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## Efficiency of mechanized pruning in apple cv. maxi gala

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**Abstract:** Pruning is one of the main management practices for apple cultivation, aiming to achieve a better balance between vegetative growth and production, but it presents a high demand for labor. Thus, mechanical pruning can minimize the operation, requiring technical feasibility and operational performance studies. Precision agriculture provides several technological tools that can be adopted at different stages of the fruit-growing production process, but reports in the area are scarce. This study evaluated the spectral behavior of apple plants during the production cycle, operational efficiency, and the main quality indices of fruits from plants subjected to different pruning systems using a vegetation sensor. The study was conducted in the 2020/21 and 2021/22 agricultural seasons in a commercial 'Maxi Gala' apple orchard under two rootstocks. The treatments consisted of standard pruning, mechanized autumn pruning, mechanized summer pruning, mechanized autumn and summer pruning, and control without pruning. The highest biomass production stages of apple plants influenced the normalized difference vegetation index values in the first growing season. Mechanized pruning treatments took less time to prune one hectare compared to standard pruning. However, no significant difference was observed between the different treatments for fruit yield and the average fresh mass of both rootstocks. Mechanized pruning treatments practically did not alter fruit quality.

**Index terms:** Innovation, Management, Mechanization.

## Eficiência da poda mecanizada em macieira cv. maxi gala

**Resumo:** A poda é uma das principais práticas de manejo da cultura da macieira visando a possibilitar melhor equilíbrio entre o crescimento vegetativo e a produção, mas apresenta alta demanda de mão de obra. Assim, a poda mecânica pode minimizar a operação, havendo a necessidade de estudos de viabilização técnica e de rendimento operacional. A Agricultura de Precisão fornece diversas ferramentas tecnológicas que podem ser adotadas em diversas etapas do processo produtivo na fruticultura, mas são escassos os relatos na área. Os objetivos do presente trabalho foram avaliar o comportamento espectral da macieira durante

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o ciclo produtivo, a eficiência operacional e os principais índices de qualidade dos frutos de plantas submetidas a diferentes sistemas de poda, por meio de sensor de vegetação. O estudo foi conduzido nas safras agrícolas de 2020/21 e 2021/22, em pomar comercial de macieiras 'Maxi Gala' sob dois porta-enxertos. Os tratamentos foram: poda-padrão, poda mecanizada no outono, poda mecanizada no verão, poda mecanizada no outono e verão e testemunha, sem poda. Na primeira safra, os estádios de maior produção de biomassa das plantas de macieiras influenciaram os valores de Índice de Vegetação por Diferença Normalizada. Os tratamentos com poda mecanizada apresentaram menor tempo para podar um hectare, se comparados à poda-padrão. Já, para o rendimento de frutos e a massa fresca média, de ambos os porta-enxertos avaliados, não se observou diferença significativa entre os diferentes tratamentos. Os tratamentos de poda mecanizada praticamente não alteraram a qualidade dos frutos.

**Termos para indexação:** Inovação, Manejo, Mecanização.

## Introduction

The apple (*Malus domestica* Borkh) production chain is one of the pioneers in implementing the integrated production system, which advocates the use of management technologies through monitoring all production stages. However, some operations are still conducted with little use of mechanization. Most cultural practices in apples are carried out manually, making cultivation very dependent on labor and increasing the cost of production over the years.

One of the main apple management practices is pruning, as it aims to provide a better balance between vegetative growth and production (RUFATO et al., 2022). Pruning is the easiest management practice to implement mechanization and has already been used although still semi-mechanically, which demands high availability of labor, in addition to not being properly consolidated due to the need for evaluations. Depending on the annual vegetative growth, the demand for pruning carried out manually may vary from 50 to 200 hours per hectare. In situations of high demand, it requires many workers and an increase in the time required to carry it out, leading to variability in pruning within the same orchard.

Precision agriculture (PA) offers several technological tools that are adopted at var-

ious stages of the agricultural production process. In Brazil, precision fruit growing has already been implemented in some crops such as citrus and vines, but there are few studies for other fruit trees, such as apples. PA technologies have great potential to evaluate and improve the prediction of the timing, intensity, and quality of pruning. The use of vegetation sensors that allow the evaluation and monitoring of plant behavior with different forms of pruning (manual and mechanized) throughout the production cycle is an alternative for producers to make more assertive decisions regarding the time and intensity of the management practice.

