Mechanized grape harvesting in Brazil: An agronomic view and new challenges

Colheita mecanizada de uva no Brasil: uma visão agronômica e novos desafios

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ABSTRACT
Mechanized grape harvesting in Brazil, although considered a strategy that can optimize the vine's production chain in the country, still raises questions about losses, damages, profitability and quality of the harvested berries. Thus, it is important to compile information available on the scarce state of the art on mechanized grape harvesting and make it available to horticulturists, scientists and industries. Therefore, this review provides an overview of the mechanization process of the grape harvest and its relationship with the establishment of managements that allow enhancing this practice. Here, we report the evolution of mechanized grape harvesting, the use and functioning of self-propelled harvesters and the challenges of mechanized harvesting. This will allow us to propose new lines of research for future investigations.

Keywords: *Vitis vinifera* L., self-propelled harvester, topography, conduction system.

RESUMO
A colheita mecanizada de uva no Brasil, embora considerada uma estratégia que pode otimizar a cadeia produtiva da videira no país, ainda gera questionamentos sobre perdas, danos, rentabilidade e qualidade dos grãos colhidos. Assim, é importante compilar informações disponíveis no escasso estado da arte sobre a colheita mecanizada de uvas e disponibilizá-las a horticultores, cientistas e indústrias. Portanto, essa revisão fornece uma visão geral do processo de mecanização da colheita de uvas e sua relação com o estabelecimento de manejos que permitem potencializar essa prática. Aqui, reportamos a evolução da colheita mecanizada de uva, o uso e funcionamento de colhedoras autopropelidas e os desafios da colheita mecanizada. Isso permitirá propor novas linhas de pesquisa para futuras investigações.

Palavras-chave: *Vitis vinifera* L., colhedora autopropelida, topografia, sistema de condução.

1 INTRODUCTION

The cultivation of grapes (*Vitis vinifera* L.), originally from the Mediterranean, has expanded worldwide and represents a profitable enterprise (SPINELLI et al., 2012). This expansion of cultivation inserted the vine in 7.2 million hectares worldwide (FAO, 2018). In Brazil, the cultivated area is 75 thousand hectares and the state of Rio Grande do Sul (RS) occupies the first place in the productivity ranking, with production of approximately 667 thousand tons in a planted area of 47.5 thousand hectares (COSTA NETO et al., 2017).

Planning and establishing vineyards is not a simple task. Many factors influence the horticultural performance of the grapevine, including the edaphoclimatic conditions (soil, temperature, solar radiation) (MIRANDA et al., 2020) and the management performed (topography, cultivar, conduction system, planting density, irrigation, pruning, harvest) (CREASY, 2017). Specifically in the latter case, one of us (Trentin, N.S.) worked directly with this horticultural crop and reported that one of the difficulties of the viticultural chain in Brazil is the lack of qualified labor to carry out these managements and cultural treatments and, among them is the grape harvest.

The harvesting of the berries, which consists of their removal from the mother plant (DURNER, 2003), can be done manually or mechanically. The choice of the harvesting method is linked to the availability of labor and financial resources, the topography of the cultivation site, the system of conducting the vineyards and the quality of the product (these factors will be discussed in the next sections of our work). For fresh consumption, the grapes must be handled delicately, preserving their serosity. Thus, the fruits are harvested manually, added in containers and sent to the consumer market (CREASY & CREASY, 2012). For the production of sparkling wine, for example, manual harvesting is mandatory because the fruits must be intact before processing begins; otherwise, strong phenolic compounds can be extracted from rachis and bark (DOMINGUES & AGUILA, 2016). However, grapes intended for the juice industry and winemaking can be harvested mechanically. In the last case (winemaking), the breaking of the fruit peels and their mixing with the juices help to extract the desired compound (CREASY & CREASY, 2012).

