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Economic Viability and Quality of Grapes Produced with and without Plastic Covering

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Abstract: Viticulture began growing in Brazil in recent years, and this growth is due to the introduction of new techniques and improvements used in vine planting, especially the use of plastic covering in the vineyard. Thus, this study aimed to evaluate the economic viability of plastic covering installation, as well as the quality of grapes produced by two cultivars, in order to compare these results with those obtained by a conventional cultivation system. The experiment was performed at an experimental farm producing grapes in southern Brazil. The grape cultivars Niagara Branca and Niagara Rosada were studied and cultivated with and without plastic covering. Data related to the costs of vineyard planting, establishment, and seasonal management, in addition to the grape revenue, were assessed. Additionally, the grape yield and quality were evaluated. The analysis of return indicators showed that the net present value was higher for the plastic-covered system, which indicates greater profitability and consequent viability of the investment. Moreover, the grape quality varied according to the cultivar and production system. In this context, it is recommended to use the cultivar Niagara Rosada for production in a plastic covering system.

Keywords: *Vitis labrusca*; protected environment; economic indicators; grape yield

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1. Introduction

Viticulture began growing in Brazil in recent years, and this growth is due to the introduction of new techniques and improvements used in vine planting. Brazil became a great producer of grapes for the manufacture of wines, juices, or even direct consumption, and the main reason for this growth was the adoption of new management strategies, especially the use of plastic covers on the plants. The cultivation of grapevine (*Vitis* sp.), originating in the Mediterranean area, expanded worldwide and represents a profitable enterprise [1]. There are thousands of grapevine varieties in the world, but the main ones currently cultivated belong to the species *Vitis vinifera*, *Vitis labrusca*, and *Vitis bourquina*, which are used in the production of wines and grape juices [2]. The planning and establishment of the vineyard is not a simple task. Many factors influence the vine's productive response, including edaphoclimatic conditions, such as soil, air temperature, and solar radiation [3], as well as the management practices, such as topography, cultivar, the conduction system, planting density, irrigation, pruning, and harvesting [4].

Viticulture is one of the most economically important agricultural sectors in the southern region of Brazil [5], which represents 73.12% of the total area in Brazil in recent years. Rio Grande do Sul is the main producing state, accumulating 62.51% of the national viticulture area, which corresponds to 46,774 ha [5]. Weather conditions and extreme events significantly affect the vine productivity and the quality of grapes. Among the factors that reduce vine productivity, the occurrence of excessive rain during the ripening and harvesting period, as well as the occurrence of fungal and bacterial plant diseases, can be reported. In this context, it is important to search for alternatives to solve such problems, and in this case, the use of plastic covering plants can be an interesting alternative for producers.

In recent years, there was a great technological evolution in the production of grapes, especially aiming at increasing the quality and quantity of grapes through specialized management techniques. One of the techniques that are used refers to the use of plastic covering on plants. This production system was studied and applied by grape producers due to the benefits provided [6–11]. However, there are still few studies that assess the economic viability of adopting plastic covering on plants as well as the influence on the grape quality, especially in the sugar level of berry juice.

The use of plastic covers in viticulture is related to several factors. The first one is the high risk of yield losses due to unfavorable weather conditions such as excessive rainfall, which favors the occurrence of a bunch rot of grapes caused by fungi [12], as well as the occurrence of hail [13]. The second aspect is related to the vine and grape protection against specific fungal diseases. The use of plastic covering provides a reduction in plant leaf wetness, and this results in a reduction in the occurrence of plant diseases, and consequently, in a reduction in the use of fungicides [8]. Accordingly [14], the authors observed a significant reduction in the number of treatments with fungicides in the protected cultivation of grapevines when compared to conventional management without coverage. In a previous study [15], a 75% reduction in the number of sprays in the cultivation of grapevines with plastic covers was observed. On the other hand, the main disadvantage of the plastic covering is related to the installation cost, which increases the grape production costs. Furthermore, it is possible to observe a reduction in the amount of solar radiation intercepted by plants due to the plastic covering. This fact can affect the quality of the grapes produced, as well as the length of the production cycle.

