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MECHANICAL PLUM PRUNING

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ABSTRACT

The most common method of plum tree pruning is a traditional method, by using manual or pneumatic shears or loppers. The persistent labor shortage imposes the need to mechanize this work operation. Preliminary results of mechanical plum pruning during the dormant period are presented in the paper. The research was performed in the orchard of the company "Agrovoće" Laktaši (Bosnia and Herzegovina) on the varieties Stanley, Čačanska lepotica and Čačanska rodna. All varieties were grafted on seedlings *Prunus cerasifera* Ehr. and trained in spindle system with a planting distance of 4.0 × 1.8 m. Pruning was done by hedging both sides with a saw-bar, while the tops were trimmed by hand from the platform. The research analyzed the efficiency of the pruning, the quality of cuts made during mechanical pruning, as well as the reaction of pruned trees regarding the formation of new growths during vegetation. Combined pruning (mechanical and manual) was significantly more efficient than manual pruning. The quality of mechanical pruning was largely conditioned by the varietal specifics of the tree architecture. No anomalies were found in the healing of wounds made during mechanical pruning. Activation of new vegetative shoots was more uniform in relation to manual pruning with a tendency to form a fruit-bearing wall. Mechanical pruning must be combined with manual pruning, which is necessary in regulating the top parts of the canopy as well as growth in the in-row space.

Key words: plum, variety, efficiency, cuts.

INTRODUCTION

Pruning is an essential practice that has a direct influence on yield and fruit quality. Pruning is a labor- and time-demanding operation that generally represents the second greatest annual expense for tree fruit producers worldwide (Nunez, 2016). Manual pruning is one of the most expensive field operations, accounting for over 25% of the total growing costs in plum production (Niederholzer et al., 2018). Over the last few decades dramatic changes have occurred in the fruit industry, with a clear evolution of training systems, the development of dwarfing rootstocks and intensive orchard management strategies. Increasing competitiveness has forced the tree fruit industry to innovate and transform traditional systems into futuristic orchards that allow the adoption of mechanization and simplification of work operations, including thinning, pruning and harvest (Nunez, 2016). Pruning accounts for a large percentage of production costs and even though its omission may not affect crop production and quality immediately, negative effects can be long lasting and irreversible. Fruit producers around the world are ultimately interested in finding a solution to increasing labor shortage and increasing demand, without compromising the quality of their crops. As fruit producers adopt new planar orchard systems there is improved potential for the mechanization of orchard operations, including pruning. Mechanical pruning can be an important tool in decreasing pruning costs (Bates & Morris, 2009), reducing alternate bearing (Ferguson et al., 1995), and maintaining trees in their allotted space. A range of practices including mechanical topping and/or side hedging (one or two directions) are beginning to be practiced by plum producers. However, questions remain on when to apply pruning measure and the intensity of mechanical pruning (Rosecrance et al., 2021). Dormant pruning typically invigorates trees, while pruning in-season reportedly decreases tree vigor (Cvetković & Mićić, 2018). Mechanical pruning operations should be timed to minimize strong vegetative regrowth. Strong regrowth following pruning can decrease fruit size in the current year and return bloom during the following year. In the previous time period, a large number of researchers studied the effects of mechanical pruning on the profitability, yield and quality of apple fruits (Miranda Sazo & Robinson, 2013; Nunez, 2016), sweet cherry (Nunez, 2016), navel orange (Kallsen, 2005), orange (Velazquez & Fernandez, 2010), tangerines (Martin - Gorriz et al., 2014), olives (Dias et al. 2012; Cherbiy-Hoffmann et al., 2012) and plum (Nowakowski et al., 2018; Nowakowski & Novakowski, 2018; Rosecrance et al., 2021). The importance of mechanical pruning is also demonstrated by the researchers' efforts to create the preconditions for its optimal efficiency with the help of information technology (Karkee et al., 2014). The aim of this paper is a preliminary analysis of the impact of the mechanical pruning in plum trees trained in spindle system on the pruning profitability, the suitability of analyzed varieties for this type of pruning, as well as the level of damage caused by applied pruning measure.

