Volume 24(2), 1 - 8, 2020
JOURNAL of Horticulture, Forestry and Biotechnology
www.journal-hfb.usab-tm.ro

The influence of manual and mechanical pruning on grape quantity and quality and the efficiency of vineyards management

Dobrei A.[1], Nistor Eleonora[1], Nan Roxana-Daniela[1], Dobrei Alina[1]*

[1*]Banat University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania", Faculty of Horticulture and Forestry, Calea Aradului 119, RO-300645, Timisoara, Romania

*Corresponding author. Email: ghitaalina@yahoo.com

Abstract The research was carried out in Minis-Maderat vineyards, on 6 hectare area, cultivated with wine grape varieties with different vigour like: Cabernet Sauvignon, Feteasca regala and Pinot noir. The necessary time-consuming for carrying out the work activities was followed due to the climatic variability that requires the decrease of the time available for carrying out the frameworks at the optimal time, as well as the comparative cost of soil maintenance and pruning works in order to evaluate the economic efficiency. By mechanical pruning, the time required for this activity was greatly decreased from 35-40 labour day/ ha to 2.2-1.4 labour day/ ha. Due to the climate variability during pruning, is difficult to find manual labour which is very expensive after all, costs that many vineyard managers can't afford. However, manual pruning still provides the highest yields and the highest production increases when there is an available manual labour and financial resources.

Key words

wine varieties, mechanical pruning, manual labour, berry quality

Growing technologies must be applied differently depending on the cultivated grape variety, the ecological conditions of each wine-growing area, the climate from each year, but taking into account the destination of production, budget availability and management of each vineyard [1].

In the last decades, crop technologies must take into account, in addition to the already known factors (climate variability, increasing inputs, soil and grape variety) a new issue, at least in Romania - lack of manual labour and implicitly increasing labour costs [25].

In the new socioeconomic circumstances, the only possibility to increase the efficiency of cultivation technologies is to use more mechanical pruning and other modern equipment for vineyard management [2, 18].

Pruning represents the work activity with the greatest impact on the annual maintenance expenses of the vineyards, reason for which researchers are searching for solutions to decrease the costs and time-consuming for each works activity [15, 24]. Grapevine pruning has been practiced since ancient times. It is believed that the Greeks adopted pruning as a work activity to increase production [23, 28].

They grow vines in low bush shape, maintained by short annual pruning. Unlike the Greeks, the Romans cultivated vines by using cordon training [12]. Some long cordon training known as „halângi' was used in grapevine growing by Geto-Dacians [25]. Pruning is a complicated and challenging work activity, for which are necessary a lot of theoretical knowledge and practical skills [3]. Workers must be trained before on the work activity technique, on the crop load for each cane and each vine. The pruning method depends on the vine training system and climate growing region [5, 16].

Within the same type of pruning, for the same variety, fruiting pruning is performed differently from vine to vine [4]. When work starts, the grape grower examines the vine, appreciate the vigour according to the number and length of one-year canes correlated with the number of fruiting wood from the previous year [17, 19].

Because grapevine is a true vine, pruning is necessary to balance the canopy, otherwise, left wild, duet o polarity organs, the fruiting wood raise each year while stripping at the base [20]. Over the years, the pruning work has been continuously improved, innovative technologies were adopted, new systems and types of vine shape and architecture were found, all of which increase the wine production [26, 27].

Material and Method

The research was carried out in a young vineyard planted in 2014 by the Restructuring Conversion Program, with interrow (2.4 m) and space between vines (1 m) to allow mechanical pruning and other work activities. Three grape wine varieties were analysed for different growth vigour. The research was

located in Minis-Maderat Vineyards, on 6 hectare area, in a randomized block design, with blocks of equal size, for each grape variety involved in the research, respectively, Cabernet Sauvignon, Feteasca regala and Pinot noir. The development and vine varieties were monitored according to pruning type applied in each experimental plot. Each treatment was replicated three times.

The main objectives of the research consisted in the partial and total mechanical pruning, which involved a large volume of work activity in order to replace the hand labour shortage. The climate variability during pruning activities requires the short time-consuming for performing each activity in the optimal moment, and the comparative cost of all work activities for estimate the profit. Another objective was to analyse the influence of pruning methods on wood maturation, bud viability, grape production and quality.