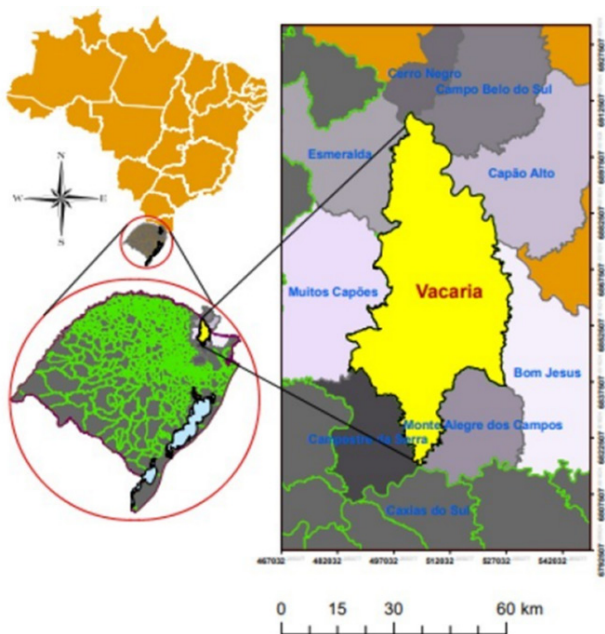
Thus, this study aimed to evaluate the spectral behavior of apple plants subjected to different pruning systems during the crop cycle, using vegetation sensors, evaluate the amount of biomass removed from plants, the main fruit quality indices, and evaluate the operational efficiency of mechanized pruning compared to manual pruning.

## Material and Methods

### *Location and characterization of the area under study*

The field experiment was conducted in the 2020/2021 and 2021/2022 agricultur-

al seasons in a commercial orchard in the municipality of Vacaria, Rio Grande do Sul (RS), Brazil, at the geographic coordinates 28°26'57" S and 50°50'29" W. The municipality of Vacaria is located in the physiographic region of Campos de Cima da Serra (Figure 1).



**Figure 1.** Location map of the municipality of Vacaria, RS, Brazil. Source: Lana, Werlang, and Saldanha (2018).

The regional climate is classified, according to Köppen, as Cfb, that is, a humid temperate climate with mild summers. The average annual rainfall is above 1,600 mm, distributed throughout the year. The average air temperature varies from 11.4 to 20.6 °C between the coldest (July) and hottest months

(January) (PEREIRA et al., 2009). The soil is classified as an Oxisol (Latossolo Bruno aluminoférrico típico – LBaf), according to Streck et al. (2018), with chemical characteristics suitable for apple cultivation.

### **Experimental design and description of treatments**

Soil samples were collected before the experiment was set up, in August 2019, at a depth of 0–0.20 from two studied blocks (Blocks 4 and 7). The experiment was conducted in two blocks of a commercial orchard, with the same row spacing but different rootstocks. Block 4 has 8.61 hectares of ‘Maxi Gala’ grafted on Marubakaido with an M9 filter and a spacing of 4 meters by 0.8 meters, totaling 3,125 plants ha<sup>-1</sup>. Block 7 has 2.35 hectares of ‘Maxi Gala’ with M9 rootstock and a spacing of 4 meters by 0.5 meters, totaling 5,000 plants ha<sup>-1</sup>. These areas were planted in 2006.

The experimental design consisted of randomized blocks with four replications. The experimental unit in Block 4 consisted of three cultivation rows 20 meters long, whereas the experimental unit in Block 7 consisted of three cultivation rows 13 meters long. The treatments were composed of the type and time of pruning (Table 1). Six central plants were selected in each experimental unit for phytotechnical evaluations.

**Table 1.** Characterization of the treatments evaluated in the experiments in both orchards.

Treatment	Treatment description
T1	Control (no pruning)
T2	Producer standard pruning (end of June)
T3	Mechanized autumn pruning (end of June)
T4	Mechanized summer pruning (end of December)
T5	Mechanized autumn and summer pruning (end of June and end of December)

The mechanized pruning method was carried out using Hidrautec HLC-3 and HLC-5 pruners coupled to a New Holland TL 75E tractor, aiming to prune the upper and the lateral parts of the canopy, respective-

ly (Figure 2A). The average speed of the operation was 3.8 km/h, and the pruners were adjusted using a trapezoid-shaped set square (Figure 2B). The maximum cutting height of the plant canopy was 4 me-

ters, with the base cutting in the upper third of 0.4 meters and the lower third of 0.8 meters, on each plant side. Standard pruning is characterized as pruning used by rural producers, aiming to remove only some vegetative branches and poorly positioned branches to improve the incidence of sunlight on the plant, without

removing branches. The operation was conducted by four employees from the company Campi Frutas, who used ladders to enable pruning in the upper third of the plant (Figure 2C). The orchard was managed by the producer following the principles of integrated apple production (CTPIM, 2020).

