Revista Iberoamericana de Tecnología Postcosecha
ISSN: 1665-0204
ISSN:
reginaldo.baez@gestagro.com.mx
Asociación Iberoamericana de Tecnología Postcosecha, S.C.
México

Quality of pecan grown in orchards with the use of different levels of technology[1]

Martins, Carlos Roberto
Farias Barreto, Caroline
de Mello Farias, Roseli
dos Santos Duarte, Cibele
Geremias Hellwig, Cristiano
Vaz Lima, Antonio Davi
Barbosa Malgarim, Marcelo

Quality of pecan grown in orchards with the use of different levels of technology[1]
Revista Iberoamericana de Tecnología Postcosecha, vol. 24, núm. 1, 2023
Asociación Iberoamericana de Tecnología Postcosecha, S.C.
Disponible en: https://www.redalyc.org/articulo.oa?id=81376287006

Reportes Frutas

Quality of pecan grown in orchards with the use of different levels of technology[1]

QUALIDADE DA NOZ-PECÃ CULTIVADA EM POMARES DE DIFERENTES NÍVEIS TECNOLÓGICOS

Carlos Roberto Martins [1]
Embrapa Clima Temperado, Brasil
carlos.r.martins@embrapa.br
https://orcid.org/0000-0001-8833-1629
Caroline Farias Barreto [2]
Faculdade IDEAU de Caxias do Sul, Brasil
carol_fariasb@hotmail.com
https://orcid.org/0000-0002-5568-5305
Roseli de Mello Farias [3]
Universidade Estadual do Rio Grande do Sul, Brasil
roseli-farias@uergs.edu.br
Cibele dos Santos Duarte [4]
Universidade Federal do Pampa, Brasil
cibasd@hotmail.com
https://orcid.org/0000-0003-1177-8670
Cristiano Geremias Hellwig [5]
Universidade Federal de Pelotas, Brasil
cristiano.hellwig@gmail.com
https://orcid.org/0000-0002-6574-8285
Antonio Davi Vaz Lima [6]
Universidade Federal de Pelotas, Brasil
antoniodv.lima@gmail.com
https://orcid.org/0000-0002-6458-9235
Marcelo Barbosa Malgarim [7]
Universidade Federal de Pelotas, Brasil
malgarim@ufpel.edu.br
https://orcid.org/0000-0002-3584-5228

Recepción: 31 Marzo 2023
Aprobación: 22 Abril 2023
Publicación: 30 Junio 2023

Notas de autor

1 Embrapa Clima Temperado, Pelotas, Rio Grande do Sul, Brazil. carlos.r.martins@embrapa.br

2 Faculdade IDEAU de Caxias do Sul, Caxias do Sul, Rio Grande do Sul, Brazil. carol_fariasb@hotmail.com

3 Universidade Estadual do Rio Grande do Sul, Rio Grande do Sul, Brazil. roseli-farias@uergs.edu.br

4 Universidade Federal do Pampa, Rio Grande do Sul, Brazil. cibasd@hotmail.com

5 Universidade Federal de Pelotas, Pelotas-RS, Rio Grande do Sul, Brazil, cristiano.hellwig@gmail.com

6 Universidade Federal de Pelotas, Pelotas-RS, Rio Grande do Sul, Brazil, antoniodv.lima@gmail.com

7 Universidade Federal de Pelotas, Pelotas-RS, Rio Grande do Sul, Brazil, malgarim@ufpel.edu.br

Abstract

Pecan farming has been expanding in Brazil, mainly in the south, where different practices and technological levels have been used in orchard management, a fact that is directly connected to nut production and quality. This study aimed at determining the quality of fruit borne by pecan trees grown in orchards that use three technological levels in Rio Grande do Sul state. The following variables were evaluated in the 2020/2021 season: number of fruit per kilogram, fruit mass, kernel mass, shell mass, kernel yield, fruit length, fruit diameter and percentage of fruit with imperfections. Fruit mass, kernel mass, shell mass, fruit length and fruit diameter were higher in the orchard that had high technological level than the other orchards. The lowest kernel yield and the highest percentage of fruit with imperfections were found in nuts borne in orchards that used little technology to lead and manage plants. Nuts produced in the orchard that applied the highest level of technology were significantly larger and heavier. It resulted in the lowest number of nuts to compose a kilogram. Therefore, this study shows that orchards that apply more practices and management produce the largest fruit with high mass and low percentage of imperfections, which determine high nut yield and quality.