Despite being considered a strategy that can optimize the vine production chain in Brazil, mechanized grape harvesting is a recent practice in the country and its effects on vineyards are beginning to be understood. Compiling information available on the scarce state of the art on mechanized grape harvesting and making it available to horticulturists, scientists and industries will allow us to know where we are and where we can go. Thus, this review provides an overview of the mechanization process of grape harvesting and its relationship with the establishment of managements that allow to enhance this practice. Here, we cover the evolution of mechanized grape harvesting, the use and functioning of self-propelled harvesters and the challenges of mechanized harvesting. This will allow us to propose new lines of research for future investigations.

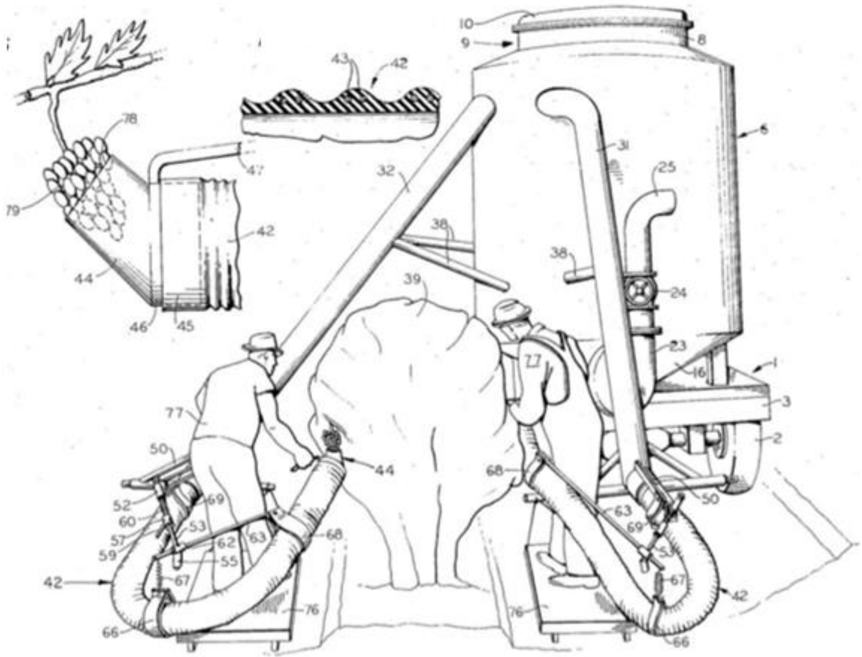
2 EVOLUTION OF MECHANIZED GRAPE HARVESTING

The main objective of introducing mechanized grape harvesting is to reduce the need for workforce and reduce annual costs. However, the initial costs necessary to introduce mechanized harvesting are high (JOBBÁGY & FINDURA, 2013; PEZZI & MARTELLI, 2015).

The concern with developing machines to replace manual harvesting is not a recent one. In 1953, the University of California, United States of America (USA), presented the first concept of a machine designed to harvest grapes. It was a coupled mechanism to an agricultural tractor, with a truss-cutting bar (in T) responsible for the extraction of grape clusters (ELORZA, 2009). Four years later, in 1957, Cornell University, USA, proposed a low-amplitude, high-frequency vertical vibration harvesting system for harvesting grapes grown in an espalier system, a requirement for mechanized harvesting (JOBBÁGY et al., 2018).

In this evolution process, several machines were designed with different principles for harvesting grapes, which were not accepted by the market. It was in 1966 that the machine created by Joseph Gallo, with a suction system, stood out from the others (Figure 1).

Figure 1. Grape harvester created by Joseph Gallo.



