

Improving vineyards management efficiency by using mechanical pruning

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Abstract The research was carried out in 2019, in a young vineyard planted in 2012 by the Restructuring Reconversion Program, designed to allow if needed the mechanical pruning and tillage. For research were chosen Feteasca neagra and Pinot noir varieties with different vine vigour. The randomized block design with three replications was allocated in a 45 ha vineyard, from Minis-Maderat, The main objective was to determine the efficiency of mechanical seasons pruning, which suppose very intensive labour for replace the shortage and time-consuming manual work. The variability was established between the manual pruning, and mechanical pruning on one hectare plots for each variety and control. Both the time required for pruning perform - knowing that the climate variability during the same day requires to concentrate the time available for working at best moment in each growing stage, and the comparative cost to quantify the economics of pruning - were analysed. The only one- growing season did not allow proper data collection order to observe the influence of manual or mechanical pruning on the yield and quality of grapes and must.

Key words

efficiency, mechanical pruning, harvesting, wine grape varieties

In recent years, crop new technologies must take into account, in addition to the already known items of hand labour- and implicitly increasing labour costs. In the new socioeconomic conditions, the only possibility to improve the cultivation technologies more efficient is to increase the level of mechanization [4].

At the same time, it is imperative that the new technologies in viticulture to consider the chemicals amount and the degradation of soil physicochemical properties decreasing [20].

The grapevine management that require a large volume of manual labour or have a major impact on the soil and the environment are: winter and summer season pruning, soil maintenance systems, pest and disease control [18, 25].

Mechanical pruning has emerged and developed due to a lack of skilled labour and to reduce costs [1]. However, the quality of mechanical pruning is clearly inferior to manual pruning; thereby after 2-3 years of mechanical pruning manual correction is required, for multi-year wood removing from the vine and for ensures the canes regeneration if necessary [6].

Canopy and production management represent important technological practices for vine balance, grapes microclimate and wine quality [5, 13].

The difficulty of finding qualified labour and the increasing costs imposed innovations which resulted in the emergence of profitable and productive machines and equipment that mechanically perform a large part

of winter and summer seasons pruning [15, 24]. Mechanical harvesting is one the most adopted mechanized practice and is increasingly required due to the large amount of labour and the difficulties for availability of manual labour during harvesting [21]; new research confirm that mechanical harvesting can reduce labour harvesting costs up to 75% [2]. Mechanical harvesting has become possible lately due to the constant improvement of the harvesters that are more gentle and precise to collect, destemming and sort grapes [3]. Mechanical harvesters can be dedicated (self-propelled) harvesters, tow-behind harvester connected to a tractor and multi-function self-propelled harvester with additional hedging and spraying units [23].

The harvest machines are not cheap, but in the longer run, harvesting turns out cheaper because one machine do the same work like 20 manual harvesters; moreover the vineyard manager can set the date and time correlated with favourable weather and optimum ripeness [12, 19]. The harvester can be use over night when days are too hot [22].

Material and Method

Field trial was carried out in Minis-Maderat Vineyard in randomized block with three replications. Two well-known varieties, Feteasca neagra and Pinot Noir, with different canopy development and vine vigour, were

considered. Each experimental plot for each variety was one hectare area.

The vineyard is new planted (2012) in hilly area with vine rows running north-south. Pruning treatments were: hand pruning (V_1 - control), semi-mechanical (V_2), mechanical (V_3) and partial mechanization (mechanized and manual) (V_4).

Mechanical pruning has been done with Coup'Eco Viti DL11-11C equipment and for grape harvesting Pellenc OPTIMUM 780 SP2 Marimea XL machine was used.

The main objective of the project was to compare the efficiency and cost of total mechanization of the pruning works and grape harvesting that involved a large volume of manual labor in order to replace the labour shortage.