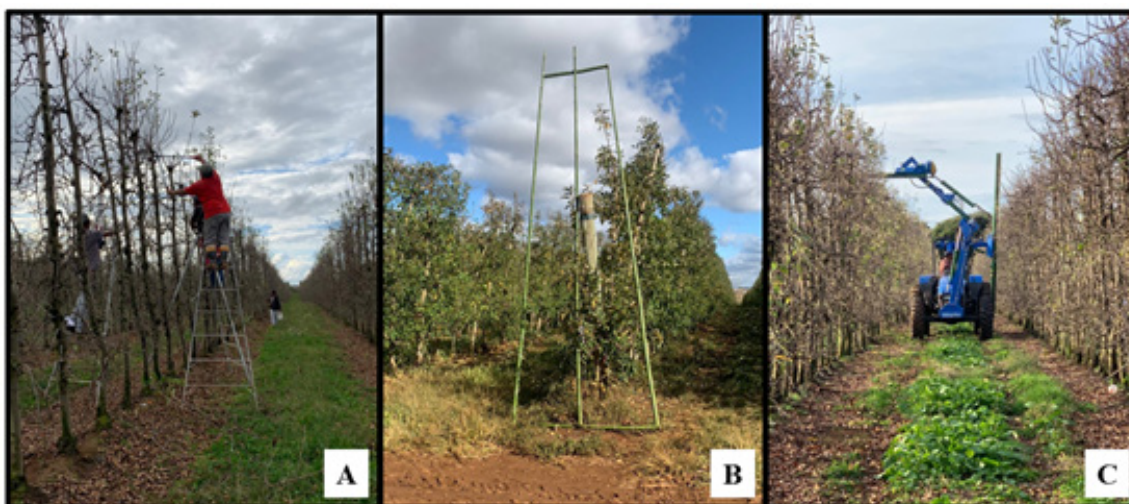


Figure 2. Manual pruning (A), set square (B), and standard mechanized pruning (C).

Meteorological data from the experimental areas monitored during the experiment period were obtained from the INMET meteorological station (A880) in the municipality of Vacaria, RS, Brazil. Data on minimum, average, and maximum temperatures and rainfall were collected. The annual rain-

fall was 2,175.0 mm in the 2020/21 growing season and 1,490.0 mm in the 2021/22 growing season. A significant reduction in fruit yield was observed in the 2021/22 cycle due to a severe water restriction caused by the La Niña phenomenon, in which there was a reduction of 250 mm (Figure 3).

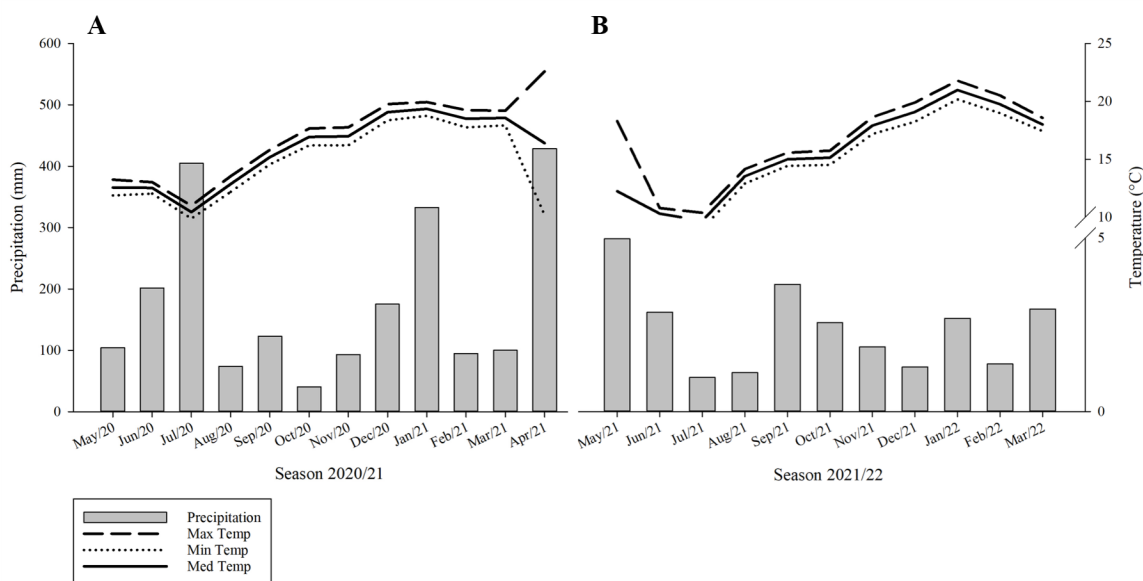


Figure 3. Air temperature (°C) and rainfall (mm) during the crop cycle in the municipality of Vacaria, RS, Brazil, in the 2020/21 and 2021/22 agricultural seasons.

## **Analyzed variables**

The amount of fresh biomass of branches removed in each pruning method was quantified using a precision scale by evaluating the pruned branches from the plot (six central plants) and, subsequently, separating the mass of branches of one year and two years or more. The operational performance of each pruning method was evaluated using a stopwatch. The data on the sampling unit size and the time required to prune the sampling unit allowed the results to be extrapolated to time (h) per area (ha) used for pruning.