MATERIAL AND METHODS

The analysis of the application of mechanical plum pruning was carried out in the production orchard of the company "Agrovoće" in the Bakinci village (272 m above sea level), municipality of Laktaši (Bosnia and Herzegovina). So far, it covers a total area of 72ha. There are many varieties in the orchard, among which the Stanley, Čačanska rodna and Čačanska ljepotica varieties predominate. All the varieties are grafted on a cherry plum seedling rootstock (*Prunus cerasifera* Ehr.). Plant spacing for all varieties is 4.0 x 1.8m. The training system is a plum spindle, formed and maintained while respecting the basic principles of this training system (Mićić et al., 2005). Regarding the soil in the orchard, barren fallow system is used between rows, while in-row space is maintained by herbicide application. Nutrition and protection against pathogens are consistent with positive agricultural practice. The research was carried out during two-year time (2021-2022) on the varieties Čačanska Rodna, Čačanska Lepotica and Stanley. Pruning was done during the dormant period by hedging both sides with a saw-bar, while the tops were trimmed manually from the platform. The top part of the trees was pruned by hand using a towed tractor platform. The usual manual pruning was control pruning, which involved pruning of the lower tree part from the ground, while the upper part of the tree was also pruned manually from a towed platform. The research analyzed the efficiency of the pruning, varietal specificities suitable for mechanical pruning, as well as the quality of cuts made during mechanical pruning. Statistical analysis was performed in the Microsoft Excel software package. The obtained results are presented tabularly and graphically.

RESULTS AND DISCUSSION

Mechanical pruning can be one of the alternative solutions in conditions of persistent labor shortage. Research in California during 2019 showed that 56% of the farmers had been unable to hire enough employees for production of their crops at some point during the past five years (Rutledge et al., 2019). The mechanical pruning within the research was carried out in two passes on both sides of the row. Pruning time per tree did not significantly differ between varieties and ranged from 11.40 to 12.08 seconds per tree (Table 1). Nunez (2016) makes similar statements about the time required for mechanical pruning of sweet cherry and apple in a spindle training system. According to the author, in a triple pass with mechanical pruning, 15 to 16 seconds of pruning were needed per tree. The speed of manual pruning in the upper part was significantly higher in the part where mechanical pruning of the lower part was performed (Table 2), which can relate to easier access to the upper part of the tree in the rows where mechanical pruning was previously performed.

Table 1. Efficiency of mechanical (combined) pruning in the analyzed varieties (s)

	Mechanical pruning (seconds per tree)	Manual pruning of the upper part from the platform (seconds per tree)	Total (seconds per tree)
Čačanska rodna	12.08	64.40	76.48
Čačanska lepotica	11.56	46.00	57.56
Stanley	11.40	77.52	88.92

Table 2. Efficiency of manual pruning in analyzed varieties (s)

	Manual pruning of the lower part of the tree - from the ground (seconds per tree)	Manual pruning of the upper part from the platform (seconds per tree)	Total (seconds per tree)
Čačanska rodna	96.30	131.36	227.99
Čačanska lepotica	48.78	89.60	138.38
Stanley	112.00	156.16	268.16

Nunez (2016) reported that mechanical pruning of apple and sweet cherry was 23 to 29 times faster compared to manual pruning, which is significantly higher compared to our research (Table 3). Pruning of the lower part of the tree (mechanical pruning) was on average 4.22 (Čačanska lepotica) to 9.82 (Stanley) times faster compared to manual pruning of the lower part. The speed of pruning of the tree upper part was faster by 1.95 (Čačanska lepotica) to 2.01 (Čačanska rodna) or up to 2.04 (Čačanska lepotica) compared to the pruning of the same varieties, where mechanical pruning was not applied.