The use of plastic covering was mainly applied to the production of table grapevine. However, due to the benefits provided, studies are needed to assess the response of grape cultivars destined for wine production. In this context, the use of plastic covering for grapes destined for wine production has great potential. The use of plastic covering can increase the production and quality of the grape [16]. For grapes destined for wine production, it is important to evaluate the sugar content in the must composition, as it is essential for yeast metabolism and consequently for the fermentation kinetics [17].

Considering the importance of grape production in Brazil, the grape producer is responsible for choosing the adoption of the plastic covering, a decision that involves several aspects, including the climatic, phytosanitary, and economic aspects. Despite this, many producers do not carry out a technical analysis on the return of the investment made, which can end up causing economic losses in the future. Thus, this study becomes important in evaluating the response of grapevine cultivars produced in a traditional cultivation system and under plastic cover, as well as in carrying out a detailed cost survey for the installation of the plastic cover. With the information obtained, it will be possible to assist grape producers in making decisions regarding the use or not of plastic coverings due to the economic feasibility and cost assessment of grapevine cultivation.

In this context, this study aimed to evaluate the economic viability of plastic covering installation, as well as the quality of grapes produced by two cultivars, in order to compare these results with those obtained by a conventional cultivation system.

2. Materials and Methods

2.1. Study Area and Experimental Design

The experiment was carried out in an experimental farm producing grapes in southern Brazil in the city of Sarandi in the state of Rio Grande do Sul, Brazil (27°57′ S, 52°55′ W), with an altitude of 503 m a.s.l. The study was carried out during the 2020/2021 harvest season. The vineyards were in their second year of production. The climate of the study area is Cfa (humid subtropical climate), which is characterized by an average annual temperatures of 19.1 °C, ranging from 38 °C to 0 °C, according to the Köppen climate classification [18]. The soil is classified as dystrophic red latosol, clayey texture, deep, and well drained [19].

A total area of 7.92 ha was divided into two production systems: (i) a traditional open field production system with an area of 5.6 ha, and (ii) a protected production system with a plastic cover with an area of 2.32 ha. The vine space was 1.20 m on the row and 3.00 m between rows. The training system was an overhead trellis system (tendone). To cover the vines in the protected cultivation system, a polypropylene plastic film was used, installed on a metallic structure in the shape of an arch with a maximum height of 3.5 m. The polypropylene plastic film with a low density was used, added with an anti-ultraviolet (anti-UV) filter, 200 µm of thickness, 185 g m^{-2} of specific weight, and solar radiation transmissivity ranging from 70 to 80%, depending on the different wavelengths measured (Brasplan c.a., Passo Fundo, Brazil).

In this experiment, two cultivars of the species *Vitis labrusca*, cv. Niagara Branca and Niagara Rosada, with and without a plastic cover, were used in the total areas of 0.81 and 0.32 ha, respectively. The cultivar Niagara Branca is characterized by high vigor and productivity, has medium-late maturity, and moderate resistance to diseases such as anthracnose and Botrytis. Its main use is for the production of wine, with particular characteristics of aroma and flavor [20]. The cultivar Niagara Rosada is used for fresh consumption, mainly due to its pink color of berry skin, which is very attractive for the consumer. In addition, it has high productivity and resistance to certain diseases [20].

The treatments were composed of two grape cultivars, Niagara Branca and Niagara Rosada, and were distributed in the two production systems. Four repetitions per each production system and per each cultivar were considered. Each repetition was composed of eight vines. For better analysis and discussion of the systems with and without coverage, the costs for the production of 1 hectare of grapes in each system were estimated.

2.2. Economic Viability Assessments—Production Costs

To carry out the analysis of the grape economic feasibility in the two cultivation systems, data sets were collected based on information obtained from the farm producer operating in that study area and historical data series. The set of data collected were: (i) production cost; (ii) cost of installing the plastic cover; and (iii) costs of maintaining the vineyard.

2.2.1. Production Costs

The grape production costs considered in this study are related to material and labor, as these costs are present throughout the grape cycle, i.e., from planting to harvest. Among the costs, the following can be mentioned: (i) preparation of the area: costs related to the preparation of the soil for planting the vines, such as harrowing and soil preparation; (ii) fertilization: cost related to the use of fertilizers at vine planting and for vineyard seasonal management; (iii) vines: costs related to the purchase of plant material; (iv) trellis: costs related to the structure to support the vineyard, such as wooden poles, wire, etc.; and (v) labor: costs related to the labor needed mainly in planting the vines, managing the vineyard, and phytosanitary treatments.

