REVISTA ELETRÔNICA CIENTÍFICA DA UERGS

Rejuvenation pruning in a pecan orchard in southern Brazil

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ISSN 2448-0479. Submetido em: 06 abr. 2023. Aceito: 12 dez. 2024.
DOI: http://dx.doi.org/10.21674/2448-0479.101.66-73

Abstract

Rejuvenation pruning in a pecan orchard in southern Brazil

This study aimed at evaluating pruning intensities as a rejuvenation method applied to a pecan orchard in order to improve fruit production and quality. The experiment was carried out in a 40-year-old orchard which had not been subject to any management in Capão do Leão, Rio Grande do Sul (RS) state, Brazil. It was conducted in both 2015/16 and 2016/17 seasons. Treatments consisted in carrying out light pruning (60 kg of limb removal), hard pruning (180 kg of limb removal) and no pruning. The experiment had a randomized block design in a factorial scheme (pruning intensity x season). Variables under analysis were production per plant, number of fruit, mean fruit mass, mean kernel mass, mean shell mass, fruit diameter, fruit length and kernel yield. Results showed that there was difference between factors related to production per plant and number of fruit. Hard pruning not only led to 4-fold increase in crops but also increased fruit and shell masses. The highest kernel percentage was found after light pruning in the second season. Hard pruning led to increase in production in the following year. Thus, hard pruning showed to be the intensity recommended for pecan orchard rejuvenation.

Keywords: *Carya illinoinensis;* pruning intensity; production; quality.

Resumen

Poda de rejuvenecimiento en un huerto de nogal pecán en el sur de Brasil

Este estudio tuvo como objetivo evaluar las intensidades de poda como método de rejuvenecimiento aplica-

do a un huerto de nogales pecán para mejorar la producción y calidad de los frutos. El experimento se llevó a cabo en un huerto de aproximadamente 40 años y con ausencia de manejo en la ciudad de Capão do Leão, Rio Grande do Sul (RS), Brasil. El período de realización del experimento fue durante las zafras de 2015/16 y 2016/17. Los tratamientos consistieron en la realización de podas ligeras (retirando 60 kg de ramas), podas severas (retirando 180 kg de ramas) y sin poda. El diseño fue en bloques al azar en un esquema factorial (intensidad de poda y zafra). Las variables analizadas fueron producción por planta, número de frutos por planta, masa media de frutos, almendras y cáscaras, diámetro y longitud de fruto y rendimiento de almendra. Los resultados mostraron que hubo diferencia entre los factores relacionados con la producción por planta y el número de frutos. La poda severa no solo condujo a un aumento de 4 veces la producción en los cultivos, sino que también aumentó la masa de frutos y cáscaras. El mayor porcentaje de almendras se encontró después de una poda ligera en la segunda zafra. La poda severa condujo al aumento de la producción en el año siguiente a su realización. La poda severa demostró ser la intensidad recomendada para el rejuvenecimiento del huerto de nogal pecán.

Palabras clave: *Carya illinoinensis;* intensidad de poda; producción; calidad.

Resumo

Poda de renovação em um pomar de nogueira-pecã no sul do Brasil

O trabalho objetivou avaliar intensidades de poda como método de renovação de pomar de nogueira-pecã, visando promover tanto a melhoria da produção quanto da qualidade dos frutos. O experimento foi conduzido em um pomar de aproximadamente 40 anos de idade que não recebia manejo, localizado no município do Capão do Leão, Rio Grande do Sul, Brasil, durante os ciclos 2015/16 e 2016/17. Os tratamentos consistiram na realização da poda leve (remoção de 60 kg de ramos); da poda severa (remoção de 180 kg de ramos) e na ausência de poda. O delineamento ocorreu em blocos ao acaso e arranjado em esquema fatorial (intensidade de poda e ciclo). As variáveis analisadas abrangeram produção por planta, número de frutos, massa média de frutos, amêndoas e cascas, diâmetro e comprimento de fruto e rendimento de amêndoa. A análise dos resultados revelou diferença entre os fatores relativos à produção por planta e número de frutos. Com a poda severa a produção obteve acréscimo quadruplicado entre safras. Além disso, a poda severa também aumentou a massa de frutos e cascas. A porcentagem de amêndoa elevou-se com a poda leve no segundo ciclo. Desse modo, a poda severa demonstrou promover um aumento da produção no ano subsequente à sua realização, apontando ser a intensidade recomendada para renovação do pomar de nogueira-pecã.