The assessment of canopy reflectance was obtained using a Greenseeker® active optical sensor, which measures the normalized difference vegetation index (NDVI). The sensor measures the reflectance of red and infrared radiation at red (650 nm) and near-infrared (770 nm) wavelengths. The vegetative canopy reflectance assessments were conducted monthly from October 2020 to April 2021 and from October 2021 to February 2022. The Greenseeker® was positioned laterally to the crop row at two heights of the plant canopy, that is, 1.20 and 2.00 meters, respectively, and the readings were taken at 0.8 meters through the linear displacement of the equipment.

Fruit yield was quantified by manually harvesting all fruits from the plot, with the total value of each plot extrapolated to  $\text{kg ha}^{-1}$ . A random sample of 20 fruits from each plot from the total harvest per plant was used to assess quality. The evaluated quality parameters were classification by category, color, determination of pulp firmness, °Brix, and the fruit iodine-starch index.

The fruits were classified into Categories 1, 2, 3, 4, and 5, based on the parameters required by Normative Instruction No. 5 of February 9, 2006, of the Ministry of Agriculture, Livestock, and Food Supply. Subsequently, the color was classified visually into Categories I, II, III, and IV. The Color

I classification presented up to 25% of the epidermis area with a red color and stripes. Fruits classified as Color II had 26 to 50%, those belonging to Color III had 51 to 75%, and those classified as Color IV had 76 to 100% of the epidermis area with a red color and stripes. The iodine-starch index and weighing the fruits, pulp firmness was assessed by cutting a portion of the skin on two opposite sides of the apple. Total soluble solids (TSS) were evaluated with a refractometer, where drops of juice were extracted from each of the fruits and the °Brix was read.

## **Statistical analysis**

Previously, the data was analyzed for the presence of outliers, which were excluded. The results were then subjected to normality and homogeneity tests. Subsequently, an analysis of variance (ANOVA) was carried out and the difference between the means of treatments was evaluated by the LSD test at a 5% level for the productivity variable. The difference between the NDVI means was evaluated using the least significant difference (LSD) using the F-test at a 5% probability of error.

## **Results and discussion**

The treatment with mechanized autumn pruning showed the lowest mass both for branches with one year and for branches two years or more among those pruned during the 2020/2021 growing season in the area with 'Maxi Gala' grafted on Marubakaido with M9 filter. Mechanized autumn pruning showed the lowest mass only of branches pruned with one year in the 2021/2022 growing season. However, the time when mechanized pruning was conducted did not affect the mass of pruned branches with two years of age or more (Table 2).

Standard pruning in the first agricultural season in the 'Maxi Gala' area grafted on Marubakaido with an M9 filter was the

only treatment that had a significant difference between the mass of branches pruned with one and two years or more. Only mechanized autumn pruning during the 2021/2022 growing season showed no statistical difference. The other treatments with mechanized pruning showed a

higher number of branches of one year removed than branches of two years of age or more. On the contrary, the mass of branches of one year removed was smaller than the mass of branches of two years or more where standard pruning was performed (Table 2).

**Table 2.** Mass of branches removed at one year and two years or more from 'Maxi Gala' grafted on Marubakaido with M9 filter and grafted on M9 in the 2020/2021 and 2021/2022 growing seasons.

Growing season	Type of pruning	Branches of 1 year removed (kg)	Branches of 2 years or more removed (kg)	Total removed branches (kg)
<b>'Maxi Gala' grafted on Marubakaido with an M9 filter</b>				
2020/2021	T2	1.12 a B	6.42 a A	7.54 a
	T3	0.19 b NS	0.29 c	0.48 b
	T4	0.68 a NS	0.69 b	1.37 b
	T5	0.89 a NS	0.79 b	1.68 b
2021/2022	T2	1.15 b B	5.19 a A	6.34 a
	T3	0.32 c NS	0.35 b	0.67 b
	T4	2.15 a A	0.68 b B	2.83 ab
	T5	1.59 ab A	0.44 b B	2.03 b
<b>'Maxi Gala' grafted on M9</b>				
2020/2021	T2	1.09 ns B	2.83 a A	3.92 a
	T3	0.31 NS	0.23 b	0.54 b
	T4	0.34 NS	0.24 b	0.58 b
	T5	0.89 NS	0.85 b	1.74 ab
2021/2022	T2	1.15 ns B	4.10 a A	5.25 a
	T3	0.41 NS	0.49 b	0.90 b
	T4	1.43 NS	0.61 b	2.04 b
	T5	1.54 NS	0.72 b	2.26 b

T1 – control; T2 – producer standard pruning; T3 – mechanized autumn pruning; T4 – mechanized summer pruning; T5 – mechanized autumn and summer pruning. Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ from each other by the LSD test ( $p < 0.05$ ); ns = not significant.