Keywords: C*arya illinoinensis*, kernel yield, nuts.

Resumo

O cultivo da nogueira-pecã está em expansão especialmente na região Sul do Brasil, porém distintos níveis tecnológicos vêm sendo adotados pelos produtores, fator que poderá influenciar na produção e qualidade das nozes. Este estudo teve como objetivo determinar a qualidade dos frutos produzidos por noz-pecã cultivada em pomares que utilizam três níveis tecnológicos no estado do Rio Grande do Sul. Foram avaliados na safra 2020/2021 as seguintes variáveis: número de frutos por kg, massas de frutos, amêndoas e cascas, rendimento de amêndoas, comprimento e diâmetro de frutos e porcentagem de frutos com defeitos. A massa de frutos, amêndoas e cascas e o comprimento e diâmetro de frutos foram superiores no alto nível tecnológico. O rendimento de amêndoa e a porcentagem de frutos com defeitos foram inferiores no baixo nível tecnológico. As nozes produzidas no pomar que aplicaram o mais alto nível de tecnologia foram significativamente maiores e mais pesadas. Isto resultou no menor número de nozes para compor um quilograma. Deste modo, evidencia-se que a adoção de um nível tecnológico mais elevado proporciona frutos maiores, com maior massa e com menor porcentagem de defeitos, constituindo para o maior rendimento e qualidade do fruto.

Palavras-chave: Carya illinoinensis, nozes, pós-colheita.

INTRODUCTION

Pecan (*Carya illinoinensis)* is a fruit tree that has been expanding in southern Brazil, but more information on orchard practices and management and research and technologies to improve the production system (Bilharva *et al*., 2018; Fronza *et al*., 2018) are needed. The fruit tree has been considered an alternative to diversify crops triggered by market demand and mainly by its rusticity. However, it requires care and specific treatment that may interfere not only with its productivity but also with fruit quality.

Brazil produced about 5.5 thousand ton pecan in 2021, a fact that made the country stand out worldwide since it ranked fourth in production, following the United States, Mexico and South Africa (Inc, 2021). An estimate shows that the culture area has increased 10-fold since 2004, i. e., it consisted of 930 hectares in that year while it consists of about 10,000 hectares nowadays (Crosa *et al*., 2020). The main Brazilian states that produce pecan are Rio Grande do Sul, Santa Catarina and Paraná (Garcia *et al*., 2019). RS stands out in this field since it holds about 70% of the area where pecan nuts are grown, besides nurseries and agroindustries that process them (Martins *et al*., 2021).

Even though pecan culture has expanded in Brazil, low productivity of orchards (from 500 to 1,000 $kg.ha^{-1}$), mainly of the ones implanted in the last decades, has become an impediment to increase fruit production and quality (Martins *et al*., 2021). Crosa et al. (2020) stated that low productivity of several pecan orchards is directly connected to the fact that they are in the juvenile phase, which means they are unproductive and have not reached their maximum production peak yet. According to Fronza and Hamann (2016), Brazilian commercial orchards which are appropriately implanted – with adequate treatment and management – have potential to produce from 2,000 to 3,000 $kg.ha^{-1}$ when they are adult. Technological levels used by farmers to lead orchards, such as pruning, fertilization, irrigation and soil management, may influence nut quality (Casales *et al*., 2018; Fronza *et al*., 2018). Pecan farmers have used different practices, technique and care (Crosa *et al*., 2020) which may affect fruit quality.

Fruit production and quality depend on several factors, such as phytosanitary control (Standish *et al*., 2021), fertility management (Wells, 2021), groundcover plants (Potter *et al*., 2012), irrigation (De Marco *et al*., 2021) and pruning management, which directly reflect technological levels used in orchards (Gonçalves *et al*., 2014; Hellwig, *et al*., 2022). Regarding nut commercialization, characteristics of kernel yield, kernel mass, nut size and shell thickness (easiness in processing) have influenced product valuation (Poletto *et al*., 2018). Therefore, this study aimed at determining the quality of pecan grown in orchards that use three technological levels in Rio Grande do Sul state, Brazil.