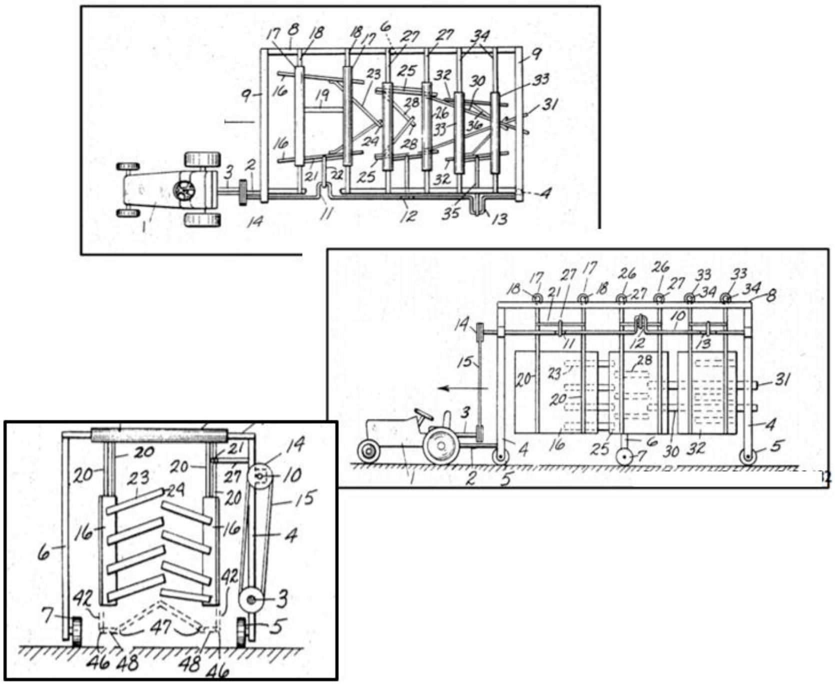
Source: Adapted from Morris & Brady (2011).

In 1969, the first harvester with trailed shaking rods was developed, designed by Joseph Ortin, from the Chisholm Ryder Company (Figure 2). The harvester was attached to an agricultural tractor activated by the power take-off and collector system that originated the shaking rods, which continue to be part of the current harvesters.

Based on this technology, several machines were launched with the same principle. In 1979, this practice continued in Europe, mainly in France. Due to the labor crisis in France, the process of importing from the USA has increased significantly, which has made the European country a new development hub with the manufacture of harvesters from emblematic companies in the agricultural sector such as Braud (now New Holland, CNH group), with first model sold in 1975, Gregoire (currently belongs to the Same Deutz-Fahr group) with first model in 1978, and Pellenc, with model sold in the early 90s (ELORZA, 2009).

In Brazil, the first grape harvester was acquired in 2010 by the Almadén winery (Miolo group), located in the municipality of Santa do Livramento (30º 53 ’27” S, 55º 31 ’58” W), RS. In 2016 there were only four harvesters active at national level (three towed and one self-propelled), all belonging to two wineries (COSTA NETO et al., 2017).

Figure 2. First grape harvester with shaking stems.



Source: Adapted from Morris & Brady (2011).

3 USE OF SELF-PROPELLED HARVESTERS

The companies Gregoire (Figure 3 A) and New Holland (Figure 3 B) remain the leaders in the production of self-propelled machines for grape harvesting. In countries like France, Germany, Australia, Austria, Italy, South Africa and Spain, self-propelled harvesters carry out 50 to 90% of the grape harvest (NOVAK & BURG, 2013).

Figure 3. Self-propelled grape pickers. A) Gregoire. B) New Holland Brauda 9060L.