Results and Discussions

Crop load is one of the work activities with the greatest influence on grape yield. Pruning influences both the current year yield of the next year's yield by influencing the bud fruitfulness [7, 29]. Pruning influences both the current year's production and next year's production through the influence it determines on the differentiation of fruit buds [8, 26].

Pruning and crop load have to be in accordance with the technological requirements of each variety, but recently the availability of hand labour must be taken into account and especially the necessity to finish pruning before the weeping stage [33, 6]. Although wine grape varieties generally resist well to normal winter temperatures, lately, climate variability associated with the attack of diseases and pests, cause in some vineyards insufficient maturation of the wood in some varieties [34].

Table 1

The influence of the pruning methods on the wood maturation in the Feteasca regala variety

Variant	Total annual shoot growth (m/ vine)	Annual wood growth		Difference to control (% from total growth)	Significance
		m/ vine	% from total growth		
V_1 Short manual pruning spur (Control)	27.40	21.97	80.20	-	-
V_2 Mixed manual rod pruning	25.00	21.71	86.50	6.40	**
V_3 Pneumatic pruning shears	26.20	22.20	84.40	4.30	*
V_4 Mechanical pruning	29.90	23.49	78.30	-1.80	-
V_5 Mechanical and hand pruning	27.90	22.37	79.90	-0.20	-

LSD5% = 3.81; LSD1% = 6.17; LSD0.1% = 9.82

Table 2

The influence of pruning methods on the wood maturation in the Cabernet Sauvignon variety

Variant	Total Annual shoot growth (m/ vine)	Annual wood growth		Difference to control (% from total growth)	Significance
		m/ vine	% from total growth		
V_1 Short manual pruning spur (Control)	30.5	23.94	78.5	-	-
V_2 Mixed manual rod pruning	28.3	23.60	83.4	4.9	*
V_3 Pneumatic pruning shears	29.2	23.94	82	3.5	*
V_4 Mechanical pruning	33.3	25.47	76.5	-2	-
V_5 Mechanical and hand pruning	31.5	24.44	77.6	-0.9	-

LSD5% = 3.27; LSD1% = 5.81; LSD0.1% = 9.34

All three varieties analyzed have good frost resistance and usually a good wood maturation. In all the experimental variants, grape varieties achieved satisfactory maturation of the wood, which did not require the yield component compensation. In varieties with high vigour, such as Cabernet sauvignon and Feteasca regala, short pruning was not the most appropriate, because the growth increased, with negative influences on wood maturation (Table 1; 2).

The variant that registered the lowest rate of wood maturation was in all cases the mechanical pruning (V_4), but the differences registered compared to the control are not statistical significant (Table 3).

Table 3

The influence of pruning methods on the wood maturation in the Pinot Noir variety

Variant	Total Annual shoot growth (m/ vine)	Annual wood growth		Difference to control (% from total growth)	Significance
		m/ vine	% from total growth		
V_1 Short manual pruning spur (Control)	16.70	15.33	91.80	-	-
V_2 Mixed manual rod pruning	15.60	14.41	92.40	0.60	-
V_3 Pneumatic pruning shears	16.20	14.92	92.10	0.30	-
V_4 Mechanical pruning	19.00	17.02	89.60	-2.20	-
V_5 Mechanical and hand pruning	17.50	15.79	90.20	-1.60	-

LSD5% = 3.11; LSD1% = 5.27; LSD0.1% = 8.89

The varieties investigated don't normally have high rate of buds affected by frost, and pruning can be performed normally. Mechanical pruning increased the rate of buds affected by frost, but doesn't influence negative the vineyard management (Table 4, 5).

