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## RESEARCH ARTICLE

# Technical and Economic Efficiency of Vine Pruning: Results of Experimental Trials of Some Cultivars of Grapevine Grown in Sicily and Determination of Break-even Point

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**Abstract:** The research presents the results carried out on Sicilian viticulture in order to study the economic sustainability of the agricultural company. In particular, the author examined the operation of dry pruning and tying of the fruiting head in espalier vineyards with tools that facilitate the work. The economic analysis highlights that equipping yourself with mechanical tools that facilitate work is convenient for both large and small wineries. The results of the research highlight that the investment to facilitate pruning and tying in Guyot-trained vineyards can also be made by wine-growing companies and is increasingly convenient as the area under vines involved increases.

**Keywords:** Vineyard pruning; Production cost; Competitive advantage

## 1. Introduction

The Italian wine production structure, as evidenced by the statistical data, is highly fragmented. In fact, the 383,648 farms (ISTAT, 2022) with an average area of 1.6 hectares <sup>[1]</sup>. For micro-enterprises, which produce an undifferentiated product, achieving a level of total unit cost lower than that of competitors is the only way to achieve a competitive advantage. In fact, for the same selling price

of the grapes, producing with lower average unit costs than competitors allows the company to improve the profit margin and be competitive in the market <sup>[2]</sup>. This situation is reflected in the company's financial structure and investment capacity. Furthermore, the increase in the net margin allows the firm to increase its self-financing capacity and consequently the remuneration of the production factors. An increase in sources of financing can, in any case, represent the driving force to start a process of growth in the

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size of companies, which in the long run allows them to establish themselves on the market with a new product compared to their competitors, also creating a differentiation advantage <sup>[3,4]</sup>. Today in developed economies the high production costs, first and foremost that of labour, do not allow wineries to be competitive. This situation also reflects the lack of generational turnover in the company, which sees the disappearance of the wine-growing companies where the work contributed by the farmer's family was the majority. Therefore viticulture without machines that facilitate some cultivation operations can no longer represent a source of competitive advantage. Our research question is: how to succeed in lowering production costs in vineyard management? To answer this question, we saw that one of the possible operations on which to intervene to lower costs is pruning and subsequent tying of the fruiting head. Today the mechanical industry makes available to winemakers a series of equipment and machines that allow a significant reduction in working times and therefore a reduction in production costs. This work aims to analyze how production costs change in wineries that introduce shears and electric tying machines into the company structure. These investments do not involve a large monetary outlay and can be made by the vast majority of wineries, even small ones. However, before their implementation it is important to know if the investment is convenient and, if so, the benefits deriving from the introduction of process innovation in the farm. Costs were estimated by comparing: a) pruning with shears and subsequent manual tying of productive shoots (manual pruning); b) pruning and tying of productive shoots using electric shears and an electric tying machine, respectively (facilitated pruning). Moving from hypothesis (a) to hypothesis (b) results in a reduction in costs.

## 2. Competitive Strategies to Reduce Production Costs

In developed economies, the achievement of a competitive advantage appears essential for companies and for the territory where they operate. Achieving this competitive advantage requires entrepreneurs to be innovators. In reality, in agriculture there are few innovative entrepreneurs and many imitators of innovations, i.e. they let others experiment with them and if they work, they imitate them. For small and medium-sized agricultural enterprises, which are the majority, it is difficult to implement innovations as they do not have sufficient means to carry out research and development. However, for those, who are subjected to the prices imposed by the operators downstream of the supply chain, it becomes of fundamental importance to achieve a cost advantage where by keeping

revenues unchanged, profit margins improve <sup>[5]</sup>. Firms that innovate first achieve a competitive advantage and have a chance to be competitive until others imitate the innovation <sup>[6]</sup>. If the company reaches a cost advantage, it can decide to reduce the level of the selling price of its offer which, while remaining above the average cost, attracts customers from other farms. In the territory, competing companies that do not adopt innovation systems are destined to lose market shares in favor of companies that have innovated. These farms can have a cost of production equal to marginal revenue or a cost of production greater than marginal revenue. In the first case, they are marginal firms, in the second case, they suffer losses for each unit of production <sup>[7]</sup>. The advantage achieved by the leading cost company, if lasting, is capable of sweeping the others from the market in the medium-long term <sup>[8]</sup>. This situation has repercussions on the financial structure and investment capacity of the farm. The higher margin that the leading agricultural company reaches allows it, on the one hand, to have greater savings and therefore greater self-financing and, on the other hand, a higher return on the invested risk capital. In the first case, the firm increases the size of its equity capital and therefore, with the same leverage effect, the stock of debt capital it can acquire. In this case, banks will be more inclined to lend to these companies, as they have a high degree of self-financing and the ability to repay the borrowed capital. In the second case, the conditions are created for a possible acquisition of new risk capital and therefore to expand the production capacity of the farm or to renew the machinery. In general, in both conditions, process innovation allows for an increase in the profit margin which is reflected in an increase in the available financial resources of the farm. As previously mentioned, considering that in the rural world, the majority of farms are small in size and have high production costs and low selling prices for agricultural products (they are affected by the decisions imposed by operators downstream of the supply chain who often operate in oligopolistic markets such as in the case of wineries or large-scale retail trade) this situation could represent a way to achieve a cost advantage <sup>[9]</sup>. This aspect is important in those territorial contexts where agriculture represents the main economic activity and therefore the competitive advantage of companies represents a way to curb agricultural and rural exodus phenomena and therefore desertification phenomena. The extreme fragmentation of Sicilian wineries, which very often combines with corporate fragmentation phenomena, penalizes the achievement of competitive advantage and the degree of innovation. In fact, we are witnessing the fact that most of these wineries, unlike before when the production chain was closed