MATERIAL AND METHODS

Quality characteristics of pecan were determined at the Embrapa Clima Temperado, located in Pelotas, Brazil. Nuts harvested in three orchards located in RS in the 2020/2021 season were analyzed. Farmers used high, medium and low technological levels to lead and manage their orchards and, consequently, their production.

The commercial pecan orchard with high technological level is located in Santa Rosa, RS (27° 55'15"S; 54°32'37"W and altitude of 330m.). In the Köppen-Geiger classification, the climate in the region is 'Cfa', mean annual temperature is 20.8 °C and mean annual rainfall is 1,801 mm. The soil is classified into Typical Dystroferric Red Latosol. The orchard is 10 years old, its spacing is 7m x 7m and no irrigation was used in the season under evaluation. Relevant characteristics in this orchard with high technological level are the use of trees grafted on the cultivar Barton, irrigation to lead plants (from implantation to the beginning of production), pollinators distributed in it, fertilization, soil correction in agreement with soil and leaf analyses, pruning, weed control and phytosanitary control based on technical guidelines. Besides, harvest was mechanical – with the use of a shaker – and followed by manual picking.

The commercial pecan orchard with medium technological level is located in Canguçu, RS (31°28'32"S; 52°56'23"W and altitude of 446.81m.). In the Köppen-Geiger classification, the climate in the region is 'Cfa', i. e., humid subtropical with well-defined seasons, mean temperature in the coldest month is <22°C and mean annual rainfall is 1,476 mm. The soil is classified into Typical Dystrophic Neosol. The orchard is 10 years old, its spacing is 9m x 7m and no irrigation system is used. It consists of trees grafted on 'Barton', pollinators distributed in it, weed control, no pruning, sporadic fertilization and sporadic phytosanitary management. Harvest is mechanical – with the use of a shaker – and followed by manual picking.

The pecan orchard with low technological level is located in Santana do Livramento, RS (30º 52' S; 55º 56'W and altitude 204m.). In the Köppen-Geiger classification, the climate in the region is 'Cfa', i. e., humid subtropical with hot summers, mild winters and regular distribution of rainfall throughout the year. The soil is classified into Red Dystrophic Argisol. The orchard is over 30 years old, its spacing is 12 m x 12 m and no irrigation system is used. It is composed of plants whose cultivars are unknown, ungrafted plants, no pruning, no fertilization, no phytosanitary control. Manual harvest is conducted by rod beating.

After the drying process, the number of fruit per kilogram was evaluated. Fruit were counted and weighed by a digital scale up to a kilogram, in agreement with the methodology proposed by Hamann *et al.* (2018). To carry out the other evaluations, 25 fruit per sample were randomly selected. Fruit length and diameter were evaluated by a digital pachymeter. Total mass, kernel mass and shell mass were evaluated by a digital precision scale and expressed as grams. In this case, fruit were individually weighed, peeled and then kernel and shell were also weighed separately. Kernel yield was also evaluated by the following equation: Kernel yield (%) = (kernel mass (g)/fruit mass (g)) x 100. Finally, a visual analysis determined the number of nuts with apparent imperfections, i. e., fruit whose kernel were shrunken, oxidized and stained.

The experiment had a completely randomized design with ten replicates of 25 fruit each. Every replicate was composed of fruit samples of ten plants. Resulting data were subject to the analysis of variance and means were compared by the Tukey's test at 5% error probability by the SISVAR statistical program, version 5.6 (Ferreira, 2014).

RESULTS AND DISCUSSION

Nut quality was influenced by its origin in terms of orchard management; thus, nut size is related to the technological level found in orchards. Size, which reflects the number of nuts needed to reach a kilogram, is an important physical characteristic to define quality (Hamann *et al.*, 2018). The largest number of fruit needed to reach a kilogram was found in the orchard with low technological level, i. e., nuts were small and light. Thus, about more 40 nuts were needed to reach a kilogram (Figure 1). The largest nuts in terms of size and weight were found in orchards that were subject to more care, management and treatments, which reflected their high technological level. Poletto et al. (2020) have reported that, in a study of morphological characteristics of Brazilian nuts, they observed that, on average, 139 fruit were needed to reach a kilogram, but the number ranged between 80 and 600 nuts. According to Senasa (2021), in the classification issued by the Argentinean legislation (Brazil does not have any definition of quality), fruit collected in orchards with high technology are large (121-140 fruit), the ones harvested in orchards with medium technology are small (161-180 fruit) and the ones picked in orchards with low technology are extra-small (181-200). Bilharva *et al.* (2018) and Hamann *et al.* (2018) have reported that 132.97 and 142.80 fruit, respectively, are needed in the case of 'Barton'; these numbers are close to the ones found in the orchard with high technological level (139.90 fruit).

