in Espírito Santo

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Authors Contributions

Edileuza Vital Galeano was responsible for project administration, study design, data analysis, drafted the manuscript and revising. Letícia Abreu Simão was responsible for data collection. Cássio Vinícius de Souza collaborated in drafted the manuscript and revising. Carlos Alberto Sangali de Mattos and José Aires Ventura for data curation and revised it. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed Consent

Obtained.

Ethics Approval

The Publication Ethics Committee of the Canadian Center of Science and Education. The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and Peer Review

Not commissioned; externally double-blind peer-reviewed.

Data Availability Statement

The data supporting this study's findings are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data Sharing Statement

No additional data are available.