Table 3. Pruning speed (x times) when using mechanical (combined) and manual pruning

	Stanley	Čačanska lepotica	Čačanska rodna
Upper part of the tree	2.01	1.95	2.04
Lower part of the tree	9.82	4.22	8.00

The time required for combined pruning (mechanical pruning and manual pruning) per unit area was from 2.80 days per hectare for the Čačanska lepotica variety to 4.32 days for the Stanley variety (Figure 1). Manual pruning was significantly slower. Pruning of one hectare took from 6.73 days for Čačanska lepotica to 13.04 days for the Stanley variety. It should be noted that the differences between the varieties are mainly determined by the difference in the time required for the lower part pruning, that is, the difference that was achieved by applying mechanical pruning.

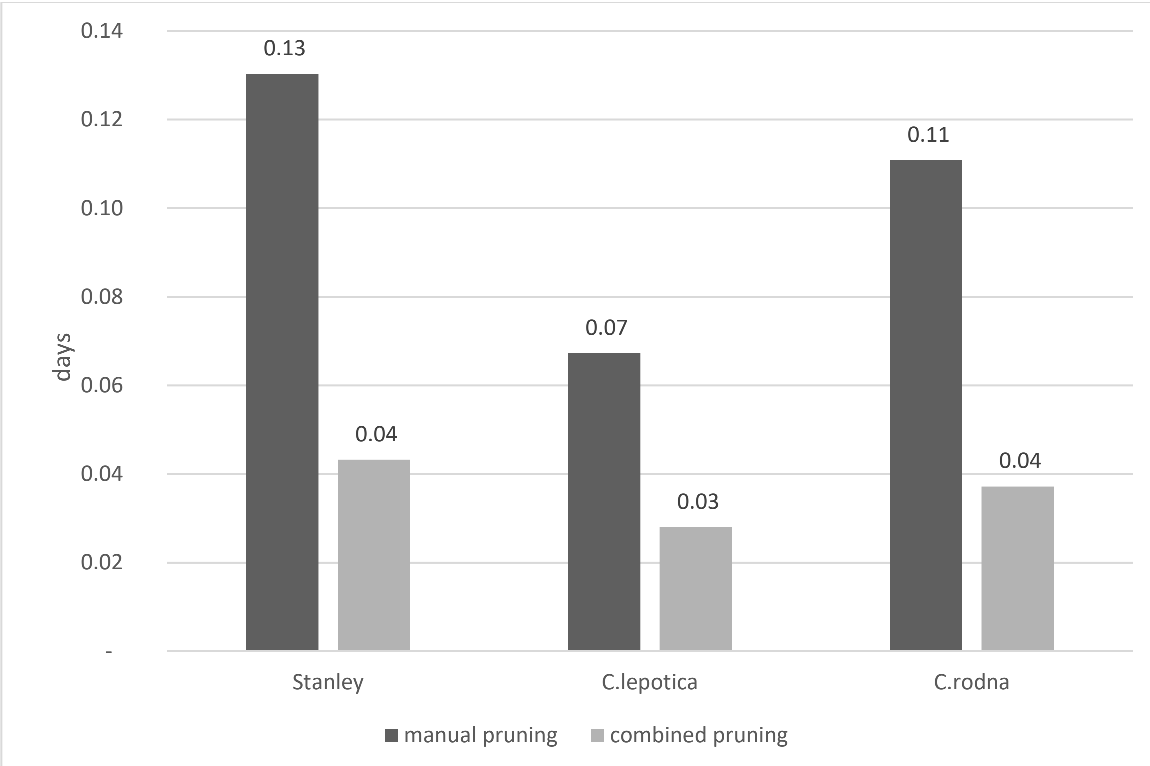


Figure 1. Pruning length depending on the applied method (day/ha)

Čačanska lepotica, Čačanska rodna and Stanley show distinct varietal specificities in terms of suitability for mechanical pruning. Stanley is characterized by a wide crown with shoots that are branching at an open angle, so mechanical pruning is very effective, and its application contributes to the formation of a regular conical training system (Figure 2 a-b).