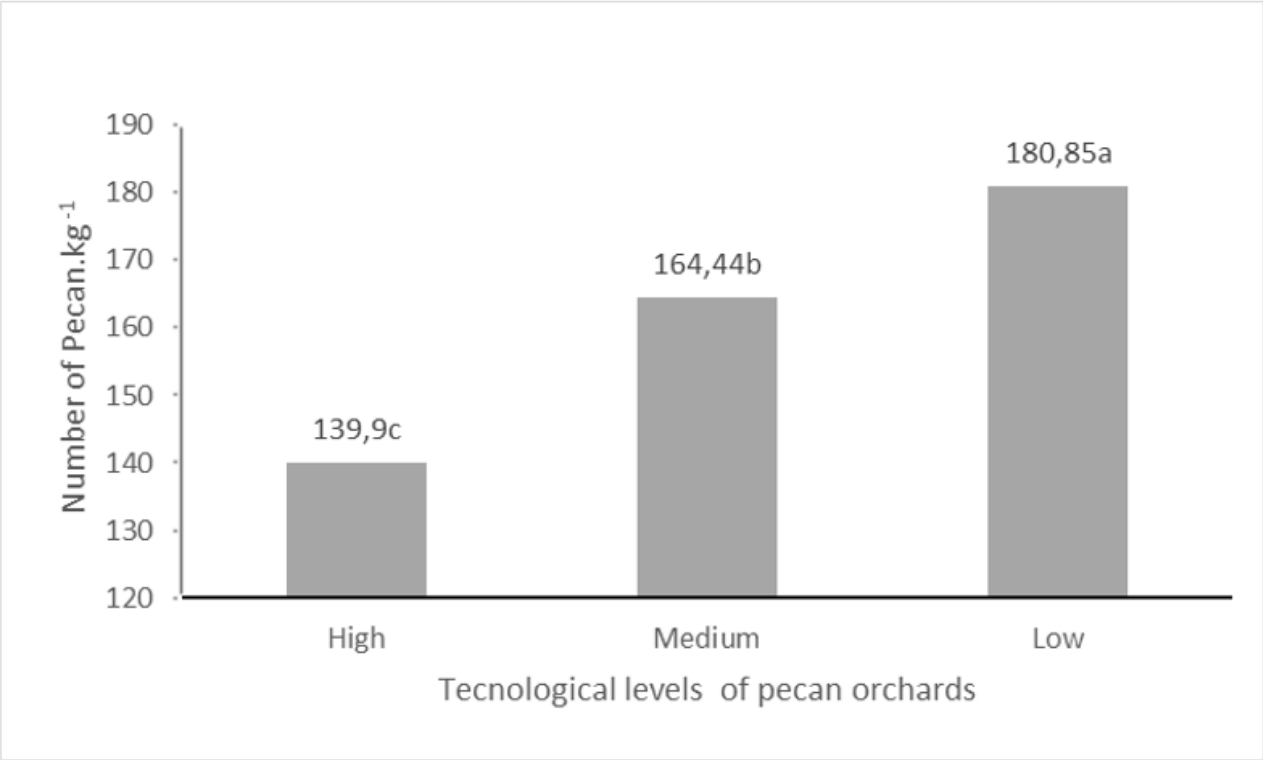

Figure 1
Number of pecan fruit harvested in orchards with three technological levels per kilogram

Fruit mass and kernel mass were higher in fruit from orchards that had high technological levels in their production (Table 1). Results corroborate the ones of other studies which show that the use of appropriate techniques in crops results in high productivity and quality fruit (Bilharva *et al.*, 2018; Crosa *et al.*, 2020; Standish *et al.*, 2021; Wells, 2021; De Marco *et al.*, 2021). Regarding the variable fruit mass alone, weigh of fruit grown in the orchard with high technological level was 17.43% higher than the one of fruit harvested in the orchard with medium technological level and 32.43% higher than fruit from the orchard with low technological level (Table 1). Fronza & Hamann (2016) stated that nuts borne by 'Barton' in an orchard in RS weighed about 7.23g.