2.2.2. Cost of Installing the Plastic Cover

The costs presented here are associated only with the plastic-covered system. In this context, all the costs are related to the structure supporting the plastic cover, the plastic, and the labor required to implement the plastic cover on the trellis. Additionally, the cost of plastic cover replacement was considered 6 years after the vineyard planting.

2.2.3. Costs for Maintaining the Vineyard

In this section, vineyard maintenance costs were considered, mainly those related to phytosanitary management (purchase of fungicidal, insecticide, and herbicide inputs) and those related to cultural treatments, such as pruning and harvesting. The labor used in these processes was also considered.

2.3. Economic Viability Assessments—Vine Revenue

For the revenue analysis, the 10-year cycle was considered to analyze the economic viability. Additionally, for the grape yield estimation, an average value between the two cultivars studied was considered, since the aim was not to compare cultivars, but the feasibility of using plastic covering.

The yield estimate was based on a historical data series [21] as presented in Table 1. The grape yields during the 10-year cycle were separated into two production systems: the traditional production system (without plastic covering) and the system with plastic covering. Moreover, to perform the analysis, the grape yield stabilizes after the 5th year. For this analysis, year 1 was considered as the moment of vine planting, resulting in higher costs, years 2 to 5 as the period of vineyard establishment, namely that of plant growth, and finally, years 6 to 10 as the period of stable production, and normal seasonal management, considering a useful life of 10 years of the vines.

Table 1. Grape yield estimation during the 10-year cycle for the traditional system without plastic covering and the system with plastic covering.

System without Plastic Covering		System with Plastic Covering	
Year	**Yield (Kg ha^{-1})**	**Year**	**Yield (Kg ha^{-1})**
1	10,000.00	1	19,000.00
2	15,000.00	2	22,000.00
3	16,000.00	3	23,000.00
4	17,000.00	4	24,000.00
5	18,000.00	5	25,000.00
5–10	18,000.00	5–10	25,000.00

To quantify the revenue of the producer, an average value of grape commercialization was used based on the values proposed by the State Center for Supply of Rio Grande do Sul (CEASA-RS). In this context, the grape yield was multiplied by the average sales value, which was BRL 2.50 for the grape produced without plastic covering and BRL 3.00 for the grape produced under the plastic covering, in order to obtain the revenue for each production system studied. The difference in the commercialization price in the two evaluated systems is related to the commercialization time, since the system with the use of plastic covering allows for production and commercialization outside the grape peak, and this results in a higher commercialization value of this system.

To calculate the economic viability of cropping systems with and without plastic covering, the minimum attractiveness rate used was 3.5%, which corresponds to the current Selic rate [22]. To obtain the cash flow of the productive years, the estimated costs and revenue for each year during the 10 years were used.

Data were organized in electronic spreadsheets in Microsoft Excel. For the economic viability analysis, the economic indicators analyzed were net present value (NPV), internal rate of return (IRR), payback period (PP), and profitability rate (PR).

In addition to the economic feasibility analysis based the 10-year cycle, a specific analysis was also carried out considering only the 2020/2021 production cycle with the data obtained by the grape producer in the two production systems studied. The data were presented in the results section separately.

2.3.1. Net Present Value

The NPV is an economic indicator of the feasibility of a project, it represents the calculation of the present value of the projected cash flow of an investment, in which all cash inflows and outflows are considered, being determined from the following Equation (1) [23]:

$$NPV = \sum_{n=1}^{n=N} \frac{FC_t}{(1+i)^n} - FC0 = \frac{FC1}{(1+i)^1} + \frac{FC2}{(1+i)^2} + \ldots + \frac{FC_N}{(1+i)^N} - FC0 \quad (1)$$

where NPV = net present value, FCN = cash flow return, on date t, considering t in years, ranging from 1 to N; FC0 = initial investment; and i = cost of capital.

When applying the NPV for decision-making, it is understood that if the value is positive, the project is economically viable and must be accepted. If the NPV = 0, the project will have no value to add to the company, but returns the investor's expected gain, being considered accepted; but if the NPV is negative, it should not be accepted [24].