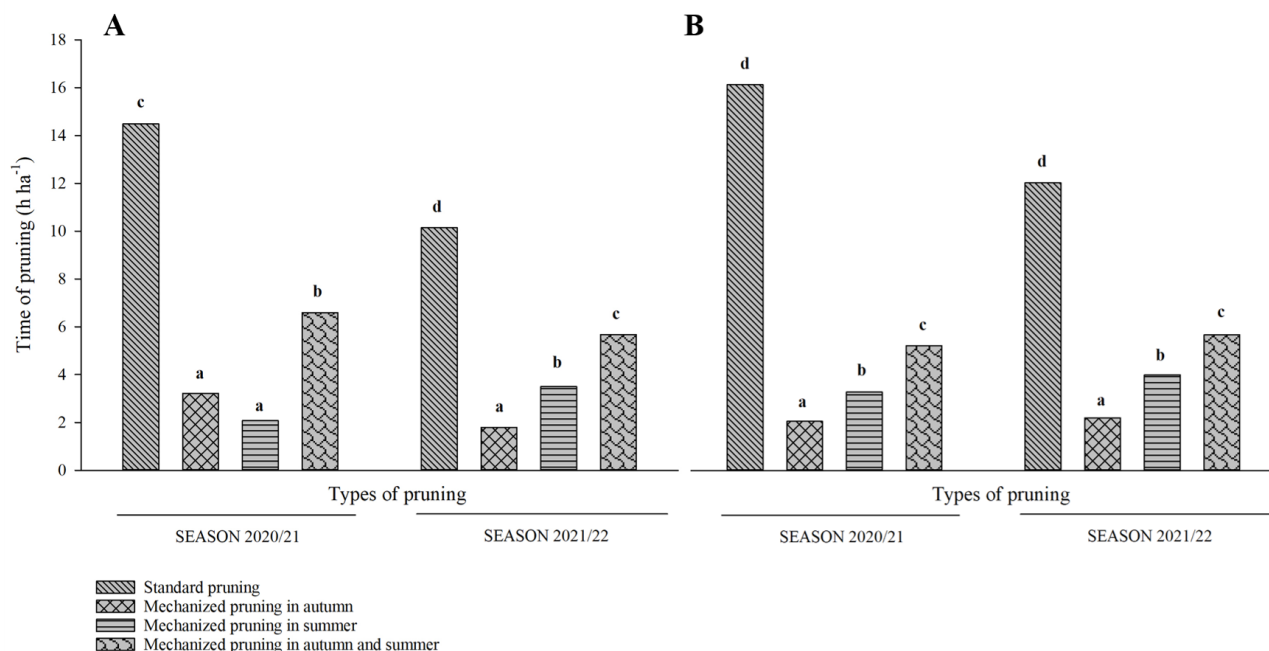
The different treatments showed no significant difference regarding the mass of branches removed from 'Maxi Gala' plants grafted on M9 relative to branches of one year of age, regardless of the analyzed growing season. The mass of branches of two years or more removed showed differences between standard and mechanized pruning, regardless of the time of execution, both for the 2020/2021 and 2021/2022 growing seasons. Only standard pruning showed a significant difference between the mass of branches removed at one year and two years or more, with a higher number of branches removed at two years or more, regardless of the analyzed growing season.

The total number of branches removed was higher in the standard pruning method, regardless of the evaluated rootstocks and growing seasons. In this case, the standard pruning method has a higher selection of branches, prioritizing the removal of the most vigorous and vegetative ones, which are normally older and heavier on the plant. In contrast, the mechanized pruning method removes branches that are outside the previously defined shape, thus leaving only those that grew from one growing season to another.

The pruning time in hours  $ha^{-1}$  for each treatment presents relevant information about

the operational gain, as manual pruning is a costly activity (T2 – standard pruning), directly influencing the operational cost of a commercial orchard. Treatments with mechanized pruning, with emphasis on autumn pruning (T3), showed a significant reduction

in the time needed to prune one hectare, regardless of the year and rootstock. Thus, mechanized pruning allowed the pruning of more hectares in a shorter time regardless of the season, enabling the optimization of human and financial resources (Figure 4).