Table 4

The influence of pruning methods on the buds fruitfulness, at the Feteasca regala variety

Variant	Fruitful buds (%)	Buds damaged by frost (%)	Difference to control (fruitful buds)	Significance
V_1 Short manual pruning spur (Control)	93	7	-	-
V_2 Mixed manual rod pruning	97	3	4	-
V_3 Pneumatic pruning shears	95	5	2	-
V_4 Mechanical pruning	85	15	-8	0
V_5 Mechanical and hand pruning	90	10	-3	-

LSD5% = 6.08; LSD1% = 10.63; LSD0.1% = 16.22

Table 5

The influence of pruning methods on the buds fruitfulness, at Cabernet Sauvignon variety

Variant	Fruitful buds (%)	Buds damaged by frost (%)	Difference to control (fruitful buds)	Significance
V_1 Short manual pruning spur (Control)	88	12	-	-
V_2 Mixed manual rod pruning	93	7	5	-
V_3 Pneumatic pruning shears	90	10	2	-
V_4 Mechanical pruning	80	20	-8	0
V_5 Mechanical and hand pruning	84	16	-4	-

LSD5% = 5.69; LSD1% = 9.98; LSD0.1% = 16.01

Table 6

The influence of pruning methods on the buds fruitfulness, in Pinot noir variety

Variant	Fruitful buds (%)	Buds damaged by frost (%)	Difference to control (fruitful buds)	Significance
V_1 Short manual pruning spur (Control)	96	4	-	-
V_2 Mixed manual rod pruning	98	2	2	-
V_3 Pneumatic pruning shears	97	3	1	-
V_4 Mechanical pruning	92	8	-4	-
V_5 Mechanical and hand pruning	92	8	-4	-

LSD5% = 6.19; LSD1% = 10.99; LSD0.1% = 16.98

The influence of different pruning methods was higher in vigorously growing varieties and less obvious in Pinot noir variety (Table 6). All pruning methods, although having a positive or negative influence on the wood maturation and bud fruitfulness, are suitable for grapevine varieties in research without affecting the yield components [10]. The variant that registered the highest percentages of matured wood and bud fertility was for all varieties the variant of mixed manual rod pruning (V_2).

Table 7

The influence of pruning methods on grape yield, at the Feteasca regala variety

Variant	Grape yield		Difference to control (kg/ha)	Significance
	(kg/vine)	(kg/ha)		
V_1 Short manual pruning spur (Control)	2.94	12.251	-	-
V_2 Mixed manual rod pruning	3.47	14.459	2.209	**
V_3 Pneumatic pruning shears	3.41	14.209	1.958	**
V_4 Mechanical pruning	2.33	9.709	-2.542	00
V_5 Mechanical and hand pruning	2.8	11.668	-583	-

LSD5% = 979.1; LSD1% = 1873.2; LSD0.1% = 3394.2

Climate conditions have determined lately, without exception, very difficult pruning activity, above all, the alternation of high with low temperatures, over the winter growing season, from November to April. These growing conditions, grape growing farmers from most wine-growing countries search solutions for the pruning in time without influence on grape yield, quality and especially on the canopy balance [11, 31]. These solutions are increasingly difficult to achieve, especially in varieties with high vigour, which require intense labour for canopy balance [9].

Minimal pruning spur is the manual pruning that requires the shortest time, and also provides satisfactory yields, particularly for the Pinot noir variety known to be less vigorous [30, 35].

.

Table 8

The influence of pruning methods on grape yield, at Cabernet Sauvignon variety

Variant	Grape yield		Difference to control (kg/ha)	Significance
	(kg/vine)	(kg/ha)		
V_1 Short manual pruning spur (Control)	2.42	10.084	-	-
V_2 Mixed manual rod pruning	3.24	13.501	3.417	***
V_3 Pneumatic pruning shears	3.14	13.084	3.000	**
V_4 Mechanical pruning	1.87	7.792	-2.292	00
V_5 Mechanical and hand pruning	2.31	9.626	-458	-

LSD5% = 902.3; LSD1% = 1695.9; LSD0.1% = 3179.3

For all grape varieties, the variant that gave the highest yields was manual rod pruning, which is more difficult for hand workers to perform. The differences registered compared to the control variant had the highest statistical significance (Table 7,8).