Palavras-chave: *Carya illinoinensis;* intensidade de poda; produção; qualidade.

Introduction

Pecan (*Carya illinoinensis*), a crop which is native to North America, has been expanding worldwide. It can be found in its native countries – the United States and Mexico –, South America (Argentina, Uruguay, Peru, Chile and Brazil), South Africa, Egypt, China and Australia (Wells, 2017; Bilharva *et al*. 2018; De Marco *et al*., 2021).

In Brazil, its first agricultural cycle took place in the 1960's when the legislation encouraged pecan production. Even though the crop improved fast, several factors, such as lack of technical knowledge, scarce assistance with management practices and high incidence of diseases, led to abandonment and consequent decrease in production (Martins *et al*., 2018).

Pruning practices are alternative solutions to revive old orchards. Pruning must be carried out from the beginning of orchard implementation up to the fifth year in order to conduct plants correctly. After the fifth year, pruning aims to increase the productive potential of the plants, that is, pruning is carried out to promote the increase of productive branches. However, over the years, pruning becomes increasingly difficult to perform without the proper equipment that reaches the height of the plants. This type of pruning enables sunlight to penetrate tree canopies, which is fundamental to the photosynthesis process and fruit production. Adult

orchards usually intercept from 65% to 70% of sunlight while dense (with more than 100 plants per hectare) and unpruned ones may reach 95% (Lombardini, 2006; Wells, 2018). Most old orchards are not subject to pruning management, a fact that results in disordered limb growth and consequent excess of shading, lack of reproductive structures and high incidence of diseases.

Pruning favors decrease in shading and, consequently, decreases relative humidity, which reflects on low possibility of diseases in orchards (Worley; Mullinix; Daniel, 1996; Kallestad; Mexal; Sammls, 2008). Pruning intensity is an important fact since the number of removed limbs may increase production and affect vegetative structures to restore plant growth (Worley; Mullinix, 1997).

There are very few studies that aim at finding alternatives to make old pecan orchards productive and address the right pruning intensity to be applied to plants. Therefore, this study aimed at evaluating the effect of intensities of rejuvenation pruning on pecan production and quality.

Material e Metods

The experiment was conducted in a private property in Capão do Leão, Rio Grande do Sul (RS) state, Brazil (latitude 31°47'13" S; longitude 52°24'43" W; altitude of 15 m), in both 2015/16 and 2016/17 seasons. In Köppen's climate classification, the climate in the area is Cfa – humid subtropical (Alvares et al., 2014).

The pecan orchard was implanted about 40 years ago. Spacing among three cultivars (Mahan, Moneymaker and one with no identification) is 10m x 10m. The cultivar evaluated by the experiment reported by this paper is Moneymaker because of its low incidence of diseases and high production. This orchard had not been subject to any pruning, which led to low production. Therefore, the experiment with different intensities of rejuvenation pruning consisted of the following treatments: 1) no pruning (Figure 1a); 2) light pruning (Figure 1b); and 3) hard pruning (Figure 1c). The design comprised five randomized blocks and every unit consisted of three plants. Besides, a factorial scheme (levels of pruning intensity x 2015/16 and 2016/17 seasons) was used. Pruning was conducted in September 2015 and consisted in removing the central limb, poorly positioned ones and sick ones in order to open more the center of the plant canopy by a Stihl® pole pruner. Light and hard pruning removed about 60 kg (± 10 kg) and 180 kg (± 20 kg) of mass, respectively. It represented approximately 10% with light pruning and 25% with hard pruning.

Figure 1 — Pecan plants and their treatments: no pruning (a), light pruning (b) and hard pruning (c). Capão do Leão, RS, Brazil.

Soil in the orchard was identified as Solodic Planosol with medium sandy and medium clay textures (IBGE, 2015). It is characterized by the flat B Horizon (Santos *et al*., 2018).

Variables under investigation in both seasons (2015/16 and 2016/17) were production per plant, yield (calculated only in relation to cultivate evaluations in the experiment), number of fruit per plant, kernel yield, fruit mass, kernel mass, shell mass, fruit length and fruit diameter. Regarding harvest, only fruit found on the soil were collected weekly, from mid-April to the beginning of June. They were placed in a forced air-drying oven at 30°C to reach expected final moisture between 4%. After the drying process, fruit borne per plant were counted and weighed by a scale with precision of 0.01 g.