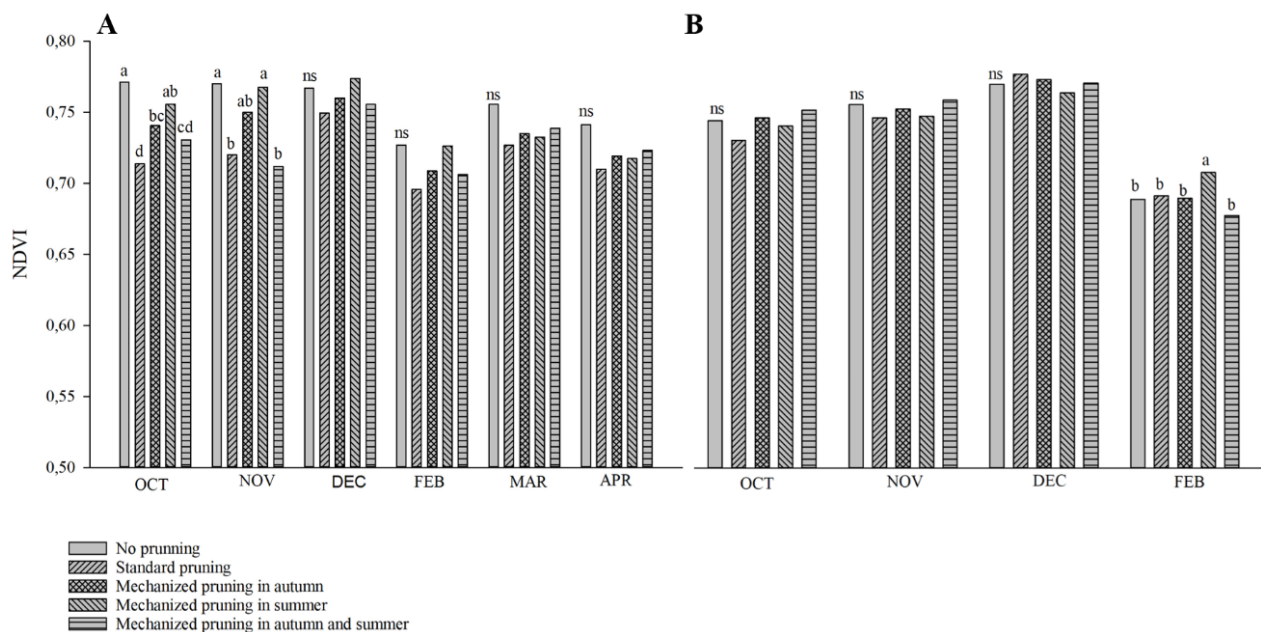
**Figure 4.** Time ( $\text{h ha}^{-1}$ ) required to prune 'Maxi Gala' grafted on M9 (A) and Marubakaido with M9 filter (B) in different types of pruning in the 2020/21 and 2021/22 growing seasons.

The normalized difference vegetation index (NDVI) estimates plant vigor through information on the chlorophyll content and biomass of the plant canopy. Only evaluations conducted in October and November presented a statistical difference between pruning practices in 'Maxi Gala' plants grafted on Marubakaido with an M9 filter in the 2020/2021 growing season, with higher NDVI values for the treatment without pruning, followed by mechanized summer pruning (Figure 5). These NDVI peaks are related to the vegetative growth peak of plants, as found by Kong and Wu (2021). However, the higher biomass production from these treatments did not translate into higher fruit yield, as pruning may or may not increase the vigor of branches but does not alter fruit production (LANDON et al., 2024).

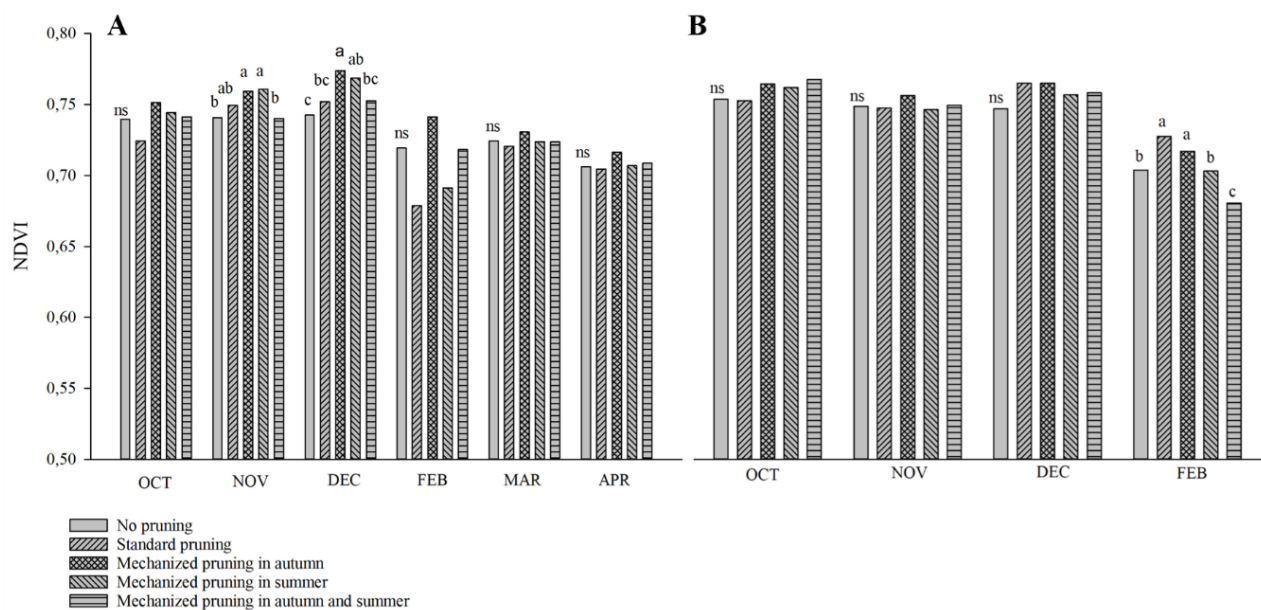
The NDVI assessments for October, November, and December showed no statistical differences in the 2021/2022 grow-

ing season due to water stress caused by the La Niña meteorological phenomenon. Only the evaluation conducted in February 2022 showed a significant difference for the mechanized summer pruning, which presented a higher NDVI than the other treatments. According to Kong and Wu (2021), the correlation between water deficiency and water scarcity influences photosynthetic capacity and nutrient accumulation and may even result in the fall of fruits and leaves.

Apple plants grafted directly onto M9 presented higher NDVI values in the first growing season, contrary to what was observed in plants grafted onto Marubakaido with an M9 filter, which presented the highest values for November and December (Figure 6). The treatment with mechanized autumn pruning stood out in both months with the highest NDVI values, followed by the treatment with mechanized summer pruning, corroborating with Dalezios et al. (2002).



**Figure 5.** Temporal dynamics of the normalized difference vegetation index (NDVI) obtained from an active optical sensor as a function of evaluation dates in ‘Maxi Gala’ grafted on Marubakaido with an M9 filter in the 2020/2021 (A) and 2021/2022 (B) growing seasons.



**Figure 6.** Temporal dynamics of the normalized difference vegetation index (NDVI) obtained from an active optical sensor as a function of the evaluation dates of ‘Maxi Gala’ grafted on M9 in the 2020/21 (a) and 2021/22 agricultural years (b).

The NDVI showed no differences or variations in evaluations in October, November, and December in ‘Maxi Gala’ plants grafted on M9 in the second growing season (2021/2022) due to the La Niña meteorological phenomenon, which caused water stress at critical moments of development of apple cultivation. A statistical difference was observed for the NDVI values from the evaluation conducted in February 2022, in

which the highest NDVI values were obtained for standard pruning and mechanized autumn pruning and the lowest NDVI values for mechanized autumn and summer pruning (Figure 5).

According to Mihaljević et al. (2021) and Kim and Glenn (2017), the biomass production and chlorophyll content of apple plants are drastically reduced under water stress, which is reflected in lower and/or more uni-

form NDVI values, indicating the health and biomass production of plants.

Fruit yield showed no statistical difference for the types of pruning and the growing seasons for the two rootstocks. Importantly, fruit yield was higher than that found in the literature, even with the adaptation of plants to the type of pruning and the water deficiency found during the growing seasons. In this sense, Li et al. (2024) and Faoro et al. (2022) found yields above 40 t ha<sup>-1</sup>. Similarly, Lopez et al. (2018) and Glenn and Tabb (2018) observed that apple plants subjected to water stress produced a smaller number of lighter fruits, resulting in a re-

duction in fruit yield.

The different pruning management strategies on 'Maxi Gala' grafted on M9 or the combination of Marubakaido with an M9 filter showed no influence on fruit color (%), regardless of the analyzed growing season (Table 3). Thus, mechanized pruning allowed a fruit color similar to that of the pruning management currently used by producers. Lugaresi et al. (2022) found that pruning performed in the summer on 'Fuji' plants showed no statistical difference between treatments and was observed that late pruning in the summer promoted redder-colored fruits.

**Table 3.** Evaluation of fruit color (%) of 'Maxi Gala' grafted on Marubakaido with an M9 filter and on M9 in Categories I, II, III, and IV in the 2020/21 and 2021/22 growing seasons.

Growing season	Treatment	Category			
		I	II	III	IV
<b>'Maxi Gala' grafted on Marubakaido with an M9 filter</b>					
2020/2021	T1	0.0 ns	8.7 ns	30.0 ns	61.2 ns
	T2	1.2	8.7	22.5	67.5
	T3	0.0	6.2	22.5	71.2
	T4	1.2	6.2	27.5	65.0
	T5	0.0	1.25	11.2	87.5
	<b>CV (%)</b>	<b>329.1</b>	<b>100.1</b>	<b>56.3</b>	<b>18.0</b>
2021/2022	T1	2.5 ns	13.7 ns	35.0 ns	48.7 ns
	T2	0.0	6.2	12.5	76.2
	T3	0.0	0.0	26.2	73.7
	T4	0.0	6.2	22.5	71.2
	T5	0.0	3.7	16.2	80.0
	<b>CV (%)</b>	<b>447.2</b>	<b>203.3</b>	<b>45.8</b>	<b>27.0</b>
<b>'Maxi Gala' grafted M9</b>					
2020/2021	T1	0.0 b	11.2 ns	31.2 ns	57.5 ns
	T2	0.0 b	15.0	27.5	57.5
	T3	3.7 a	7.5	26.2	62.5
	T4	0.0 b	16.2	35.0	48.7
	T5	2.5 a	20.0	31.2	46.2
	<b>CV (%)</b>	<b>126.5</b>	<b>84.8</b>	<b>44.0</b>	<b>38.5</b>
2021/2022	T1	3.7 ns	11.2 ns	25.0 ns	60.0 ns
	T2	1.2	6.2	17.5	75.0
	T3	0.0	3.7	20.0	76.2
	T4	1.2	2.5	30.0	66.2
	T5	0.0	5.0	21.2	73.7
	<b>CV (%)</b>	<b>209.8</b>	<b>116.4</b>	<b>45.7</b>	<b>16.0</b>

Means followed by the same letter in the column do not differ from each other by the LSD test ( $p < 0.05$ ); ns = not significant. T1: control (no pruning); T2: producer standard pruning; T3: mechanized autumn pruning; T4: standard summer pruning; T5: standard autumn and summer pruning.

There was practically no effect of pruning treatments on fruit color in both rootstocks, which had already been confirmed by Bound and Summers (2001), who discussed that the TSS of fruits increased with the severity of pruning in the autumn-winter, but the reverse was true for plants pruned in the spring. Lugaresi et al. (2022) and Almeida and Fioravanço (2018) observed results that corroborate those found in the present study, in which pruning variation provided no statistical variation in TSS (Table 4).

In terms of fruit pulp firmness, only 'Maxi Gala' grafted onto M9 performed during the second growing season showed a statistical difference (Table 4). The control treatment presented firmer fruit pulps, followed by mechanized summer pruning. According to Guerra et al. (2021), the fruits of pruned apple plants had a lower firm-

ness rate than the control fruits (no pruning) at harvest. However, 'Maxi Gala' plants grafted onto Marubakaido with an M9 filter in both growing seasons, and 'Maxi Gala' grafted onto M9 in the first growing season showed no statistical difference between treatments.

The starch-iodine analysis of 'Maxi Gala' grafted on Marubakaido with an M9 filter in the first growing season showed a statistical difference. Fruits from manual pruning showed more advanced maturation than other treatments, followed by mechanized autumn pruning. However, 'Maxi Gala' fruits grafted on M9 showed no difference in this maturation test in the second growing season (Table 4). Similarly, Lugaresi et al. (2023) and Guerra et al. (2021) observed that variation in pruning management did not influence the iodine-starch test.

**Table 4.** Post-harvest quality assessment of 'Maxi Gala' fruits grafted on Marubakaido with an M9 filter and on M9 in the 2020/21 and 2021/22 growing seasons.

Growing season	Treatment	Average fresh mass (g)	TSS (°Brix)	Firmness (lbs.)	Iodine-starch (1-9)
<b>'Maxi Gala' grafted on Marubakaido with an M9 filter</b>					
20/21	T1	131.6 ns	11.9 ns	14.2 ns	5.8 b
	T2	125.3	12.0	13.0	7.4 a
	T3	128.3	11.9	13.8	6.5 ab
	T4	130.5	11.7	14.0	6.1 b
	T5	126.6	11.8	14.3	6.1 b
21/22	T1	132.2 ns	15.1 ab	15.3 ns	7.0 ns
	T2	122.5	15.8 a	15.7	6.5
	T3	138.4	15.0 ab	14.5	7.5
	T4	129.8	14.2 bc	14.0	7.3
	T5	135.6	14.0 c	14.6	7.1
<b>'Maxi Gala' grafted on M9</b>					
20/21	T1	123.4 ns	11.5 ns	16.5 ns	4.1 ns
	T2	121.7	11.3	16.2	4.2
	T3	127.3	11.3	16.5	3.9
	T4	123.9	11.2	16.6	3.5
	T5	131.9	11.3	16.6	3.5
21/22	T1	122.8 ns	15.1 ns	17.4 a	5.5 ns
	T2	135.0	14.8	15.7 bc	6.5
	T3	141.1	15.3	16.3 abc	5.0
	T4	126.6	15.1	17.0 ab	5.6
	T5	131.5	14.8	15.2 c	6.4

T1 – control; T2 – producer standard pruning; T3 – mechanized autumn pruning; T4 – mechanized summer pruning; T5 – mechanized autumn and summer pruning. Means followed by the same letter in the column do not differ from each other by the LSD test ( $p < 0.05$ ); ns = not significant.

Importantly, plants where mechanized pruning was conducted need to be reviewed to remove diseased branches, which serve as a source of inoculum for the rest of the area. In addition, vegetative branches need to be removed, as they compete with productive branches for photoassimilates.

## Conclusion

Mechanized pruning is faster compared to standard pruning, regardless of the season of execution. Mechanized pruning conducted in the autumn reduces the time required to prune a hectare of apple plants by up to 80%. The pruning time for mechanized pruning is shorter than that obtained with

standard pruning, regardless of the season of execution.

The mechanized pruning method allowed fruit yields similar to pruning traditionally conducted by producers, regardless of the rootstock and season of execution.

Mechanized pruning at different seasons does not influence the quality parameters of 'Maxi Gala' apples grafted on M9 or Marubakaido with an M9 filter.

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