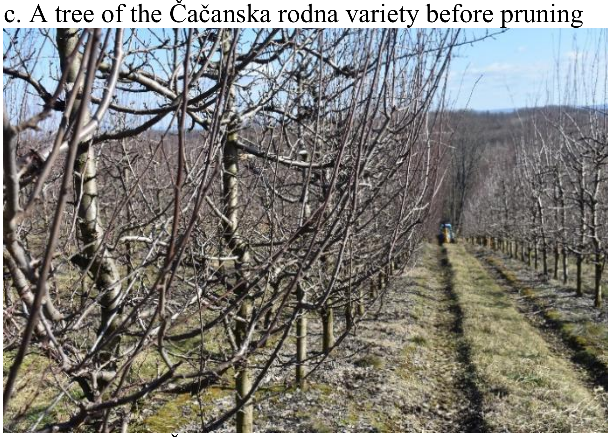
Čačanska rodna (Figure 2 c-d) is characterized by flexible and long shoots, which form a hanging (pendulous) shape, and that represents a difficulty during pruning. The greatest challenge in mechanical pruning is the Čačanska lepotica cultivar, where the structure is dominated by shorter fruiting shoots, while longer one-year shoots are mostly upright and closer to the central leader (Figure 2 e-f). Mechanical pruning usually only results in the shortening of such shoots in the upper part, which affects the activation of the top part of the shortened shoot.

a. A tree of the Stanley variety before pruning

b. A tree of the Stanley variety after pruning


c. A tree of the Čačanska rodna variety before pruning


d. A tree of the Čačanska rodna variety after pruning


d. A tree of the Čačanska lepotica variety before pruning


e. A tree of the Čačanska lepotica variety after pruning

Figure 2. Appearance of tested varieties before and after mechanized pruning (a-d)

A wider spreading of the mechanical pruning practice is hindered by an irrational approach of many producers. For instance, several wine producers believe that in mechanically pruned vineyards the quality of grapes and the wine made of them is of inferior quality as compared to traditionally pruned vineyards despite the absence of evidence to that effect. However, many producers are concerned about the risk of excessive damage to trees during mechanical pruning, which could lead to viral and fungal infections and possibly to withering of the shoots. Rosecrance et al. (2021) state that pruning results in thousands of nonselective cuts that are potential entry points for rain-splashed fungal spore infection from diseases such as *Cytospora* and *Botryosphaeria*. Spraying with a fungicide soon after any pruning can reduce the risk of infection. The analysis of plum mechanical pruning in the previous period showed that a lower percentage of cuts (30-40%) were correctly done, i.e., "clean" (Figure 3a), while many cuts were made with minor or major damage to the wood and bark (Figure 3 b-d). Regardless of the cuts quality that were made during the research (immediately after pruning and during the vegetation period), no changes were noted that would indicate the appearance of diseases.

a. Correct ("clean") cut

b. Cut with more bark damage ("unclean" cut)

c. Different types of cuts in the upper part of the tree

d. Cut with more bark damage ("unclean" cut)

Figure 3. Appearance of different cuts made during mechanized pruning

CONCLUSIONS

Preliminary research on plum mechanical pruning indicates the potential of applying this pomotechnical measure in regular production. Mechanical plum pruning should be combined with manual pruning in the top part of the crown. The effectiveness of combined pruning compared to manual pruning is on average 2.4 to 3.1 times higher, depending on the variety. Varietal specificities manifested through tree architecture significantly affect the efficiency and quality of mechanical pruning application. In the previous work, because of cuts, no negative occurrences (health status of the plants) have been registered, but slightly greater damage to the bark and wood was noted. Mechanical pruning shows the potential to reduce production costs, improve workers' safety and efficiency and increase long-term sustainability of fruit production; however, there is considerable work remaining to find the best conditions for an optimal mechanization of pruning.

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REFERENCES

Nunez, J.A.G. (2016). The effects of mechanical pruning on yield, fruit quality and vegetative growth in apple and sweet cherry. *Diss. Washington State University*.