Table 9

The influence of pruning methods on grape yield, at Pinot noir variety

Variant	Grape yield		Difference to control (kg/ha)	Significance
	(kg/vine)	(kg/ha)		
V_1 Short manual pruning spur (Control)	2.10	8.751	-	-
V_2 Mixed manual rod pruning	2.16	9.001	250	-
V_3 Pneumatic pruning shears	2.14	8.917	167	-
V_4 Mechanical pruning	1.94	8.084	-667	0
V_5 Mechanical and hand pruning	2.06	8.584	-167	-

LSD5% = 501.2; LSD1% = 899.3; LSD0.1% = 1575.2

Using pneumatic scissors gave superior yields compared to the control and in the same time decreased the time required for work activity [13]. For all varieties, the variant of mechanical pruning gave the lowest yields, the differences registered compared to the control being the only ones with negative significance. For hand pruning associated to the mechanical pruning, the differences from the control were less obvious, which proves to be a convenient alternative if there is hand labour availability, but not enough to perform the hand pruning. In wine grape varieties, the technological quality of grapes is mandatory for competitive wines on the wine market with many competitors and increasing consumer demands [21].

Table 10

The influence of pruning methods on grape quality, at Feteasca regala variety

Variant	Sugar (g/l)	Acidity (g/l H_2SO_4)	Difference to Control (Sugar g/l)	Significance
V_1 Short manual pruning spur (Control)	198	5.60	-	-
V_2 Mixed manual rod pruning	213	5.10	15	*
V_3 Pneumatic pruning shears	213	5.10	15	*
V_4 Mechanical pruning	191	6.00	-7	-
V_5 Mechanical and hand pruning	195	5.80	-3	-

LSD5% = 11.82; LSD1% = 20.1; LSD0.1% = 27.2

Table 11

The influence of pruning methods on grape quality in Cabernet Sauvignon variety

Variant	Sugar (g/l)	Acidity (g/l H_2SO_4)	Difference to Control (Sugar g/l)	Significance
V_1 Short manual pruning spur (Control)	204	5.10	-	-
V_2 Mixed manual rod pruning	222	4.60	18	*
V_3 Pneumatic pruning shears	222	4.60	18	*
V_4 Mechanical pruning	196	5.70	-8	-
V_5 Mechanical and hand pruning	200	5.40	-4	-

LSD5% = 11.98; LSD1% = 21.1; LSD0.1% = 29.8

Table 12

The influence of pruning methods on grape quality, in Pinot Noir variety

Variant	Sugar (g/l)	Acidity (g/l H_2SO_4)	Difference to Control (Sugar g/l)	Significance
V_1 Short manual pruning spur (Control)	214	4.60	-	-
V_2 Mixed manual rod pruning	221	4.30	7	-
V_3 Pneumatic pruning shears	219	4.40	5	-
V_4 Mechanical pruning	207	5.00	-7	-
V_5 Mechanical and hand pruning	210	4.80	-4	-

LSD5% = 12.93; LSD1% = 19.79; LSD0.1% = 29.15

All three varieties chosen for research are versatile varieties with high quality potential [21]. In these varieties, the sugar accumulations were higher enough for all variants to allow the wines a classification in the superior categories (Table, 10, 11, 12).

Concerning the pruning variants, there is no influence on the wines quality, but the chosen vinification technology can make the difference.

The pruning options influenced to some extent the grape quality, but without statistical significance. The lowest berry sugar content was recorded for all three varieties when mechanical pruning was applied, but without high influence on wine quality. The influence of mechanical pruning had a higher negative influence on grape yield and much less on berry sugar accumulations.

The very high sugar accumulation potential of these three varieties makes them suitable for mechanical pruning, without major influence on wine quality.

In addition to the usual economic issues, lately viticulture management is very much influenced by climate variability and the difficulty of providing the necessary workforce trained in grapevine canopy management [22].

Table 13

The influence of mechanical pruning on costs and time consuming for work activities

Variant	Variety	Day labour /ha	Time consuming (days/ha)	Cost (lei/ha)	Difference to control (lei/ha)
V_1 Short manual pruning spur (Control)	Feteasca regala	34	27.2	4080	-
	Cabernet Sauvignon	37	29.6	4440	-
	Pinot noir	27	21.6	3240	-
V_2 Mixed manual rod pruning	Feteasca regala	38	30.4	4560	480
	Cabernet Sauvignon	42	33.6	5040	600
	Pinot noir	29	23.2	3480	240
V_3 Pneumatic pruning shears	Feteasca regala	28	22.4	3360	-720
	Cabernet Sauvignon	29	23.2	3480	-960
	Pinot noir	21	16.8	2520	-720
V_4 Mechanical pruning	Feteasca regala	1.33	1.064	958	-3122
	Cabernet Sauvignon	1.43	1.144	1030	-3410
	Pinot noir	1.23	0.984	886	-2354
V_5 Mechanical and hand pruning	Feteasca regala	14.33	11.464	2499	-1581
	Cabernet Sauvignon	15.43	12.344	2691	-1749
	Pinot noir	12.23	9.784	2133	-1107