2.3.2. Internal Rate of Return

The value obtained by calculating the IRR characterizes the rate of return on invested capital [24]. The IRR is obtained through the projected cash flow, with no need to set a value for the discount rate (interest) being determined according to the Equation (2):

$$IRR = \sum_{t=1}^{n} \frac{FCt}{(i+1)^t} = 0 \quad (2)$$

where IRR = internal rate of return; i = rate of return; FCt = cash flow over time; and t = discount time for each cash entry.

In an investment decision, it is considered that if the value of the IRR is greater than the value of the cost of capital, the project is economically viable. If it is inferior, the project is rejected, as it will not create value [24].

2.3.3. Payback Period

Payback is an indicator that defines the period necessary for the profits of an investment to recover the capital that was invested [24]. The payback analyzed in this study took into account the cost of money over time, as indicated in Equation (3):

$$I = \sum_{t=1}^{t} \frac{FCt}{(1+K)^1} \quad (3)$$

where I = initial capital invested; FCt = cash flow in time period t; K = cost of capital; and t = time to recover the invested capital.

2.3.4. Profitability Rate

The rate of profitability is measured by the ratio between the present value of net operating cash inflows and outflows. In practice, it indicates the return obtained by the company for each BRL 1.00 invested. All results are expressed in values updated by the minimum attractiveness rate, being determined according to the Equation (4):

$$PR = \frac{\sum_{j=1}^{n} \frac{FCj}{(1+i)^j}}{abs(FC_0)} \quad (4)$$

where PR = profitability rate; FCj = cash flow in period j; i = interest rate; j = analyzed time period; n = number of periods; and FC_0 = cash flow for year 0.

2.4. Grape Yield and Quality Assessments

Yield and quality evaluations were carried out at the time of grape harvest in the different treatments evaluated. Yield was determined by the average mass of bunches obtained at harvest and by counting the number of bunches per plant. The quality assessment was performed by determining the total solids content, which indicates the sugar content of the grape. Therefore, 100 grape berries of each cultivar were collected; specifically, 25 berries per replicate of each cultivar for the plots cultivated with and without plastic covering, totaling 400 berries. The sampling for the evaluation was when the grape was ready for harvest, based on characteristics such as color, sweetness, and the experience of the producer. The grapes without plastic covering were the first to reach the point of harvest, and in this way, the evaluation of the two cultivars in the systems with and without plastic covering was carried out.

After the berries were crushed and the juice was filtered, a refractometer was used to read the concentration of the total soluble solids (TSS, composed mainly of sugars) in the berry juice, expressed as °Brix [25].

2.5. Statistical Analysis

The economic viability data were organized and analyzed using the Excel platform. For grape quality data: Brix degree, analysis of variance was performed, and when significant differences were detected, the means were evaluated by Tukey's test at a significance level of 5% ($\alpha = 0.05$). Analyses were performed using the R statistical software package [26].

3. Results and Discussion

3.1. Economic Viability of Production Systems with and without Plastic Covering

The results presented in Tables 2 and 3 relate the costs of the stages of vineyard planting, establishment, and seasonal management of the grape cultivated during a 10-year production cycle in systems without and with plastic covering, respectively.

Table 2. Total cost of vineyard planting, establishment, and seasonal management of 1 hectare of cv. Niagara Branca and Niagara Rosada cultivated with a traditional system without plastic covering.

Annual Production Cost	Vineyard Planting (BRL) First Year	Vineyard Establishment (BRL) Year 2–5	Vineyard Seasonal Management (BRL) Year 6–10
Wood structure	25,000.00	-	-
Wire	25,000.00	-	-
Labor—trellis installation	5000.00	-	-
Grape seedlings	25,000.00	-	-
Labor—vine planting	1800.00	-	-
Base fertilization and soil correction	3000.00	-	-
Annual fertilization	-	2000.00	2000.00
Phytosanitary treatments	-	957.00	957.00
Labor—cultural treatments	2000.00	7000.00	7000.00
Total	86,800.00	9957.00	9957.00

The costs of the traditional cultivation system of the vineyard during the 10-year cycle can be seen in Table 2. The vineyard planting was performed in 2018 and had an initial investment of BRL 86,800.00. This value was higher than that described by other authors, such as [27–29], who reported a cost of approximately BRL 60,000.00 for the installation of 1 hectare of vines. The higher vineyard planting cost described in this study may be related to price differences in the market for materials used for installation, vines, and labor. However, maintenance costs were approximately BRL 10,000.00, a value close to those obtained by other authors [27–29].