Table 1
Fruit mass, kernel mass, shell mass and kernel yield of fruit borne by pecan trees and harvested in orchards with three technological levels in the 2020-2021 season.

Treatment	Fruit mass (g)	Kernel mass (g)	Shell mass (g)	Kernel yield (%)
High technology	7.40 a	3.92 a	3.48 a	53.70 a
Medium technology	6.11 b	3.22 b	2.88 b	52.85 a
Low technology	5.00 c	2.58 c	3.41 a	43.01 b
P > F	0.0001	0.0001	0.0037	0.0001

Means followed by different letters in a column differ by the Tukey's test at 5% probability.
ns not significant

Concerning differences in kernel mass (Table 1), which is the main part to be consumed, results show differences among the three technological levels considered in orchard management (Table 1). The highest kernel mass was found in nuts grown in the orchard with the highest technology, since its mean value was 3.9g. Poletto *et al.* (2020), based on 60 accessions, showed that mean nut mass was 3.8g, but they found fruit whose kernel weight ranged between 0.8g and 6.9g. Silva *et al.* (2017) analyzed kernel mass in different pecan orchards and found high values that ranged from 0.82 to 6.33g. Regarding shell mass (Table 1), nuts grown in orchards with intermediate technological level exhibited low quantity of shell.

The highest volumes of fruit mass and kernel mass in orchards with refined technological level enable to suppose that certain items, such as nutritional management and specific phytosanitary control (which does not take place in orchards with low technology), favors nuts to reach better performance.

Kernel yield was higher in fruit grown in orchards with high and medium technological levels (Table 1). This superiority in quality is also revealed in an important qualitative and productive index, which is kernel yield. This variable shows whether nuts are well filled and have fine shells (Bilharva *et al.*, 2018). Hamann *et al.* (2018) stated that kernel yield is the main characteristic observed by industries when they determine the price of pecan nuts per kilogram. The authors also reported that kernel yield is characterized by the ratio of kernel and amount of shell, expressed as percentage. There may be variation due to production of the cultivar, production of every plant, soil fertility, water deficit, diseases and other factors. The lowest kernel yield was found in nuts grown in the orchard with low technological level. The difference was about 10%, by comparison with the other orchards (Table 1). Results of the variable corroborate the ones found by Bilharva *et al.* (2018) who reported that indexes between 43.77 and 51.40% were found in fruit produced in southern Brazil. Poletto *et al.* (2020) found similar indexes, i. e., kernel yield found in accessions under study exhibited nuts whose mean kernel yield was about 47.9% and values ranged between 38% and 59%. Hamann *et al.* (2018) reported values of kernel yield that ranged from 43 to 52% in fruit borne by 'Barton' while Silva *et al.* (2013) reached the highest kernel yield in 'Mahan' (57.12%) and Mokochinski (2015) found that fruit borne by 'Shawnee' and 'Barton' exhibited the highest kernel yields: 56.69% and 54.19%, respectively. It is desirable to find values around 50%, regardless of cultivars and selections.

It should be highlighted that, besides lack of fertilization and phytosanitary care, orchards composed of ungrafted plants may have problems related to self-pollination, which may contribute to low kernel yield (Fronza *et al.*, 2018). It happened to kernel yield in fruit grown in the orchard with low technology, since trees were not grafted, had no identification and self-pollination could occur. Formation of fruit, and mainly of kernel, is sensitive to these factors, a fact that leads to variation in characteristics as the result of conditions plants are subject to (Poletto *et al.*, 2018).

Nuts grown in the orchard with high technology were significantly better than the others in terms of length and diameter (Table 2). Results of this study are similar to the ones reported by Bilharva *et al.* (2018), whose fruit length ranged between 33.43 and 34.95mm and fruit diameter ranged from 21.71 to 22.34mm. Poletto *et al.* (2020) found similar means, i. e., 40.7mm in length and 21.9 in diameter while Silva *et al.* (2017) found fruit length between 20.83 and 57.32mm and diameter between 14.38 and 24.59mm. According to De Marco *et al.* (2021), irrigated plants bear fruit with significantly higher mass and dimensions than plants in orchards that do not have any irrigation system.