Researchers are still trying to find solutions to reduce the time required for pruning, including mechanical pruning. The difficulty of pruning depends a lot on the cultivated variety, vigorous varieties need longer time consuming and additional costs for pruning [14, 32].

The variant that required the highest expenses and many days of work was in the case of all varieties, the manual rod pruning. At the opposite was the variant of mechanical pruning with the lowest expenses (saving over 3400 lei per hectare). By simply using the pneumatic pruning shears, it was possible to decrease the expenses due to the increase of the hand labour efficiency, but also to the shortening of the necessary time for activity works.

The pruning variants influenced differently the main economic indicators, such as the expenses per hectare, the production increase and the cost price per grape kilogram.

The pruning costs varied widely from 958 lei / ha to 5040 lei / ha. The most expensive work activities are for manual rod pruning, which require a considerable budget, while mechanical pruning have the lowest costs.

By using pneumatic shears instead of the manual scissors, a significant decrease of costs was achieved without an obvious decrease in yield and quality.

Another favourable option for costs decrease is the mechanical pruning followed by the hand pruning correction, of which can be harvested satisfactory grape yield. At the same time, this variant recorded convenient cost prices per kilogram of grapes.

The mechanical pruning was the variant that registered by far the lowest cost prices per kilogram of grapes, proving to be the most indicated variant in the conditions in which the financial resources of the vineyard are reduced. On the other hand, the grape production increase compared to the control variant is a negative one.

Conclusions

Viticulture is an intensive sector of agriculture that is characterized by an intensive land use. However, viticulture needs in some situations a large volume of manual activity. The recent difficulties in finding the available workforce have required solutions to increase mechanical technological sequences that require less manual labour, including pruning.

The mechanical pruning is possible and efficient, especially in grape wine varieties. It is in some vineyards the only available pruning option. By mechanical pruning, the time required for pruning was greatly decreased from 35-40 labour days / ha to 2.2-1.4 labour days / ha. The climate variability, hot days, chilly mornings, or rainy days create difficulties in finding hand labour to carry out work activities in the vineyards, or increase much the cost of vineyard maintenance, which many vineyard managers can't afford.

Mechanical pruning, although negatively influences the grape productions and the lifetime of the vineyard, it seems that will be a basic choice in the future and in certain situations, and the only solution to continue the activity in viticulture.

A variant that keeps a balance between the activity work expenses, the production and the biological stability of the vineyard, is the mechanical pruning combined with the manual pruning correction. This variant allows a decrease by 50-60% of the necessary time for pruning, with acceptable grape production quality and a relatively low production cost. However, manual pruning remains the method that ensures the highest grape productions and the highest values of the production increase when the vineyard has the labour force and financial resources.

The choice of one or the other of the pruning options remains an option of each vineyard depending on the

cultivated variety, the financial resources available in late winter, early spring, the availability of manual labour and last but not least the climate conditions of each year so that the pruning to be completed in appropriate time.