The total costs for vineyard planting, establishment, and seasonal management for the plastic cover cropping system can be seen in Table 3. The initial investment to install this system was BRL 171,800.00, much higher than that assessed for the traditional system without plastic cover. The main difference was due to the cost of the plastic cover, which was BRL 85,000.00. It is important to highlight that there may be differences in value depending on the type of material and the supplier from which the plastic cover was purchased.

In addition, it is possible to observe in Table 3 that the establishment and seasonal management costs, referring to years 2 to 10, were higher in the system with plastic cover. This is due to the greater amount of labor required in this system. In this system, constant pruning of the branches and leaves that grow out of the plastic cover is necessary. Additionally, the need to change the plastic cover was considered, and its useful life can vary from 3 to 5 years.

Table 3. Total cost of vineyard planting, establishment, and seasonal management of 1 hectare of cv. Niagara Branca and Niagara Rosada cultivated with a system with plastic cover.

Annual Production Cost	Vineyard Planting (BRL) First Year	Vineyard Establishment (BRL) Year 2–5	Vineyard Seasonal Management (BRL) Year 6	Vineyard Seasonal Management (BRL) Year 7–10
Wood structure	25,000.0	-	-	-
Wire	25,000.0	-	-	-
Labor—trellis installation	5000.0	-	-	-
Plastic cover	85,000.0	-		
Grape seedlings	25,000.0	-	-	-
Labor—vine planting	1800.0	-	-	-
Base fertilization and soil correction	3000.0	-	-	-
Annual fertilization	-	2000.0	2000.0	2000.0
Phytosanitary treatments	-	261.0	261.0	261.0
Labor—cultural treatments	2000.0	9000.0	9000.0	9000.0
Cover plastic replacement	-	-	40,000.0	-
Total	171,800.0	11,261.0	51,261.0	11,261.0

However, in the system with plastic cover, the grape producer has a lower cost for phytosanitary treatments. In the 2020/2021 crop season, a total of 11 applications of fungicide were performed in the traditional system, totaling a cost of BRL 957.00, while in the system with plastic cover, only three applications were performed, generating a cost of BRL 261.00. This reduction in the application of chemical pesticides is related to the protection from rain with a consequent reduction in free water on the leaves and bunches, which results in a reduction in the incidence of diseases. Additionally, a previous study [14] reported a decrease of 57.5% in the incidence of botrytis bunch rot, 89.5% for grape ripe rot, and 84.5% for acid rot due to plastic covering, which allows the reduction in the use of fungicides. Moreover, reducing the use of chemical pesticides in the area with plastic covering can promote more sustainable production, reducing environmental risks and the risk of contamination for the producer.

The results obtained show that the costs of vineyard planting, establishment, and seasonal management in the system with plastic covering are higher than those produced in the traditional system, with a difference of approximately 55%, considering each grape production cycle. However, besides these costs, the grape producer should also consider the difference in grape productivity when using plastic covering or not.

The grape yield was evaluated in the 2020/2021 crop season when the vineyard of both systems was in the second year of production. It was possible to observe that the yield was higher in the system with plastic covering, which reached 22,000 kg ha^{-1} (Table 4). In the system without plastic covering, the yield was 15,000 kg ha^{-1}, showing a decrease of approximately 32%.

The higher yield obtained in the production system with plastic covering could be related to the more favorable micrometeorological conditions [9], mainly to a lower impact of adverse weather conditions such as excessive rainfall. In addition, the cover changes the intensity and quality of light due to the photo-selective and light-dispersive capacity of the plastic material [30], which could allow a more favorable solar radiation condition for grape production. In addition, air temperature and humidity are modified in the covered environment [31,32]. Changes in micrometeorological conditions caused by cover directly influence plant physiology and morphology [33], as well as affect the production system as a whole [34], including grape quality [8,31].

Table 4. Yield, average commercialization price, and revenue obtained for 1 hectare of the cultivars Niagara Branca and Niagara Rosada produced with a system without plastic covering and with plastic covering in the 2020/2021 crop season.