within the company, deliver the grapes directly to the cellar, while less than a hundred (usually medium-large companies) transform and bottle their own products<sup>[11,12]</sup>. From an economic point of view, the productive specialization has determined that the low prices of the grapes imposed on the winegrowers do not allow to remunerate the factors of production. In the second case (large companies), having companies of a certain economic size that produce a bottled product, a differentiated product, such as wine, makes it possible to increase the added value of the farm.

### 3. Materials and Methods

Pruning, carried out in the month of January when the vine is in the dormant phase, involves the removal of all the shoots except the fruiting head which is subsequently tied to the galvanized wire of the espalier. The economic analysis, to identify the minimum optimal size that the company must have to invest, was carried out in Sicily considering the data on a winery located in the province of Trapani. The business reflects the majority of businesses in the area, both in terms of vineyard management methods and entrepreneurial orientation<sup>[12-14]</sup>. The data collection took place in March 2023 via questionnaire and direct interview with the entrepreneur. The cultivars taken into consideration are Nero d'Avola, Merlot, Syrah, and Chardonnay, trained on the espalier system with a density of around 5,000 plants/hectare and with Guyot pruning.

The test compared the costs of pruning in two different ways:

- a) pruning with shears and subsequent manual binding of the productive shoots (manual pruning);
- b) pruning and tying of the productive branches using respectively electric shears and an electric tying machine (facilitated pruning).

All the cost items that the winegrower must bear for pruning in the two execution methods (manual and facilitated) were therefore considered. The total cost for pruning is given by the sum of the fixed and variable costs. Fixed costs include the reintegration of agricultural capital and interest on it. Variable costs, on the other hand, are represented by maintenance, electricity, labor, the expense of twine or tube for tying, and interest on the advance capital<sup>[15,16]</sup>. The total unit cost is given by the fixed costs related to the number of hectares of vines on which the intervention is carried out, to which are added the variable costs referring to each hectare of vines that undergo the intervention. Subsequently, the minimum surface area was estimated—break-even point—which makes the cost of manual pruning equal to the facilitated one. By comparing the fixed and variable costs of the two pruning execution hypotheses, it is possible to find the break-even point, i.e.

the vineyard area for which the cost of manual pruning (hypothesis a) is equal to that of facilitated pruning (hypothesis b). The break-even point is obtained by solving the following equation:

$$Cfa/x + Cva = Cfb/x + Cvb \quad (1)$$

from which:

$$x = (Cfa - Cfb)/(Cvb - Cva) \quad (2)$$

where:

Cfa = annual fixed costs assumption a;

Cfb = annual fixed costs hypothesis b;

Cva = variable costs per hectare of vineyard area hypothesis a;

Cvb = variable costs per hectare of vineyard area hypothesis b;

x = break-even point (hectares of vineyard area).

The break-even point refers to the choice of the pruning and tying operation of the fruiting head. This methodology allows us to determine and measure the cost advantage and to carry out the appropriate microeconomic assessments for companies in terms of production, sales, and marketing strategies<sup>[17-19]</sup>.