Niederholzer, F., Jarvis-Shean, K., Lightle, D., Milliron, L., Stewart, D., & Summer, D.A. (2018). Sample Costs to Establish an Orchard and Produce Prunes *(Sacramento Valley, USA: UCCE, UC-AIC, UC DAVIS-ARE*), pp. 23.

Bates, T., & Morris, J. (2009). Mechanical cane pruning and crop adjustment decreases labor costs and maintains fruit quality in New York 'Concord' grape production. *Horttechnology 19 (2),* pp. 247–253.

Ferguson, L., Maranto, J., & Beede, R. (1995). Mechanical topping mitigates alternate bearing of 'Kerman' pistachios (Pistacia vera L.). *Horticulture Science 30 (7),* pp. 1369–1372.

Cvetković, M., & Mićić, N. (2018). Twenty years of experience in intensive plum production on Prunus cerasifera Ehrh. rootstock. *Scientific Papers Serie B Horticulture, LXII,* pp. 175–179.

Miranda Sazo, M. & Robinson, T. L. (2013). Recent advances of mechanization for the tall spindle orchard system in New York state - Part 1. *New York Fruit Quarterly, 21(1),* pp. 15-20.

Kallsen, C. E. (2005). Topping and manual pruning effects on the production of commercially valuable fruit in a midseason Navel orange variety. *Horticulture Technology, 15(2),* pp. 335-341

Velazquez, B. & Fernandez, E. (2010). The influence of mechanical pruning in cost reduction, production of fruit, and biomass waste in citrus orchards. *Applied engineering in agriculture, 26(4),* pp. 531-540.

Martin - Gorriz, B., Porras, I. & Torregrosa, A. (2014). Effect of mechanical pruning on the yield and quality of 'Fortune' mandarins. *Spanish Journal of Agricultural Research, 12(4),* pp. 952-959

Dias, A. B., Peca, J. O. & Pinheiro, A. (2012). Long-term evaluation of the influence of mechanical pruning on olive growing. *Agronomy journal, 104(1)*, pp. 22-25

Cherbiy-Hoffmann, S., Searles, P., Hall, A. J. & Rousseaux, M. C. (2012). Influence of light environment on yield determinants and components in large olive hedgerows following mechanical pruning in the subtropics of the Southern Hemisphere. *Scientia Horticulture, Volume 137,* pp. 36-42

Nowakowski, T., & Nowakowski, M. (2018). Assessment of tree sprouts pruning with various types of cutting units. *Agricultural Engineering,* pp. *22*.

Nowakowski, T., Dąbrowska, M., Sypuła, M., & Strużyk, A. (2018). A method for evaluating the size of damages to fruit trees during pruning using different devices. *Scientia Horticulturae*, *242*, pp. 30-35.

Karkee, M., Adhikari, B., Amatya, S. & Zhang, Q. (2014). Identification of pruning branches in tall spindle apple trees for automated pruning. *Computers and electronics in agriculture, Volume 103*, pp. 127- 135.

Mićić, N., Đurić, G., and Cvetković, M. (2005). Sistemi gajenja šlive. [Growing systems and pruning of plum]. Belgrade, Republic of Serbia: *Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia*, pp.60.

Rutledge, Z., Taylor, J.E., Neagu-Reed, S., Little, B., and Kranz, D. (2019). Still Searching for Solutions: Adapting to Farm Worker Scarcity Survey 2019 (*Davis, CA, USA: California Farm Bureau Federation and University of Dalas*), pp.11.

Rosecrance, R., Milliron, L., & Niederholzer, F. (2021). Mechanical pruning of'Improved French'prune trees. In *XII International Symposium on Plum and Prune Genetics, Breeding and Pomology 1322* (pp. 253-258).

Cvetković, M., Glišić, I. P., & Pašalić, B. (2021, September). Plum training systems on vigour rootstocks-experience from Serbia and Bosnia and Herzegovina. In *XII International Symposium on Plum and Prune Genetics, Breeding and Pomology 1322* (pp. 229-238).