System without Plastic Cover			
Grape	Yield (Kg ha^{-1})	Average commercialization price (BRL Kg^{-1})	Revenue (BRL ha^{-1})
Niagara Branca and Niagara Rosada	15,000	2.50	37,500.00
System with Plastic Cover			
Grape	Yield (Kg ha^{-1})	Average commercialization price (BRL Kg^{-1})	Revenue (BRL ha^{-1})
Niagara Branca and Niagara Rosada	22,000	3.00	66,000.00

Studies carried out in different regions of Brazil with different grapevine cultivars grown with different production systems observed higher grape yield in systems with plastic cover. The authors reported higher grape yield under plastic covering for the cultivar Moscato Giallo in Flores da Cunha-RS [35] and in cultivar BRS Morena in Jales-SP [9].

The average price obtained for the grapes produced in the plastic cover system was higher, which resulted in higher total revenue (Table 4). The grape bunches produced under plastic covering showed higher visual quality, both in the size of the berries and in the appearance of the bunch, which allowed the producer to market this grape at a higher price. In addition, another factor that can benefit for the increase in the price of commercialization of the grape is the delay of 6 to 7 days in the harvest, provided by the delay in the maturation of the grapes in the system with plastic cover. This fact allows the producer to offer the fruit for a longer time and outside the production peak. At the peak of production, due to the high supply of grapes, prices tend to decrease. In previous studies [36–39], it was observed that the use of plastic covers modifies the commercialization period, and strategies to improve the commercialization time were adopted by grape producers.

Results of risk and return on investment indicators for grape production systems with and without plastic covering are presented in Table 5.

Table 5. Risk and return on investment indicators for 1 hectare of grape cultivated in a system without plastic covering and with plastic cover.

Indicators	System without Plastic Cover	System with Plastic Cover
Net present value (BRL)	171,625.48	291,933.20
Internal rate of return (%)	29	29
Profitability Rate (BRL)	2.98	2.70
Payback period (years)	3.69	3.46

It is possible to observe that the covered system allowed an increase in NPV by 70% with respect to the traditional system (Table 5). Thus, although the NPV of both systems showed a good viability of the investment, that of the system with plastic covering was higher, showing a greater return for this system. In a previous study [29], a positive NPV above BRL 200,000.00 was reported, highlighting the viability of grapevines cultivated under plastic cover. The higher NPV for a production system results in higher economic viability, which indicates that the grape production system with plastic covering has great economic viability, being higher than the traditional system.

The internal rate of return was +29% of the amount invested for the two systems and higher than the minimum rate of attractiveness, indicating that, in both cases, the investment was profitable. For every 1.00 invested, BRL 2.98 was returned in the traditional system and BRL 2.70 in the plastic-covered system, as indicated by the profitability rate.

The payback period was similar for both systems and indicates that the time to recover the initial investment was approximately 3.5 years.

Based on the results presented in Table 5, it is possible to affirm that both production systems are economically viable. However, the system with plastic cover, in addition to presenting a higher NPV, allows the producer to have greater security in grape production. This security is related to the frequent occurrence of extreme events in the study region, such as excessive rain during the maturation/harvest period, hail fall, and frost. This greater safety in production is not considered in the economic feasibility analysis. Moreover, another important factor to be considered is the reduction in the use of chemical pesticides to control diseases.

3.2. Grape Quality in Systems with and without Plastic Cover

The results related to the grape quality, assessed by the Brix degree of the beery juice of grapes produced in a traditional system and with plastic cover, are shown in Figure 1.

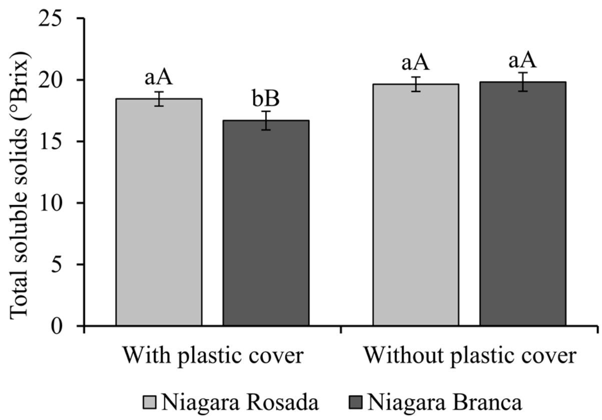

Figure 1. Total soluble solid concentration in berry juice of cultivar Niagara Rosada and Niagara Branca produced with plastic covering and without it (values corresponding to histograms with the same letter do not differ from each other, by Tukey's test, at 5% error probability. Lowercase letters compare the production systems with and without plastic covering and uppercase letters compare the cultivars within each system).