Table 2
Fruit length, fruit diameter and percentage of fruit with imperfections borne by pecan trees and harvested in orchards with three technological levels in the 2020-2021 season.

Treatment	Fruit length (mm)	Fruit diameter (mm)	Percentage of fruit with imperfections (%)
High technology	41.23 a	22.35 a	12.30 c
Medium technology	36.34 b	20.47 b	19.04b
Low technology	39.55 ab	20.37 b	31.04 a
P > F	0.0011	0.0009	0.0276

Means followed by different letters in a column differ by the Tukey's test at 5% probability.
ns not significant

Regarding imperfect kernel, it was directly related to the orchard, i. e., the highest level of kernel with imperfections was found in fruit grown in orchards with low technological level (Table 2). It reinforces the importance of phytosanitary and nutritional management, which may have been decisive in the orchard where it is not carried out. Besides, implantation of orchards with grafted seedlings and a defined cultivar ('Barton', in this case) collaborates to yield fewer nuts with imperfections.

It should be highlighted that, in general, parameters under evaluation may be mainly influenced by orchard management techniques, such as the ones related to soil fertility and scab, the main disease that affects pecan. Bock *et al.* (2017) showed that scab control also influences nut size and yield when they evaluated the effect of fungal control on plant height. They also reported that, in the tallest parts of plants, where fungal control is less efficient, scab was more aggressive and decreased nut weight, i. e., the less scab control, the lower the values of pecan mass. Noperi-Mosqueda *et al.* (2020) showed that good organic-mineral fertilization influences nut quality directly since it improves fruit mass, decreases the number of nuts per kilogram and increases yield. However, if fertility is not adequate, these parameters may decrease. Another important factor is zinc application; if its levels are low, pecan trees may bear fruit with low quality (Hounnou *et al.*, 2017). Giuffré *et al.* (2017) have emphasized that recovery of orchards, which have been subject to neglected management, is slow and gradual. An example is the beginning of their production (from 5 to 10 years).

In general, the technological level used for growing pecan trees affects fruit yield and quality. Results of this study emphasize that pecan crops need care and treatment so that they may reach good production and quality.

CONCLUSIONS

The use of care and treatment in pecan orchards enables improvement in fruit quality. Good technological level not only improves fruit mass, fruit size and kernel yield but also decreases nut imperfections.

Acknowledgments

We would to thanks EMBRAPA, CAPES and CNPq for fellowships and grant allocation.
The authors declare that there is no conflict of interest.

REFERENCES

Bilharva MG, Martins CR, Hamann JJ, Fronza D, De Marco R & Malgarim MB (2018) Pecan: from Research to the Brazilian Reality. Journal of Experimental Agriculture International, 23: 1-16.

Bock CH, Hotchkiss MW, Brinkman TB, Stevenson KL, Goff WD, Smith MW, Wells L & Wood BW (2017) Severity of scab and its effect on fruit weight in mechanically hedge-pruned and topped pecan trees. Plant Disease, 101:785-793.

Casales FG, Watt EV & Coetzer GM (2018) Propagation of Pecan (*Carya illinoensis*): A review. African Journal of Biotechnology, 17:586–605.

Crosa CFR, De Marco R, Souza RS & Martins CR (2020) Tecnologia de produção de noz-pecã no sul do Brasil. Revista Científica Rural, 22:249-262.

De Marco R, Martins CR, Herter FG & Zoppolo R (2021) The irrigation effecton nuts growth and yield of *Carya illinoinensis*. Anais da academia brasileira de ciências, 93:e20181351.

Fronza D & Hamann JJ (2016) Técnicas para o cultivo da nogueira-pecã. Santa Maria: Universidade Federal de Santa Maria: Colégio Politécnico da UFSM. 424 p.

Fronza D, Hamann JJ, Both V, Anese RO & Meyer EA (2018) Pecan cultivation: general aspects. Ciência Rural, 48:e20170179.