Ten fruit per plant were selected to have their diameter and length measured by a digital caliper (Matrix®) (up to 150 mm). Fruit had their kernel and shell weighed separately by an analytical scale. Kernel mass was divided by total sample mass and multiplied by 100 to find kernel yield, expressed as percentage.

The analysis of variance (ANOVA) was used for data analysis; in case of significance, means were compared by the Tukey's Test at 5%.

Results and Discussion

There was interaction among factors in the following variables: production per plant, yield (Table 1), number of fruit per plant and kernel yield (Table 2). There was no interaction among factors in mean fruit mass, mean kernel mass, mean shell mass, fruit diameter and fruit length (Table 3). However, fruit mass and shell mass exhibited differences regarding the factor pruning intensity.

Pruning influenced production per plant and yield positively since there was evolution in seasons when light and hard pruning were carried out (Table 1). Light pruning led to increase of 44.62% in production in both seasons (from 2015/16 to 2016/17) and resulted in yield estimate of 1301.2 $kg.ha^{-1}$, while increase was higher (76.76%) when hard pruning was conducted. Concerning absence of pruning, the process declined, i. e., limb and leaf overlapping led to a small number of fruit.

In terms of the analysis of production within a season, the first one exhibited no significant different among treatments. It should be highlighted that, in this season, there were 18 and 17 rainy days in pollination months (September and October), respectively, while there were 19 rainy days in the harvest month (April), a fact that may have affected production. In addition, pecan with vivipary were harvested but they were not viable for evaluation. Vivipary is a gene-environment phenomenon in which embryos keep growing during fruit ripening, before fruit detach from parents; it is related to some factors, such as high moisture in the soil (Wood, 2015; Rodríguez-Gonzáles *et al*., 2022).

However, in the second season, there was an inversion which showed that hard pruning led to the highest production, i. e., 81.34% higher than the treatment with no pruning and 54.22% higher than the treatment with light pruning. Difference in production in both crops is associated with alternate bearing, which is characterized by oscillation in production, which means that ON years (high production) are followed by OFF years (low production) (Wood; Conner; Worley, 2003.; Noperi-Mosqueda *et al*., 2020).

Estimate of yield in the second crop, when pruning was hard, was 2841.1 $kg.ha^{-1}$ (Table 1). Improved Brazilian commercial orchards with proper cultural treatment have potential for productions between 2000 and 3000 kg.ha-1 (Fronza; Hamann, 2016). In Mexico, production is lower than this value. In the experiment conducted by Arreola Ávila *et al*. (2010), mean production per plant was 35 kg but trees were 27 years old. Wells' results (2012) were similar to the ones found in Mexico, but they were found in the United States when 25-year-old trees were evaluated. Hellwig *et al*. (2022) testing two pruning managements (hedge and central) in an orchard with a high density of plants, observed greater production with central pruning in the "On" production cycle, associating it with factors such as reduction of dry branches, greater luminosity and aeration in the canopy of plants.

Table 1 – Production per plant and yield of pecan trees subject to three pruning intensities in both 2015/16 and 2016/17 seasons in Capão do Leão, RS, Brazil.

Treatments	Production per plant (kg)		Yield (kg ha^{-1})	
	2015/16 crop	2016/17 crop	2015/16 crop	2016/17 crop
No pruning	14.0 Aa	5.3 Ab	1400.4 Aa	527.4 Ab
Light pruning	7.2 Aa	13.0 Ab	716.0 Aa	1301.2 Ab
Hard pruning	6.6 Ba	28.4 Aa	664.0 Ba	2841.1 Aa
P > F	0.0041		0.0041	
C.V. (%)	37.13		37.13	

* Different uppercase letters on a line and small ones in a column differ among themselves by the Tukey's test at 5%.

The number of fruit also increased when both light and hard pruning were conducted, while no pruning led to its decrease in the second evaluated cycle (Table 2). Decrease in number of fruit was 2.5-fold higher when there was no pruning. In the treatment with hard pruning, difference between crops was 4.6-fold. Besides, in the 2016/17 season, hard pruning differed statistically from the other treatments, a fact that shows that it is an interesting strategy to be used in orchards over 30 years old.