It is possible to observe in Figure 1 that the average contents of total soluble solids for the two cultivars and the two production systems were higher than 15 °Brix. In Brazil, this value is considered adequate for grape commercialization, either for direct consumption or for vinification. In addition, it is possible to observe a significant difference in TSS between cultivars and between cultivation systems. The cultivar Niagara Branca showed the lowest TSS concentration with an average value of 16.69 °Brix when cultivated under plastic cover, differing from the cultivar Niagara Rosada, which showed an average value of 18.45 °Brix. Additionally, a significant difference was observed between production systems in the case of the cv. Niagara Branca: the highest values were observed for the traditional system compared to the system with plastic cover.

The lower °Brix values observed for the plastic-covered production system could be explained by two main factors. The first one is related to the reduction in solar radiation that reaches the plant in this production system, since solar radiation is essential for the maturation process and sugar accumulation in the fruit. In previous studies [40–44], it was observed that the use of plastic covering modifies important factors of vineyard microclimate, reducing the photosynthetically active radiation incident available for the plants, the wind speed, the diurnal relative humidity, the reference evapotranspiration, and increasing the air temperature: these facts may affect the accumulation of sugar in the fruit. In the present study, lower levels of TSS could be attributed to the lower availability of radiation provided by the plastic cover. The second factor that influenced the TSS of the grape produced in the plastic-covered system is related to the period of the ripening and harvesting of the fruits. In the system without plastic cover, maturation occurs naturally, in the production system with plastic cover, there may be a delay in grape maturation and accumulation of sugars as observed by other authors [39–42]. This same result was observed by [44], who reported that grapes grown in the system without plastic covering reached ripeness earlier than the system plastic covering. This delay in maturation may be related to the interference in the physiological process, possibly due to the decrease in solar radiation.

The results obtained in this study demonstrate that there is variation in some aspects of grape quality as a function of the cultivar and the production system. However, the °Brix of the berry juice of cultivar Niagara Rosada did not differ significantly in the production systems with and without plastic covering, and in addition, it presented high °Brix values with respect to Niagara Branca, which was interesting for the moment of grape commercialization. This information is important for grape producers, especially in terms of choosing the cultivar to be used for the implementation of a new vineyard under plastic cover. In this context, it is recommended, based on the information obtained in this study, to use the cultivar Niagara Rosada for production in a system with plastic cover.

4. Conclusions

The results and information presented in this study are important for planning and decision-making by grape producers. The use of a plastic-covered production system requires care and planning, especially concerning investment cost.

The cultivation of Niagara Branca and Niagara Rosada grapevine in a plastic-covered system presented a higher cost with the initial investment and seasonal management when compared to the traditional system. However, the use of plastic covering made it possible to increase grape yield and allowed the supply of fruit outside the peak of supply, increasing its value in commercialization. Despite the high cost of the initial investment and further management, when observing the return indicators, the grape cultivation in the system with plastic covering presented a higher NPV at the end of 10 years than in the traditional system, indicating greater profitability of this system. In addition, the other indicators studied in this trial showed values that confirm that the cultivation of grapes in a system with plastic covering is viable.

The use of plastic covering influenced the quality of the grapes, especially for the cultivar Niagara Branca, which presented a lower content of total soluble solids when compared to the traditional system. However, this fact is not limiting, since the values obtained were higher than 16 °Brix, which is considered adequate for grape commercialization.

This study sought to provide alternatives for the development of a more economically viable grape production system in order to produce grapes in a safer way (i.e., protection against hail and excessive rain), in addition to allowing for the reduction in the use of chemical pesticides due to the use of plastic covering, which enables more sustainable production with lower environmental risks. In this context, the use of plastic covers for grape production is recommended, mainly due to the economic viability and grape yield.

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