### 4. Results and Discussions

The pruning and tying costs were calculated according to the methodology set out above, distinct for the two hypotheses examined. Comparing the two hypotheses, in the case of the Nero d'Avola cultivar the total unit cost amounts to 1,046.33 euros/hectare for manual pruning (hypothesis a), against 1,127.62 euros/hectare for facilitated pruning (hypothesis b). For Merlot, the values are respectively 1,052.61 euros/ha compared to 1,149.21 euros/hectare. For Syrah, the values are 1,130.28 euros/hectare and 1,239.39 euros/hectare. Finally, for Chardonnay, values respectively equal to 992.86 euro/hectare and 1,113.59 euro/hectare are recorded. The differences between the four cultivars studied, considering that the density of plants per hectare is homogeneous, can be attributed to the greater vigor that the black berried cultivars have compared to the Chardonnay which translates into a greater need for work for cutting the shoots. Total unit costs for manual pruning decrease irrelevantly, as the hectares of vineyards increase since most of them are made up of variable costs which are constant for each hectare of surface subjected to pruning and binding. The total unit costs of facilitated pruning, on the other hand, undergo a significant reduction depending on the vineyard area pruned. In this case, the fixed costs—which in the case of manual pruning are equal to 7.07 euros—assume a certain importance, depending on the monetary outlay incurred by the entrepreneur to invest, and are equal to 401.00 euros. For the four cultivars exam-

ined, the break-even points, which justify the investment in the company, are respectively equal to 1.26 hectares for Nero d'Avola; 1.32 hectares for Merlot; 1.38 hectares for Syrah and 1.44 hectares for Chardonnay. In the latter case, the minimum optimal size is greater than in the other cultivars due to the lower work requirement. Given the break-even points, therefore, it is clear that the investment to facilitate pruning and tying in Guyot-pruned vineyards can also be made by companies smaller than 2 hectares in size. In the light of these results, we have measured the real decrease in pruning costs which derive above all from the reduction in working times and therefore from the relative cost. The transition from manual pruning (hypothesis a) to facilitated pruning (hypothesis b) in the case of vineyards equal to the minimum optimal size determined makes it possible to reduce the labor cost item by 32% in Nero d'Avola, by 30.6% in Merlot, 27.6% in Syrah and 29.3% in Chardonnay. This decrease is directly reflected in the item "interest on advance capital", resulting in an overall decrease in variable costs per hectare. As the vineyard area subjected to pruning increases, it will always be more convenient to operate with hypothesis b) compared to a). In fact, in companies with a vineyard area of 5 hectares for the Nero d'Avola cultivar, the reduction in the total costs of pruning and binding is 22.5%, for Merlot it is 20.9%, for Syrah it is 18.3%, while for Chardonnay there is a reduction of 19.7% (Table 1).

**Table 1.** Total costs for pruning of vineyards and tying of productive shoots in wine-growing farms with a vineyard area of 5 hectares.

	Nero d'Avola	Merlot	Syrah	Chardonnay
<i>a) Manual pruning and tying hypothesis</i>				
costs	5,203.27	5,234.77	5,623.12	4,936.02
<i>b) Hypothesis of pruning and tying in a facilitated way</i>				
costs	4,034.10	3,821.25	4,592.95	3,963.95
Variazione (%) b/a	-22.5	-20.9	-18.3	-19.7

Compared to previous studies, where we talk about bringing together different companies to make significant investments to reduce costs (purchasing machines together), this research highlights that even small wine-growing companies can make investments on their own that reduce production costs<sup>[20]</sup>. This work, compared to previous studies<sup>[21]</sup>, is new as it is suitable for current cost conditions. In the validity of this research, one of the limits is the market conditions as the assessments were made according to the market conditions of 2023. As the conditions change, the indicators clearly change.

## 5. Conclusions

In viticulture, as well as in many sectors of Italian agriculture, the ability to contain production costs represents an indispensable choice for the company. The lowering of the average cost allows the company to arrive on the market with a price (always higher than the average cost) lower than that of its competitors, who are destined to lose market shares in favor of the company that produces at lower costs. The exploitation of economies of scale and the accumulation of experience allow the company that has managed to lower the total unit costs to activate a growth process which, in the medium-long term, leads it to cover an economic-productive position of leader in the sector in which it also operates from a supply chain perspective. In addition to creating a competitive advantage for the company, this condition promotes the development of the territory, encourages investment, and creates income and employment. The modest prices of the grapes, which in recent agricultural years have characterized the wine grape market, combined with high corporate fragmentation, determine a crisis in the wine sector. Intervening on pruning costs through the use of tools that facilitate the work represents a way forward both for large companies and above all for small and medium-sized wine-growing enterprises, which make up the vast majority of the production structures of Italian viticulture. Ultimately, process innovation allows the company to recover competitiveness margins and remain competitive in the market.

## Author Contributions

The research was done by Filippo Sgroi and Federico Modica. Filippo Sgroi wrote Sections 2, 3, 4, and 5, and Federico Modica collected the data and wrote Section 1 (Introduction).

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## Data Availability

The data presented in this study are available on request from the corresponding author.

## Conflict of Interest

The author disclosed no conflicts of interest.

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