References

1. Allebrandt, R., Marcon F., José L., Würz, D.A., Bem, B., Pereira de, K., Aike A., Rufato, L., 2017. Pruning methods on the yield performance and oenological potential of 'Nebbiolo' grapevine. Pesquisa Agropecuária Brasileira, 52(11), pp. 1017-1022. https://doi.org/10.1590/s0100-204x2017001100007.
2. Archer E., Van Schalkwyk D., 2007. The effect of alternative pruning methods on the viticultural and oenological performance of some wine grape varieties. S. Afr. J. Enol. Vitic., 28**,** pp. 107-139.
3. Bernizzoni, F., Gatti, M., Civardi, S., Poni, S., 2009. Long-term performance of Barbera grown under different training systems and within-row vine spacings. American Journal of Enology and Viticulture, v.60, pp.339-348.
4. Christensen, L.P., 1985. Fruitfulness and yield characteristics of primary and lateral canes of 'Thompson Seedless' grapevines. Am. J. Enol. Vitic. 37, pp. 39–43.
5. Christensen, L.P., Leavitt G.M., Hirschfelt D.J., Bianchi M.L., 1994. The effects of pruning level and post-budbreak cane adjustment on 'Thompson Seedless' raisin production and quality. Am. J. Enol. Vitic. 45, pp. 141–149.
6. Clingeleffer, P.R., Petrie, P.R., Ashley, R.M., 2005. Suitability of minimal pruning and other low-input systems for warm and cool climate grape production, 3-10. In: Proc. XIV Int. GESCO Vitic. Congr., Geisenheim (Germany).
7. Clingeleffer, P.R., 2013. Mechanization in Australian vineyards. Acta Hort*.,* 978**,** pp. 169-177.
8. Dobrei A., Dobrei Alina Georgeta, Nistor Eleonora, Posta Gh., Malaescu Mihaela, Balint M., 2018. Characterization of grape and wine quality influenced by terroir in different ecosystems from Romania cultivated with Feteasc㠠neagră, Scientific Papers-Series B-Horticulture, Agriculture for Life and Life for Agriculture Annual Conference, Vol. 62, pp. 247-253.
9. Dobrei A., Nistor Eleonora., Sala F., Dobrei Alina, 2015. Tillage practices in the context of climate change and a sustainable viticulture, Not Sci Biol, 2015, No 7(4). Print ISSN 2067-3205; Electronic 2067-3264, pg 500-504.
10. Dobrei Alina Georgeta, Dobrei A., Nistor Eleonora, Camen D., Chisalita I., 2016. Analysis of crop modelling efficiency in vine-growing farms, Multidisciplinary Scientific Conferences on Social Sciences and Arts, Book 2, vol.5,SGEM2016 Conference Proceedings, ISBN 978-619-7105-76-6 / ISSN 2367-5659, 24-31 43-50 pp. DOI: 10.5593/SGEMSOCIAL2016/B25/S07.006.
11. Guerra, B., Steenwerth, K., 2012. Influence of floor management technique on grapevine growth, disease pressure, and juice and wine composition: a review. Am. J. Enol. Vitic*.,* 63, pp. 149-164.
12. Jacquat, C, Martinoli, D., 1999. *Vitis vinifera* L., Wild or cultivated? Study of the grape pips found at Petra, Jordan; 150 B.C.–A.D. 40. Veg Hist Archaeobot. 1999;8: 25–30. doi: 10.1007/BF02042839
13. Jackson, D.I., Lombard, P.B., 1993. Environmental and management practices affecting grape composition and wine quality: a review. Am. J. Enol. Vitic*.,* 44, pp. 409-430.
14. Keller, M., 2010. Managing grapevines to optimise fruit development in a challenging environment: a climate change primer for viticulturists. Australian Journal of Grape and Wine Research 16, pp. 56-69. doi:/10.1111/j.1755-0238.2009.00077.x.
15. Kumar, H., Tomer, N.S., 1978. Pruning studies on Himrod cultivar of grape. Har. Hort. Sci., 7 (1-2), pp. 18-20.
16. Lakso, A.N., 1999. Physiology of minimal versus normal pruning of Concord grapes. Proc. Michigan State Hortic. Soc*.,* 128**,** pp. 138-141.
17. Lider, L.A., Kasimatis, A.N., Kliewer W.M., 1975. Effect of pruning severity on the growth and production of 'Thompson Seedless' grapevines. Am. J. Enol. Vitic. 26, pp. 175–78.
18. Lopes, C., Melicias, J., Aleixo, A., Laureano Castro, O.R., 2000. Effect of mechanical hedge pruning on growth, yield and quality of Cabernet Sauvignon grapevines. Acta Hort., 526, pp. 261-268.
19. Main, G.L., Morris, J.R., 2008. Impact of pruning methods on yield components and juice and wine composition of Cynthiana grapes. Am. J. Enol. Vitic*.,* 59, pp. 179-187.
20. McCarthy, M.G., Cirami, R.M., 1990. Minimal pruning effects on the performance of selections of four *Vitis vinifera* cultivars. Vitis*,* 29, pp. 85-96.
21. Nistor Eleonora, Dobrei Alina Georgeta, Dobrei A., Camen D., Velicevici Giancarla, Prundeanu H., Baiduc M., 2017. Crop estimation and variability of yield components in Cabernet Sauvignon, Merlot, Pinot Noir and Burgundy varieties. Journal of Horticulture, Forestry and Biotechnology (ISSN 2066-1797, Volume 21(4), pp. 73- 76.
22. Nistor Eleonora, Dobrei Alina Georgeta, Dobrei A., Camen D., 2018, Growing season climate variability and its influence on Sauvignon blanc and Pinot gris berries and wine quality: Study Case in Romania (2005-2015), South African Journal of Enology and Viticulture, Vol. 39, No. 2, ISSN 2224-7904 (online) ISSN 0253-939X (print), DOI: http://dx.doi.org/10.21548/39-2-2730.