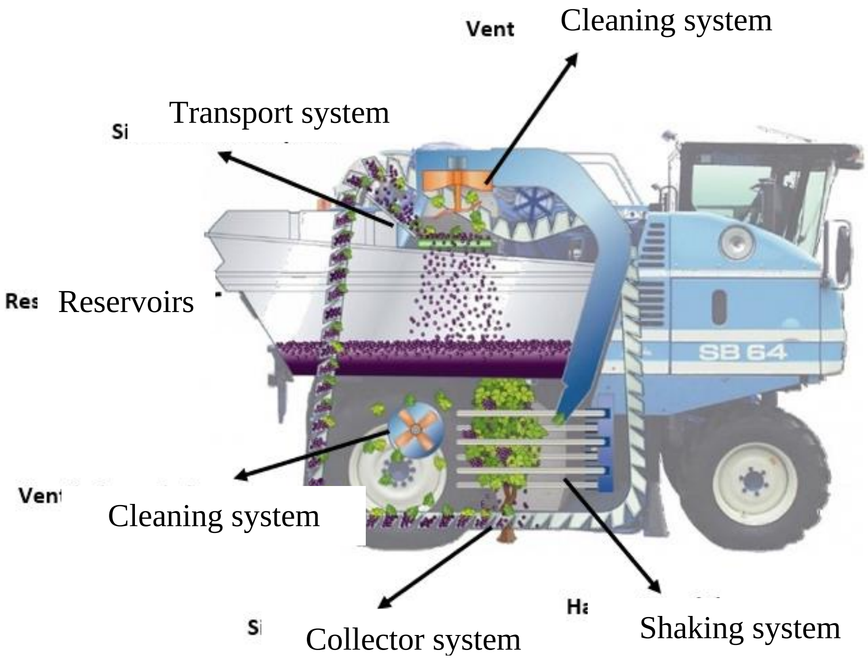
B)

Source: Mogorrón, H. C.

The basic elements that all self-propelled harvesters have in common are: shaking system, collecting system, transport system, cleaning system, reservoirs and cabin (Figure

4). The shaking stems detach the berries from the clusters, which fall on the collecting system that takes the grapes to the transport system and, later, to the reservoirs. During this process, the harvester has fans to remove materials lighter than the grape (Figure 4).

Figure 4. Self-propelled harvester systems.



Source: authors.

Although they represent a gain for the wine chain in Brazil and world, self-propelled harvesters are not totally efficient in relation to the losses of grapes during the harvest. The main adjustments of these harvesters refer to the number of shaking rods, the amplitude and frequency of the vibrations of these rods and the travel speed of the machine (ELORZA, 2009).

The literature reports that the losses of grape grains to the soil are not influenced by the frequency of stem vibrations, for example. The losses are mainly due to the constructive characteristics of the machine and to the structural and physiological characteristics of the grapevine (PEZZI & CAPRARA, 2009). In the same survey, the authors indicated that the largest losses (from 1.9 to 3.8%) were caused by the cleaning system.

The performance of self-propelled harvesters is different depending on the brand and model of the machine. Novak & Burg (2013) investigated the performance of two self-propelled harvesters (Gregoire G 152 and New Holland VL 6060). The Gregoire G

152 harvester had a lower percentage of fall losses (0.8 to 1.45%) compared to the New Holland CL6060 (0.8 to 1.52%). However, the New Holland VL 6060 harvester showed a lower percentage of unharvested grain losses when compared to the Gregoire G 152.

Although the main objective of mechanizing the grape harvest is to reduce the need for labor, wine growers demand information about the costs of this investment to weigh their choices. Therefore, here we will show a study developed by Domingues & Aguila (2016) comparing mechanized and manual harvesting costs. The authors evaluated 154.9 hectares under mechanical harvesting and 366.7 hectares with manual harvesting and reported that the cost of manual harvesting was 133.3% higher than the value obtained for mechanical harvesting. The area of 41.92 hectares represented the balance point (equivalent costs) between the costs of manual and mechanical harvesting. Above this area, referring to the equilibrium point, the mechanical harvest of the grape is economically justified, indicating that producers can invest in the technology.

4 CHALLENGES OF MECHANIZED HARVESTING

The state of RS, Brazil, presents approximately 40.4 thousand hectares occupied by vineyards, distributed in 161 municipalities (MELLO & MACHADO, 2020). In this state, the main producing region is the upper slope of the northeast region, called "Serra Gaúcha", where viticulture is developed on small properties. From 1875 onwards, this region was colonized by Italian immigrants, who started vine cultivation (MANFIO, 2019). Over the years, the wine tradition has been maintained, the grape has become the main agricultural product and wine the maximum exponent of the local culture (PIEROZAN, 2019).

Vineyard management, such as mechanized harvesting, can be carried out more efficiently than manually. The use of machines not only completes practices at the right time, but also frequently reduces production costs, especially in the workforce (CAPRARA & PEZZI, 2011). For the management to be carried out by machines, the vineyards must be designed according to the operations of the machines. However, due to the rugged topography, the "Serra Gaúcha" vineyards are not very mechanized, with the predominant use of family labor. In addition, the predominant plant conduction system in this region is trellised. Therefore, the traditional practices of establishing vineyards, such as planting in narrow rows and using the trellis type conduction system, should be replaced by wide rows and the insertion of vineyards in an espalier system.

Due to these main limitations (topography and conduction system), viticulture in RS is expanding to new agricultural frontiers, such as the region of the western border of RS, called "Campanha Gaúcha". In this region, the flat topography and the conduction of vineyards in a espalier system allow the use of mechanized technology during the grape harvest, which contributes to potentiate the cultivation of the vine. For this reason, the most mechanized vineyards in Brazil are concentrated in the "Campanha Gaúcha".

The interaction between the machine and the grapevine is one of the most promising lines of research to improve the performance of grape pickers. The machine-plant relationship affects the results of the grape harvest in terms of yield, product quality and preservation of the vine (PEZZI et al., 2005). Mechanized harvesting can have positive and negative consequences on the quality of berries and wine. The advantages of mechanization are the task speed, allowing the fruits to be harvested at the most appropriate time. In addition, the harvest can be carried out at night, which guarantees a low temperature, preventing the triggering of enzymatic, non-enzymatic oxidation and early fermentation processes, which avoids the deterioration of the quality of the berries. The main disadvantage of mechanized harvesting is the lower quality in the selection of berries (JOBBÁGY et al., 2018).

Other limitations of mechanized harvesting are the low vineyards, which are difficult to harvest, and the old vineyards with branches displaced from the lines, which can contribute to impurities in the harvested grapes. The pruning system adopted also interferes with mechanized grape harvesting: less rigorous pruning (where the plants have more buds, leaves and branches) gives rise to a greater load of grapes and this can translate into a better harvest in relation to more drastic pruning, because the machine wraps the leaves and branches to shake the plant.

5 FINAL CONSIDERATIONS AND FUTURE PROSPECTS

The mechanization of the grape harvest, although still in the implementation phase in many places in the world, presents itself as an essential tool for the expansion and development of vitiviniculture.

The mechanized harvesting of grapes for winemaking is a fact that has passed the point of "no return". The concentration of the largest wine-growing area in countries with very high labor costs such as California (USA) and European Union states (France, Spain and Italy) makes the development of these machines and their introduction on the market an unstoppable event in current economic conditions.

The huge investment these machines require makes it more appropriate for them to be owned by agricultural service companies. The trend towards high-value crops, such as vineyards, may characterize service outsourcing, where highly mechanized and professional companies would offer their agricultural services to winegrowers through the provision of management such as pre-pruning, pruning, harvesting, phytosanitary treatments and others.

The investment must be amortized with the use of the grape harvest for other jobs and for that, the manufacturers endowed the grape harvesters with enormous versatility. Firstly, the grape harvesters, with minor adaptations, could harvest other products inserted in a 2D trellis type conduction system, such as hedgerow olive grove, pistachio, almond or, very interesting for Brazil, coffee. Second, the harvesters could perform pre-pruning, pruning and phytosanitary treatments.

The winegrower must understand that the success of mechanized harvesting is, first of all, to have a plantation suitable to be harvested in this mechanized system. Also, during winter, spring and summer, managements like pruning, thinning of shoots and driving must be carry out with a view to mechanized harvesting, in order to eliminate in winter pruning the shoots contrary to the direction of the harvest, to eliminate in the spring shoots perpendicular to the planting line and control the height of the planting in the summer and driving all the shoots to a 2D volume.

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