Data for all parameters collected during research were statistically analysed for significant differences between means, by one-way ANOVA analysis of variance (Statistica 10; StatSoft Inc., Tulsa, Okla). Significant differences were determined at $p < 0.05$.

Results and Discussions

Crop loading has major impact on grape yield, on vines lifespan and profitable vineyard longevity [10]. Winter and summer pruning keeps the growth and fruiting in balance and at the same time can positively or negatively influence vineyard lifetime [16]. In the same time, pruning is a very expensive work that until recently was performed exclusively by hand [18]. Climate variability during crop load pruning makes difficult to find qualified labour to accept a normal or extended work schedule in harsh climate [14]. For these reasons, the cost of manual labour for pruning works is more and more expensive, with a negative impact on this work in vineyards due to short favourable time when can be performed [7]. These shortcomings require finding solutions for the mechanization of these works. Mechanical pruning has greatly shortened the time required to perform this work, but there are still issues to be clarified regarding the quality of these works and their influence on production, quality and biological balance of vineyard [9].

Table 1

The influence of mechanical pruning on costs and time consuming

Variant	Variety	Necessary human (days /ha)	Labour (days/ha)	Cost (lei/ha)	Difference to control (lei/ha)
V_1 manual pruning (Control)	Feteasca neagra	39	31	4680	-
	Pinot noir	26	21	3120	-
V_2 Semi-mechanical pruning	Feteasca neagra	28	22	3360	-1320
	Pinot noir	19	15	2280	-840
V_3 Mechanical pruning	Feteasca neagra	1.3	1.04	1033	-3647
	Pinot noir	1.2	0.96	954	-2166
V_4 Partial mechanization (mechanical + manual)	Feteasca neagra	16.3	13	2833	-1847
	Pinot noir	13.2	11	2394	-726

The experimental variants had different behaviour concerning pruning cost and labour days to perform. For both varieties, manual pruning was the most expensive and required several days of labour per hectare.

By using pneumatic pruning shears in variant V_2 , both the labour cost and time consuming have been significantly decreased, the pneumatic scissors replacing a part of the necessary human effort.

The mechanical pruning decreased in both grape varieties for the labour cost, by saving over 3600 lei per hectare and for the time consuming by almost 30 days. This variant is a viable solution both in case manual labour shortage, and in case of unfavourable climate conditions for pruning progress.

Shoot and canopy pruning is difficult to accomplish, extensive in time, from the middle of May to a few days before harvest. These works involve a lot of manual labour that highly increase the maintenance costs of the vine and vineyard.

In the experimental variants are tested different combinations with different degrees of mechanization,

to test both the influence of pruning works on the production costs and on the quality of the grapes.

The data regarding the influence of pruning on the grapes quality must be increased over a longer period of time for a certain interpretation. Regarding the level of expenses, it is greatly amplified for summer manual pruning.

The climate of May and June in the viticultural areas of Romania is extremely variable in last decades, with heavy rainy days alternating with very hot days with high "pressure" on the canopy growth, increasing at the same time the risk of disease and pest attack. To avoid such issues is necessary to balance the crop load on vine and the whole canopy.

Carrying out pruning quickly and on time is increasingly difficult given the difficulty of finding qualified labour. In these circumstances it is necessary to carry out mechanical summer pruning with the help of high-performance machines and equipment for pinch back shoot tips, shoot thinning and leaf removal.

Table 2

The influence of mechanical pruning on costs and time consuming

Variant	Variety	Necessary human (days/ha)	Labour (days/ha)	Cost (lei/ha)	Difference to control (lei/ha)
V ₁ Shoot thinning + desuckering + pinching back shoot tips + leaf removal (Control)	Feteasca neagra	36	28.8	4320	-
	Pinot noir	31	24.8	3720	-
V ₂ Shoot thinning + desuckering + pinching back shoot tips + mechanical leaf removal	Feteasca neagra	23.8	19.04	2923	-1397
	Pinot noir	20.7	16.56	2551	-1169
V ₃ Shoot thinning + desuckering + mechanical pinching back shoot tips + leaf removal	Feteasca neagra	20	16	2535	-1785
	Pinot noir	16	12.8	2055	-1665
V ₄ Mechanical summer pruning	Feteasca neagra	1.7	1.36	406.5	-3913.5
	Pinot noir	1.5	1.2	382.5	-337.5

Harvesting grapes is of utmost importance that can be performed on time only if there are human labour and significant financial resources [27]. Growing demands on the wine market for high quality wines, give to the harvesting work activity a special importance in winemaking, which can make the difference between a good wine and an exceptional one [8]. Therefore, the

harvest must be correlated with climate conditions so as to allow grapes to keep and transmit to the wine the freshness, flavour and aromas specific to each variety [26]. For high quality wine, each variety requires an optimal harvest time which in specific situations can last only a few hours [17].

Table 3

The influence of mechanical pruning on costs and time consuming

Variant	Variety	Necessary human (days /ha)	Labour (days/ha)	Cost (lei/ha)	Difference to control (lei/ha)
V ₁ Manual harvesting	Feteasca neagra	16	11.2	1920	-
	Pinot noir	12	8.4	1440	-
V ₂ Mechanical harvesting	Feteasca neagra	0.5	0.4	397.5	-1522.5
	Pinot noir	0.5	0.4	397.5	-1042.5

In last decades, high temperatures during harvest have imposed specific measures that have essentially changed the well-known grape harvesting technology [11]. Increasingly, the nocturnal grapes harvesting has become necessary when the lower temperatures during the night allow the preservation of the aromas which are mostly volatilized at harvesting over 25°C. Grape harvest during night could not be possible without mechanical harvesters [2].

The use of these modern machines is possible only in the case of wine grape varieties and significantly reduces by up to 10 times the harvesting costs compared to manual harvesting. In case of insufficient manual labour, it was not uncommon for the grape harvest to be prolonged, sometimes until close to winter, which negatively influenced the production of grapes and the quality of the wines [3]. Extensive harvesting exposes the crop to the risk of powdery mildew and gray rot as a result of changing climatic conditions in certain autumns [7]. In order to compress and manage the harvesting of each variety at the optimal ripening moment, there are not many solutions; can be chose mechanical harvesting or increase the manual labour. Shorter harvesting is favourable for

wine quality; instead, increase the pressure on the winemaking, which must have precise flows and appropriate equipment [1]. Soil tillage are also expensive for vineyards managers with a major impact on the production costs and must be done carefully taking into account both the vine and the physical and chemical properties of the soil without degradation [11]. The tillage work between rows was mechanical, but lately are used vineyard rotary hoes with working head without injuring the plants. New equipments are more and friendly with environment, with less negative impact on soil and less carbon emissions. The variant with the highest cost and which required most days of labour per hectare was the variant V₁, using manual hoeing on vine row; it was the variant with the lowest pollution due to the replacement of an important part of burned fuel with manual work. In other variants, by replacing the manual labour with the rotary hoe or mowing on vine rows, decrease the labour cost and the time consuming necessary for their processing. The soil maintenance with rotary hoes must alternate with the maintenance by mowing in order to protect the physical properties of the soil and to not destroy the organic matter.

Table 4

The influence of the soil mechanical tillage on the costs and the time consuming

Variant	Variety	Necessary human (days/ha)	Labour (days/ha)	Cost (lei/ha)	Difference to control (lei/ha)
V ₁ Manual hoe vine row + rotary hoe interrow (Control)	Feteasca neagra	20	16	2670	-
	Pinot noir	20	16	2670	-
V ₂ Rotary hoe vine row + rotary hoe interrow	Feteasca neagra	3	2.4	1215	-1445
	Pinot noir	3	2.4	1215	-1445
V ₃ Rotary hoe + mowing interrow	Feteasca neagra	2.7	2.16	1110	-1560
	Pinot noir	2.7	2.16	1110	-1560
V ₄ Mowing vine row + mowing interrow	Feteasca neagra	2.5	2	800	-1870
	Pinot noir	2.5	2	800	-1870

The mechanical technological sequences has become more and more necessary lately, being the only solution that allows the timely execution of the works in case of the labour shortage, impossible to anticipate a few years ago [14]. Through mechanization, it was possible both to reduce the management expenses with considerable amounts of almost 11,000 lei per hectare

and the need for labour days per hectare by up to 65-80 days.

The mechanization of some technological sequences that require a lot of manual labour (summer pruning, harvesting) is the only solution that allows the extension of the activity in many vineyards irreparably affected by the global labour crisis.

Table 5

The influence of the main mechanical technological sequences on the costs in the Feteasca neagra variety (lei / ha)

Technological work	Labour costs			
	Manual (Control)	Partial mechanical	Medium mechanical	Total mechanical
Pruning	4680	3360	2833	1033
Soil tillage	2670	1215	1110	800
Summer pruning	4320	2932	2535	406.5
Harvesting	1920	1920	1920	397,5
Total costs	13590	9427	8398	2637
Difference to control	-	-4163	5192	-10953

Table 6

The influence of the main mechanical technological sequences on the costs in the Pinot noir variety (lei / ha)

Technological work	Labour costs			
	Manual (Control)	Partial mechanical	Medium mechanical	Total mechanical
Pruning	3120	2280	2394	954
Soil tillage	2670	1215	1110	800
Summer pruning	3720	2551	2055	382,5
Harvesting	1440	1440	1440	397.5
Total costs	10950	7486	6999	2534
Difference to control	-	-3464	-3906	-8416

Table 7

The influence of the main mechanical technological sequences on time consuming in Feteasca neagra variety (days/ha)

Technological work	Labour costs			
	Manual (Control)	Partial mechanical	Medium mechanical	Total mechanical
Pruning	31	22	13	1.04
Soil tillage	16	2.4	2.16	2
Summer pruning	26.8	19.04	16	1.36
Harvesting	11.2	11.2	11.2	0.4
Total costs	85	54.64	42.36	4.8
Difference to control	-	-30.36	-42.64	80.02

Table 8

Influence of the main mechanical technological sequences on time consuming in Pinot noir variety (days/ha)

Technological work	Labour costs			
	Manual (Control)	Partial mechanical	Medium mechanical	Total mechanical
Pruning	21	15	11	0.96
Soil tillage	16	2.4	2.16	2
Summer pruning	24.8	16.56	12.8	1.2
Harvesting	8.4	8.4	8.4	0.4
Total costs	70.2	42.36	34.36	4.56
Difference to control	-	-27.84	-35.84	65.64

Conclusions

The vineyard management requires annual financial and human resources, to which are added the high depreciation rates due to the high costs of setting up a vineyard.

These considerable financial efforts have recently led to a number of other issues, such as climate change and the labour crisis, which are making it increasingly difficult the work in viticulture.

As a result, the mechanization of the main technological sequences has become a major objective both in the Romanian and in the world viticulture. From the beginning, the vineyards are designed in such a way that, if necessary, they allow the total mechanization of the maintenance works.

Engineers and specialists in viticulture and related fields must find complex, multidisciplinary solutions that will allow this total mechanization but at the same time to preserve the quality of wine products. Certainly, the most difficult technological sequence to mechanize, without affecting the quality of the wine and the biological balance of the vines is the pruning for crop load. However, the latest machines and equipment, correlated with the design of a certain training system, allowed the complete mechanization of this work.

The only issue to which the mechanical pruning does not have solutions yet, is the decreasing of lifespan of the vineyard to at most 16-18 years. The mechanical works has considerably decreased expenses for vineyard management by up to 60-70% therefore their depreciation is no longer an issue, even if the economic exploitation period decreased.

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