23. Pavlov, A., 1998. Pruning of grape cultivar Naslada. Rastenier dni Nauki, 35(6), pp. 468-470.
24. Pérez-Bermúdez P., Olmo M., Gil J., García-Ferriz L., Olmo C., Boluda R., Gavidia I., 2015. Effects of traditional and light pruning on viticultural and oenological performance of Bobal and Tempranillo vineyards. OENO One, 49(2), 145-154. https://doi.org/10.20870/oeno-one.2015.49.2.88.
25. Petru A., Dobrei A., Ghiţă Alina, Blidariu C., 2013. Studies concerning the soil and vine maintenance mechanization in vineyard, The 19th International Symposium on Analytical and Environmental Problems, Szab Kémiai Szakbizottság Analitikai és Környezetvédelmi Munkabizottsága, Szeged, Hungary, ISBN: 978-963-315-141-9, pg. 265-268.
26. Petrie, P.R., Clingeleffer, P.R., Krstic, M.P., Welsh, M.A., 2003. Pruning to improve grape and wine quality in warm, irrigated vineyards. Aust. N.Z. Grapegrower Winemak., 472, pp. 55-58.
27. Pezzi, F., Balducci, G., Barca, E., Caprara, C., 2013. Effects of winter pruning on physical and mechanical properties of grapes. Acta Hort., 978, pp. 347-352.
28. Rousseau J., Pic L., Carbonneau A., Ojeda H., 2013. Incidence of minimal pruning on wine quality. Acta Hort., 978, 309-316.
29. Reynolds, A.G., 1988. Response of Okanagan Riesling vines to training system and simulated mechanical pruning. Am. J. Enol. Vitic., 39, pp. 205-212.
30. Reynolds, A.G., Wardle, D.A., 2001. Evaluation of minimal pruning upon vine performance and berry composition of Chancellor. Am. J. Enol. Vitic., 52, pp. 45-48.
31. Rousseau, J., Pic, L., Carbonneau, A., Ojeda, H., 2013. Incidence of minimal pruning on wine quality. Acta Hort., 978, pp. 309-316.
32. Senthilkumar, S., Vijayakumar, R.M., Soorianathasundaram, K., Durga Devi, D., 2015. Effect of pruning severity on vegetative, physiological, yield and quality attributes in grape (*Vitis vinifera* L.): A Review. Current Agricultural Research Journal, 3(1), pp. 42-54.
33. Taylor, J.A., Bates, T.R., 2012. Sampling and estimating average pruning weights in Concord grapes. American Journal of Enology and Viticulture, 63(4), pp. 559–563.
34. Tomasi, D., Gaiotti, F., Sansone, L., Lovat, L., Marcuzzo, P., Belfiore, N., Vincenzi, S., Matese, A., Bonato, L., 2013. Mechanical pruning, no pruning and manual pruning: effects on grape composition and health status of "Pinot Gris" and "Cabernet Sauvignon" cultivars in the "Piave" AOC area of Veneto region. Acta Hort., 978, pp. 317-326.
35. Zheng, W., del Galdo, V., García, J., Balda, P., Martínez de Toda, F., 2017. Use of minimal pruning to delay fruit maturity and improve berry composition under climate change. American Journal of Enology and Viticulture 68, pp. 136-140. doi:/10.5344/ajev.2016.16038.