Table 2 – Number of fruit per plant and kernel yield of pecan trees subject to three pruning intensities in both 2015/16 and 2016/17 seasons in Capão do Leão, RS, Brazil.

Treatments	Number of fruit per plant (n)		Kernel yield (%)	
	2015/16 crop	2016/17 crop	2015/16 crop	2016/17 crop
No pruning	2476.00 Aa	996.00 Ab	44.00 Aa	47.97 Aab
Light pruning	1229.33 Aa	2229.33 Ab	44.95 Ba	51.40 Aa
Hard pruning	986.00 Ba	4546.00 Aa	49.10 Aa	43.77 Ab
P > F	0.0059		0.0167	
C.V. (%)	38.50		5.38	

* Different uppercase letters on a line and small ones in a column differ among themselves by the Tukey's test at 5%.

Regarding kernel yield, only light pruning led to significant increase in crops, mainly in the 2016/2017 one (Table 2). In terms of pruning intensity, light pruning was better than hard pruning in the 2016/2017 crop. The treatment with no pruning was neither worse than light pruning nor better than hard pruning. Kernel yield is a very important criterion in the pecan chain since it defines nut quality and market prices.

Mean fruit mass reflects nut size and filling, i. e., the larger the mass, the fewer fruit are needed to compose, for instance, a kilo. In this study, mean fruit mass was larger when hard pruning was conducted, by comparison with the treatment with no pruning, while light pruning was not different from the other treatments (Table 3). Mean shell mass was also larger when hard pruning was conducted, by comparison with both light pruning and no pruning. Mean kernel mass did not exhibit any difference in the treatments.

Table 3 – Fruit mass, kernel mass, shell mass, fruit length and fruit diameter of pecan trees subject to three pruning intensities in both 2015/16 and 2016/17 seasons in Capão do Leão, RS, Brazil.

Treatments	Fruit mass (g)	Kernel mass (g)	Shell mass (g)	Fruit length (mm)	Fruit diameter (mm)
No pruning	5.59 b	2.58 ns	3.01 b	34.23 ns	21.51 ns
Light pruning	5.88 ab	2.83	3.05 b	37.58	21.57
Hard pruning	6.52 a	3.05	3.49 a	37.58	22.33
2015/2016	6.16 ns	2.84 ns	3.32 a	36.23 ns	21.79 ns
2016/2017	5.80	2.80	3.00 b	35.41	21.75
P > F (pruning)	0.0279	0.1046	0.0236	0.5260	0.0674
P > F (crop)	0.1360	0.7700	0.0258	0.7581	0.8803
P > F (pruning x crop)	0.4667	0.0636	0.1457	0.9921	0.4036
C.V. (%)	6.69	9.53	6.73	13.58	2.19

* Means with different letters in the column differ by the Tukey's test at 5%. ns = nonsignificant.

Neither fruit length nor fruit diameter showed any difference in the treatments (Table 3). Cargnelutti Filho *et al*. (2015) evaluated length and diameter of pecan borne by the cultivar Moneymaker and found values between 21.34 and 23.63 mm and from 29.65 to 36.61 mm, respectively. These parameters are very close to the ones of the experiment reported by this paper.

Concerning shell mass, reaching low values is interesting. The lowest results were 3.01 g when there was no pruning and 3.05 g with light pruning; they differed from the result of hard pruning (3.49 g). The result of absence of pruning is close to the one found by Cargnelutti Filho et al. (2015), who got the lowest one (3.01 g).

Regarding kernel mass, high results became significant. However, this variable exhibited no difference. In general, results ranged between 25.45 and 33.58 g, which were close to the ones reported by Cargnelutti Filho *et al*. (2015).

Preliminary results show that pruning leads to increase in production in the following season. When it is not conducted, a large canopy is maintained and there is more shading within the plant, a fact that results in production losses. The intensity of hard pruning was more satisfactory in terms of increase in production per plant. Thus, it became an important practice to remove overlapping limbs. Further studies should evaluate not only more seasons but also more pruning intensities.

Conclusions

Intensity of rejuvenation pruning influences pecan production directly. Hard pruning results in higher production one year after the practice is carried out and increases fruit mass by comparison with unpruned plants.

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