Garcia MV, Moraes VN, Bernardi AO, Oliveira MS, Mallmann CA & Boscardin J (2019) Mycological quality of pecan nuts from Brazil: Absence of Aflatoxigenic fungi and aflatoxins. Ciência Rural, 49:1-8.

Giuffré L, Ciarlo E, Giardina EB & Bonafina C (2017) Fertilization Strategies in: Pecan and Effects On Soil Properties And Plant Growth. Journal of Agriculture and Veterinary Science, 10: 21-25.

Gonçalves MAL, Cocco C, Vignolo GK, Picolotto L & Antunes LEC (2014) Efeito da intensidade de poda na produção e qualidade de frutos de pessegueiro. Revista Brasileira de Fruticultura, 36:742-747.

Hamann JJ, Bilharva MG, Barros J, Marco R & Martins CR (2018) Cultivares de Nogueira-pecã no Brasil. Pelotas, Embrapa. 43p. (Documento, 478).

Hellwig CG, Martins CR, Vaz Lima AD, Farias BC, Medeiros JF & Malgarim MB (2022) Hedge and central pruning in a high-density pecan orchard in southern Brazil. Comunicata Scientiae, 13:e3842.

INC (2021). Nuts and Dried Fruits Global Statistical Review 2019/2020. Available at: <https://www.nutfruit.org/>;. Acesso em: 10 out. 2021.

Martins CR, Nava D, Nava G, Lazarotto M, Zandona RR, De Marco R, Hellwig CG, & Souza RS (2021) Manejo aumento da produtividade de pecaneiras. Hortifruti: campo e negócio, 197:62-66.

Mokochinski FM (2015). Estimativa de produção, caracterização física e perfil químico de amêndoas de nogueira-pecã. Maester' degree. Universidade Estadual do Centro Oeste, Guarapuava, 66p.

Noperi-Mosqueda LC, Soto JM, Esteban SE, Navarro LE, Pérez R, Flores MA, Yáñez R. M (2020) Yield, quality, alternate bearing and long-term yield index in pecan, as a response to mineral and organic nutrition. Notula e Botanica e Horti Agrobotanici Cluj-Napoca, 48:342-353.

Poletto, T, Poletto I, Silva LMM, Muniz MFB, Reiniger LRS, Richards N & Stefenon, VM (2020) Morphological, Chemical and genetic analysis of 401 southern Brazilian pecan (*Carya illinoinensis*) accessions. Scientia Horticulturae, 261:108863.

Poletto T, Fantinel VS, Muniz MFB & Dutra A F (2018) Tamanho de amostra para caracterização de frutos de *Carya illinoinensis*. Agropecuária Científica no Semiárido, 14:103-107.

Potter MT, Heerema RJ, Schroeder J, Ashigh J, Vanleeuwen D & Fiore C (2012). Mature pecan orchard floor vegetation management: impacts on tree water status, nutrient content, and nut production. HortScience 47:727–732.

Senasa (2014) Reglamento técnico sobre identidad y calidad de la nuez de pecán (*Carya illinoinensis* Wangenh K. Koch) con cáscara. Available at: http://www.senasa.gob.ar/;. Acessado 07/09/2021.

Silva LMM, Züge LF, Poletto T & Poletto I (2017) Emergência de plântulas de diferentes fenótipos de nogueira-pecã. In: Salão Internacional de Ensino, Pesquisa e Extensão. Bagé. Unipampa. p. 1-1.

Silva FB, Silva FJT, Fernandes FS, Leal LV & Poletto, I (2013) Isolamento e seleção de Trichoderma spp. antagonistas à Pestalotiopsis clavispora, patógeno da nogueira-pecã, Revista Brasileira de Agroecologia. 8:109-118.

Standish J R, Brenneman TB, Bock CH & Stevenson KL (2021) Fungicide resistance in Venturia effusa, cause of pecan scab: current status and practical implications. Phytopathology, 111:244-252.

Wells ML (2021) Pecan Response to Nitrogen Fertilizer Source. HortScience, 56:368-373.

Notes

[1] This work is part of the research was carried out at the Embrapa, Universidade Estadual do Rio Grande do Sul, Universidade Federal de Pelotas and the research was supported by the institutions in question CNPq (Conselho nacional de desenvolvimento científico e tecnológico) and CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior).