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MORPHOMETRY OF SEEDS OF *Lachesiodendron viridiflorum* (*Fabaceae*)

MORFOMETRIA DE SEMENTES DE Lachesiodendron viridiflorum (Fabaceae)

MORFOMETRÍA DE SEMILLAS DE Lachesiodendron viridiflorum (*Fabaceae*)

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ABSTRACT

Lachesiodendron viridiflorum, popularly known as surucaina, is a native tree species in Brazil that has potential for the recovery of degraded areas, and for the generation of timber and non-timber products. The present study aimed to describe physical characteristics of seeds from two matrices of L. viridiflorum located in the North region of Minas Gerais. Seeds collected in Montes Claros and Nova Porteirinha were evaluated for: biometric characteristics (length, width and thickness), weight of a thousand seeds, number of seeds per kilogram, water content and seed shape. Seeds exhibited little variation in biometric aspects within each batch, especially in relation to thickness. Between batches, statistical difference was observed only for thickness. As for the format, the seeds of both lots were classified as spherical and flattened. Positive and significant correlations that differed between the two lots were found between width and thickness, as well as between width and surface area and seed volume variables. This information contributes to seed technology and obtaining lots for the use of that species.

RESUMO

Lachesiodendron viridiflorum, conhecida popularmente como surucaina, é uma espécie arbórea nativa do Brasil que apresenta potencial para a recuperação de áreas degradadas, geração de produtos madeireiros e não madeireiros. O presente estudo teve como objetivo descrever características físicas de sementes de duas matrizes de L. viridiflorum localizadas na região Norte de Minas Gerais. Sementes coletadas em Montes Claros e Nova Porteirinha foram avaliadas quanto as: características biométricas (comprimento, largura e espessura), peso de mil sementes, número de sementes por quilograma, o teor de água e o formato das sementes. As sementes exibiram pouca variação nos aspectos biométricos dentro de cada lote, especialmente em relação à espessura. Entre os lotes foi observada diferença estatística apenas para a espessura. Quanto ao formato, as sementes de ambos os lotes foram classificadas como esféricas e achatadas. As correlações positivas e significativas que diferiram entre os dois lotes foram encontradas entre a largura e a espessura, bem como entre a largura e as variáveis de área superficial e volume de sementes. Estas informações contribuem para a tecnologia das sementes e obtenção de lotes para a utilização da referida espécie.

RESUMEN

Lachesiodendron viridiflorum, conocido popularmente como surucaina, especie arbórea originaria de Brasil que tiene potencial para la recuperación de áreas degradadas, generación de productos maderables y no maderables. El presente estudio tuvo como objetivo describir las características físicas de las semillas de dos matrices de L. viridiflorum ubicadas en la región Norte de Minas Gerais. Las semillas recolectadas en Montes Claros y Nova Porteirinha fueron evaluadas por: características biométricas (largo, ancho y espesor), peso de mil semillas, número de semillas por kilogramo, contenido de agua y forma de la semilla. Las semillas exhibieron poca variación en aspectos biométricos dentro de cada lote, especialmente en relación con el grosor. Entre lotes, se observó diferencia estadística solo para el espesor. En cuanto al formato, las semillas de ambos lotes se clasificaron en esféricas y aplanadas. Se encontraron correlaciones positivas y significativas que diferían entre los dos lotes entre el ancho y el grosor, así como entre las variables ancho y superficie y volumen de semilla. Esta información contribuye a la tecnología de semillas y obtención de lotes para el aprovechamiento de esa especie.

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INTRODUCTION

Lachesiodendron viridiflorum (Kunth) P. G. Ribeiro, L. P. Queiroz & Luckow (= *Piptadenia viridiflora* (Kunth) Benth.), popularly known as surucaina, is a tree species that belongs to the Fabaceae family. Originally from South and Central America, this species has a wide geographic distribution, being found in the Northeast, Central-West and Southeast regions of Brazil, in different types of vegetation, such as the Caatinga, the Cerrado and the Pantanal (Queiroz, 2023; Ribeiro et al., 2018).

It is a pioneer species recommended for the recovery of degraded areas, and its wood can be used in light carpentry and in the manufacture of tool handles (Carvalho, 2014). In the Northeast region of Brazil, its bark is used in folk medicine to treat asthma, gastrointestinal spasms, and toothache (Agra et al., 2007). A protein structure with antitumor, antimicrobial, fungicidal and bactericidal properties was extracted from the seeds (França, 2018). The seed extract showed insecticidal action on *Aedes aegypti larvae, pupae and adult mosquitoes* (Barbosa et al., 2014); and the leaves showed vermifuge action against the nematode *Haemonchus contortus* in sheep (Morais-Costa et al., 2015).

Given the ecological importance and potential use of surucaina, information related to forestry such as seed technology is scarce. Although a previous study examined the characteristics of *L. viridiflorum* seeds and identified variations in biometric parameters (Cangussu et al., 2018), there remains a gap in research aimed at understanding how genetic factors and environmental conditions surrounding the matrix of surucaina influence the biometrics of its seeds.

Among the physical attributes of seeds, biometrics can assist in several areas of research, such as identifying species that are phenotypically similar (Bezerra et al., 2014); in studies on seed development and maturation (Pessoa et al., 2012); as well as identifying genetic divergences for a species (Bispo et al., 2020). Furthermore, significant correlations are observed between biometric parameters and the physiological quality of the seeds (Biruel et al., 2010). However, seed biometric parameters can vary substantially depending on genetic factors and environmental conditions (Freire et al., 2015; Bezerra et al., 2022).

This information is important for seed technology and the composition of batches with adequate quality for different purposes, such as the recovery of degraded areas and the silvicultural production of wood and non-wood products. In view of the above, the present study aimed to describe physical characteristics of seeds from two *Lachesiodendron viridiflorum* arrays located in the northern region of Minas Gerais.

METHODOLOGY

Seeds of *Lachesiodendron viridiflorum* were collected in two locations in the North of the State of Minas Gerais: one in Montes Claros (16°41'4.48512" S and 42°50'51.58896" W) and one in Nova Porteirinha (approximately 15°46'28.32" S and 43°16'1.51" W). For the correct identification of the species, the exsicata located in the "Herbarium VIC" with registration number VIC-37475 was used as a parameter for comparison.

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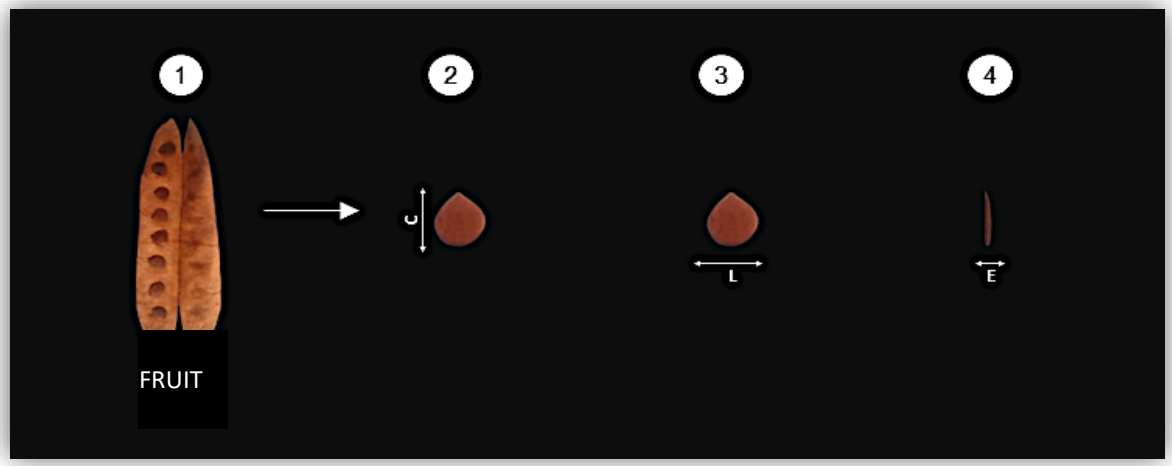
The seeds were manually removed from the fruits, placed in a polyethylene bag and stored in a refrigerator (5.0 - 9.0 °C) until the start of the experiment at the Forest Species Propagation Laboratory of the Federal University of Minas Gerais, Campus Montes Claros.

To carry out the evaluations, only visually perfect seeds were selected; that is, seeds that presented good formation, free from mechanical damage such as predation. The study of biometric characteristics included measuring 100 seeds of each parent tree, obtaining the length, width and thickness using a digital caliper with an accuracy of 0.01 mm. The length was measured from the base to the apex of the seeds; the width was obtained in the central median part, between the right and left sides; and the thickness was measured in the region between the back and the belly of the seed, perpendicular to the width (Figure 1).

Figure 1. Dimensions considered for biometrics in (1) *Lachesiodendron viridiflorum fruit*; (2) length (3) width and (4) thickness of the seeds.



Source: Authors (2023).

The values obtained from measurements of the orthogonal axes of the seeds were used to determine the geometric mean diameter (1), the surface area of the seeds (2), and the volume of the seeds (3) (Sahay & Singh, 1994; Mccabe et al., 2005; Mohsenin, 1993); with “a,b ,c” referring to the values of width, thickness and average length of the seeds.

$$DMG = (\mathrm{abc})^{1/3} \quad (1)$$

$$A_s = \pi DMG^2 \quad (2)$$

$$V = \pi \frac{abc}{6} \quad (3)$$

The data of the described parameters were submitted to statistics with a completely randomized design, two treatments (matrices) and four replications, each containing 25 seeds. Analysis of variance was performed and means were compared using the Tukey test at a 5% significance level, using the ExpDes.PT package, R Studio® software version 4.2.2. In addition, Pearson's correlation coefficients were estimated, verifying significance using the t test. For the parameter’s length, width and thickness of the seeds, frequency classes were determined using Sturges' rule (4).

$$\mathrm{k} = 1 + 3{,}33\,.\,\log_{10}.\mathrm{n} \quad (4)$$

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The characterization of the shape of the seeds was carried out by calculating the J and H coefficients. The J coefficient aims to classify the seeds as elliptical, spherical, oblong/reneform based on the relationship between length and width. The H coefficient (mm) categorizes seeds as flat, semi-full or full based on the relationship between thickness and width (MAPA, 2015).

To determine the weight of a thousand seeds (5), eight sub-samples of 100 seeds were weighed on a precision scale, in accordance with the recommendations of the Rules for Seed Analysis (Brasil, 2009). The degree of humidity was determined at 42 and 30 months of storage for seeds from Nova Porteirinha and Montes Claros, respectively. The determination was carried out using the oven method at 105±3 °C, for a period of 24 hours (6) (Brazil, 2009), using 4 replications containing 20 seeds for each batch. The data were analyzed using a completely randomized design.

$$(PSM) = \frac{peso\ da\ amostra\ .\ 1000}{n°\ total\ de\ sementes} \quad (5)$$

$$\%\ de\ Umidade\ (U) = \frac{100(P-p)}{P-t} \quad (6)$$

RESULTS AND DISCUSSION

The values for the weight of a thousand surucaina seeds for the Montes Claros and Nova Porteirinha matrices corresponded to 55.17 g and 53.92 g, respectively, and there was no statistical difference between the values. Consequently, it was observed that the number of seeds per kilogram was similar for both matrices, presenting averages of 18,134 seeds for Montes Claros and 18,580 seeds for Nova Porteirinha.

The values were numerically higher than the results obtained in other studies carried out for the same species. Cangussu et al., (2018) found the weight of a thousand seeds equivalent to 39.77 g for seeds collected in Vitória da Conquista, Bahia. Regarding the number of seeds per kilogram, it is important to note that Lorenzi (2016) mentioned a value of 26,000 seeds per kilogram for the same species, which is higher than that found in this study.

These variations in the weight and quantity of seeds per kilogram can be attributed to several factors, including environmental conditions during the process of seed formation and development (Baskin & Baskin, 2014), variations in the allocation of photoassimilates by the plant to the seeds (Freitas et al., 2014) and moisture content, which can make seeds lighter or heavier (Souza et al., 2022). Furthermore, the weight of a thousand seeds may be related to the dimensions, maturity and integrity of the seeds (Brasil, 2009).

Regarding size, surucaina seeds were classified as small, considering the average weight of a thousand seeds for the two lots (54.545 g) of less than 200 g (Brasil, 2009). Among the types of vegetation in which the surucaina naturally occurs is the Caatinga (Ribeiro et al., 2018), where species are generally reduced in size, a characteristic that is associated with extreme environmental conditions such as water deficiency (Da Costa Patrício & Trovão, 2020). Under these conditions, the reduced size of the seeds favors the need for less water for the

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germination process and seedling formation when compared to larger seeds (Da Costa Patrício & Trovão, 2020).

The average degree of humidity of the seeds collected in Montes Claros and Porteirinha was 8.2% and 7.6%, respectively. No significant difference was observed between batches. Cangussu et al. (2018) observed a moisture content of 9.0% for seeds of the same species. This reduced degree of humidity is an indication of the orthodox behavior of the seeds in storage. Orthodox seeds tolerate drying at low humidity levels as well as low storage temperatures (Roberts, 1973).

As to biometric data, Montes Claros seeds showed variations in length (6.52 to 10.14 mm), width (5.50 to 8.10 mm) and thickness (0.13 to 1.34 mm). Variations in the geometric mean diameter (1.95 to 4.63 mm), surface area (11.95 to 67.23 mm) and volume (3.89 to 51.84 mm) are also observed (Table 1).

Relating to the seeds from the Nova Porteirinha matrix, variations were found for length (7.08 to 10.05 mm), width (5.60 to 8.35 mm) and thickness (0.96 to 1.42 mm) (Table 2). Variations were also observed for the geometric mean diameter (3.57 to 4.64mm), surface area (40.12 to 67.57 mm²) and volume (23.90 to 52.23 mm³).

Table 1. Biometry of *Lachesiodendron viridiflorum* seeds from the Montes Claros and Nova Porteirinha, MG matrices.

Parameters	Montes Claros				Nova Porteirinha			
	x̄ ± DP	Min	Max	CV	x̄ ± DP	Min	Max	CV
Length (mm)	9,03 ± 0,57	6,52	10,14	6,29%	8,99 ± 0,47	7,08	10,05	5,18%
Width (mm)	6,91 ± 0,58	5,50	8,1	8,42%	6,91 ± 0,52	5,6	8,35	7,54%
Thickness (mm)	1,12 ± 0,16	0,13	1,34	14,51%	1,19 ± 0,08	0,96	1,42	7,10%
DMG (mm)	4,10 ± 0,37	1,95	4,63	8,94%	4,20 ± 0,22	3,57	4,64	5,14%
A_s (mm²)	53,32 ± 8,49	11,95	67,23	15,92%	55,40 ± 5,62	40,12	67,57	10,15%
V (mm³)	36,98 ± 8,15	3,89	51,84	22,04%	38,92 ± 5,86	23,90	52,23	15,05%

Source: Authors (2023). *Coefficient of variation (CV); Standard Deviation (SD); Maximum (Max); Average (x̄); Minimum (Min).

The data regarding thickness showed less variation within each batch and a significant difference between the matrices. Seeds from Nova Porteirinha were thicker (1.19 mm) compared to seeds from Montes Claros (1.12 mm) (Table 2).

Table 2. Comparison of mean values for biometric parameters of *Lachesiodendron viridiflorum* seeds from Montes Claros and Nova Porteirinha, MG.

Parameters	Montes Claros	Nova Porteirinha	CV
	x̄	x̄	
Length (mm)	9,03 a	8,99 a	2,12%
Width (mm)	6,91 a	6,90 a	1,55%
Thickness (mm)	1,12 b	1,19 a	2,52%
DMG (mm)	4,10 a	4,20 a	1,74%
A_s (mm²)	53,32 a	55,40 a	3,17%
V (mm³)	36,98 a	38,92 a	4,44%

Source: Authors (2023). *Averages followed by identical lowercase letters in the line do not differ from each other using the Tukey test at 5% significance. *Coefficient of variation (CV) and mean (x̄)

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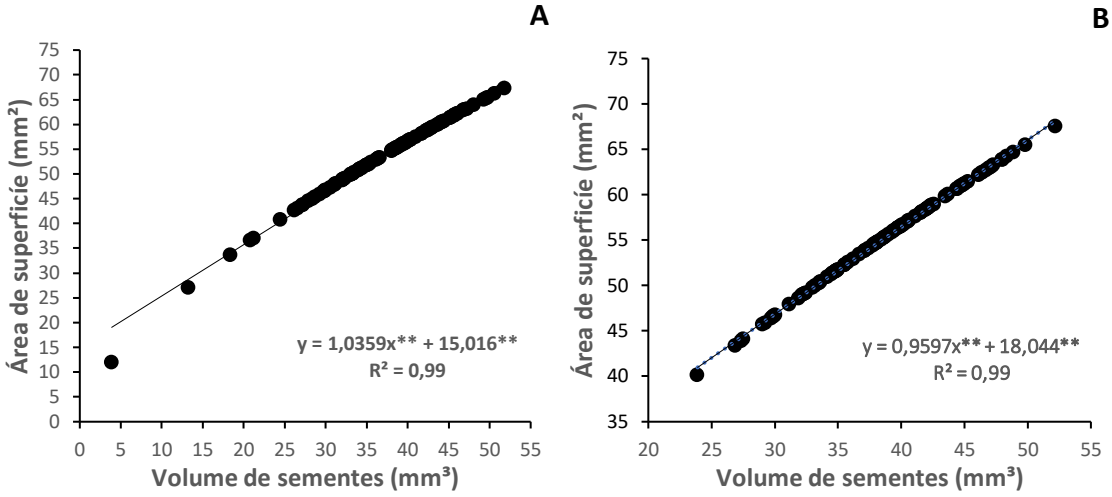
For seeds of the species under study, Cangussu et al. (2018) found numerically lower averages for the variable's length (8.050 mm), width (6.529 mm) and thickness (0.997 mm). Biruel et al. (2010) also observed different thickness values for seed lots of *Libidibia ferrea* var. *leiostachya* (Benth.) L. P. Queiroz (*Fabaceae*), with the greater thickness and rounded shape of the seeds favoring physiological quality.

The surface area and volume data fit the linear regression model with a coefficient of determination of 0.99 for both seed lots tested (Graph 1). As a result of the regression, a behavior is observed in which, together with the increase in seed volume, there is an increase in surface area values, demonstrating a positive correlation. The volume and surface area of the seeds are directly proportional.

Graph 1. Linear regression of surface area and volume *of Lachesiodendron viridiflorum* seeds from the cities of Montes Claros (A) and Nova Porteirinha (B).



Source: Authors (2023).

Information about the volume of a seed refers to the space it occupies in terms of its three-dimensional shape and size. The relationship between seed volume and surface area may be related to the degree of humidity. Fathollahzadeh et al. (2009), while studying *Prunus* seeds *armeniaca* L. (Rosaceae), observed that the volume and surface area of apricot seeds increased linearly with moisture content.

Concerning frequency distribution, eight classes were established, based on the range of values found for each parameter evaluated (length, width and thickness) (Graph 2).

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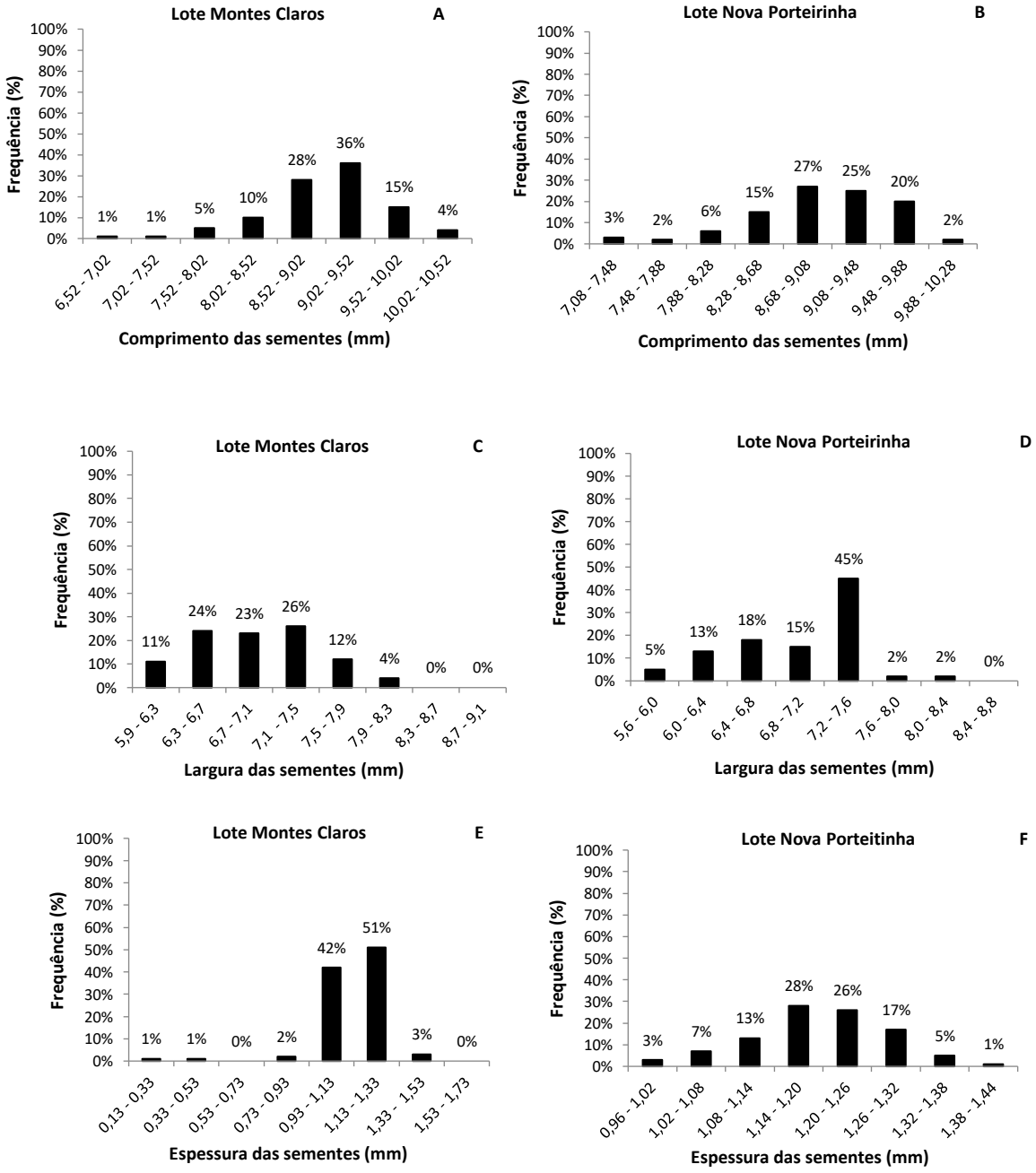
Graph 2. Frequency graphs of *Lachesiodendron viridiflorum* seed biometrics: A- length (mm) of the Montes Claros lot; B- length (mm) of the Porteirinha lot; C- width (mm) of the Montes Claros lot; D- width of the Porteirinha lot; E- thickness (mm) of the Montes Claros lot; F- thickness (mm) of the Porteirinha lot.



Source: Authors (2023).

It was observed that the most representative classes for seeds collected in Montes Claros considering length, width and thickness were respectively: 9.02 to 9.52 mm (36%); 7.1 to 7.5 mm (26%); and 1.13 to 1.33 mm (51%). For seeds from Nova Porteirinha, the most representative classes for length, width and thickness corresponded to 8.68 to 9.08 mm (27%); 7.2 to 7.6 mm (45%); and 1.14 to 1.20 (28%), respectively.

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When analyzing the shape of the seeds, the J value found for the two lots was 1.31 mm; while the H values found were 0.16 (Montes Claros) and 0.17 mm (Nova Porteirinha) (Table 3). Seeds with J values between 1.31 and 1.42 mm are classified as spherical and seeds with H values less than 0.69 mm are classified as flat (MAPA, 2015). Thus, the seeds from the two matrices were classified as spherical and flat.

Table 3. Characteristics of the shape of *Lachesiodendron viridiflorum* seeds from the Montes Claros and Nova Porteirinha, MG matrices.

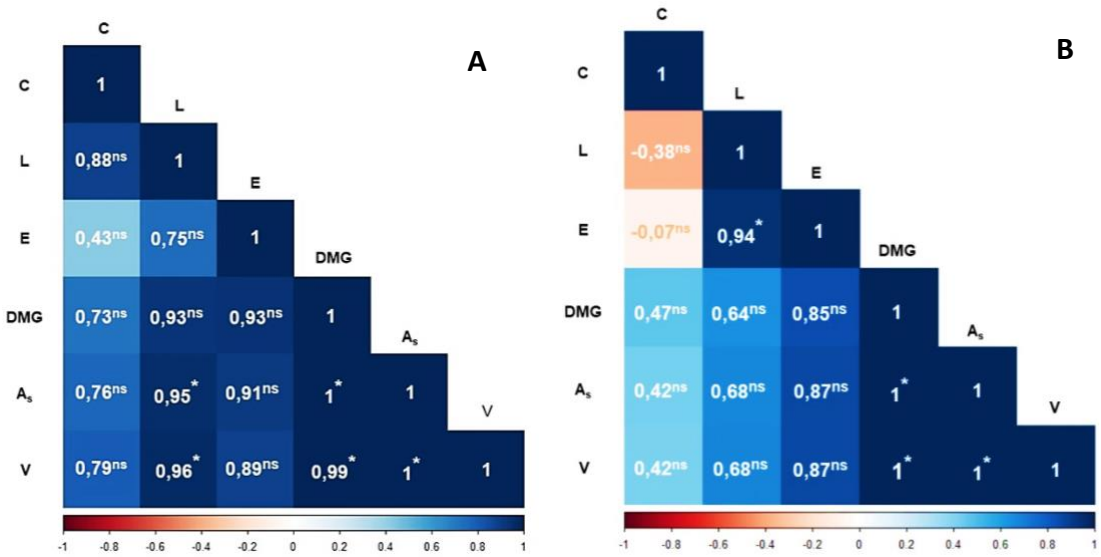
Location	Coefficients		Form
	J	H	
Montes Claros	1,31	0,16	Spherical and flat
Nova Porteirinha	1,31	0,17	Spherical and flat

Source: Authors (2023).

In addition to the reduced size, the shape of the seeds may also be associated with the adaptation characteristics of the species to the environmental conditions of its natural occurrence. After dispersal, seeds may remain lodged underground. In the presence of humidity, the reduced size and flattened spherical shape of the seeds may contribute to the contact surface, favoring imbibition, the initial stage of the germination process.

From the correlation analysis matrices of the biometric parameters, it was observed that the positive and significant correlations (5% significance level) were very strong, that is, they presented R>0.90 (Graph 3).

Graph 3. Pearson correlation matrix for the physical properties of *Lachesiodendron viridiflorum* seeds from the cities of Montes Claros (A) and Nova Porteirinha (B).



(*) Significance at 5% level. Source: Authors (2023).

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For the Montes Claros lot, significant correlations were observed between the variable width, surface area and seed volume; between the geometric mean diameter and the surface area and volume of seeds; between the surface area and the volume of the seeds.

Meanwhile, for seeds from Nova Porteirinha, significant correlations were found between thickness and width; between the geometric mean diameter with the surface area and volume; and between surface area and volume.

The significant correlations found have a great influence on the physical aspects of the seeds. The relationship between thickness and width directly influences the calculation of the H coefficient, playing an important role in preserving the shape of the seeds. Variations in width, length and thickness influence DMG values and seed volume. Knowledge about these values is important to understand the development and physical characteristics of seeds.

Continuing biometric studies for *L. viridiflorum* seeds is important considering sampling, that is, expanding the number of matrices in different locations. This information contributes to seed technology and obtaining batches with adequate quality for the different possibilities of use of the species.

FINAL CONSIDERATIONS

In this work, little variation was observed in biometric aspects within each batch, especially in relation to thickness. Only the average thickness values were significant, presenting 1.19 mm and 1.12 mm for seeds from Novas Porteirinha and Montes Claros, respectively.

The seeds were classified as spherical and flat.

The positive and significant correlations that differed between the two lots were between width and thickness (Nova Porteirinha), and between width and the variables of surface area and seed volume (Montes Claros).

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REFERENCES

Agra, M. D. F., Freitas, P. F. D., & Barbosa-Filho, J. M. (2007). Synopsis of the plants known as medicinal and poisonous in Northeast of Brazil. Revista *Brasileira de Farmacognosia*, 17, 114-140. https://doi.org/10.1590/S0102-695X2007000100021

Araujo, R. F., Silva, F. W. S., Araujo, E. F., de Oliveira Assis, M., & Veiga, V. R. (2019). Avaliação sanitária de sementes de feijão usadas por agricultores familiares da zona da mata. *Revista Brasileira de Agropecuária Sustentável*, 9(3). https://doi.org/10.21206/rbas.v9i3.8366

Barbosa, P. B. B. M., Oliveira, J. M. de, Chagas, J. M., Rabelo, L. M. A., Medeiros, G. F., Giodani, R. B., Silva, E. A., Uchôa, A. F., & Ximenes, M. de F. (2014). Evaluation of seed extracts from plants found in the Caatinga biome for the control of *Aedes aegypti*. *Parasitology research*, 113, 3565-3580. https://doi.org/10.1007/s00436-014-4022-6

Baskin, C. C. & Baskin, J. M. (2014). *Seeds: ecology, biogeography, and evolution of dormancy and germination* (2ª ed.). San Diego: Academic Press.

Bezerra, A. C., Zuza, J. F. C., Barbosa, L. D. S., Azevedo, C. F., & Alvo, E. U. (2022). Biometrics of mulungu seeds from different mother plants in the semi-arid region of Paraíba, Brazil. *Revista Caatinga*, 35, 393-401. https://doi.org/10.1590/1983-21252022v35n215rc

Bezerra, F. T. C., de Andrade, L. A., Bezerra, M. A. F., da Silva, M. L. M., Nunes, R. C. R., & da Costa, E. G. (2014). Biometria de frutos e sementes e tratamentos pré-germinativos em *Cassia fistula* L. (Fabaceae-Caesalpinioideae). *Semina: Ciências Agrárias*, 35(4Supl), 2273-2286. https://doi.org/10.5433/16790359.2014v35n4Suplp2273

Biruel, R. P., de Paula, R. C., & de Aguiar, I. B. (2010). Germinação de sementes de *Caesalpinia leiostachya* (Benth.) Ducke (pau-ferro) classificadas pelo tamanho e pela forma. *Revista árvore*, 34(2), 197-204. https://doi.org/10.1590/S0100-67622010000200001

Bispo, R. B., Dardengo, J. D. F. E., Bispo, R. B., Bispo, R. B., & Rossi, A. A. B. (2020). Divergência genética entre genótipos de *Mauritia flexuosa* L.f. por meio de morfometria de frutos e sementes. *Nativa*, 8(4), 585-590. https://doi.org/10.31413/nativa.v8i4.8622

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. (2009). Regras para análise de sementes. Brasília: MAPA; ACS.

Cangussu, A. C. V., Caetano, A. P. O., Santos, J. L., de Castro Filho, M. N., & Cardoso, A. D. (2018). Biometric analysis and breaking of dormancy of seeds of *Piptadenia viridiflora* (Kunth) Benth. *Floresta*, 48(3), 355-362. http://dx.doi.org/10.5380/rf.v48i3.55068

Carvalho, N. M., & Nakagawa, J. (2012). *Sementes: ciência, tecnologia e produção* (5ª ed.). Jaboticabal: FUNEP.

Carvalho, P. E. R. (2014). *Espécies arbóreas brasileiras: Surucucu - Piptadenia viridiflora*, p. 523-529. Colombo: Embrapa Florestas.

Da Costa Patrício, M., & Trovão, D. M. D. B. M. (2020). Seed biometry: another functional trait in caatinga. *Acta Scientiarum. Biological Sciences*, 42, 1-11. https://doi.org/10.4025/actascibiolsci.v42i1.51183

Fathollahzadeh, H., Mobli, H., Tavakkoli, M., Ebrahimzadeh, M. R., & Tabatabaie, M. H. (2009). Some physical properties of '*Sonnati Salmas*' apricot pit. *Agricultural Engineering International: CIGR Journal*. Recuperado de https://cigrjournal.org/index.php/Ejounral/article/view/1157/1179

Ferreira, R. A. & Barretto, S. S. B. (2015). Caracterização morfológica de frutos, sementes, plântulas e mudas de pau-brasil (*Caesalpinia echinata* LAM.). *Revista Árvore*, 39, 505-512. https://doi.org/10.1590/0100-67622015000300011

França, A. F. J., de. (2018). *Uma proteína de sementes de Lachesiodendron viridiflorum: uma alternativa para combate de agentes microbianos e células tumoriais*. (Tese de doutorado). Universidade Federal do Rio Grande do Norte, Natal, RN, Brasil.

Freire, J. M., Piña-Rodrigues, F., Santos, A. L. F. D., & Pereira, M. B. (2015). Intra-and inter-population variation in seed size and dormancy in *Schizolobium parahyba* (Vell.) Blake in the Atlantic Forest. *Ciência Florestal*, 25, 897-907. https://doi.org/10.5902/1980509820592

Freitas, P. G. N., Claudio, M. T. R., Tavares, A. E. B., Magro, F. O., Cardoso, A. I. I., & Bardiviesso, E. M. (2014). Poda apical para produção de frutos e sementes de abóbora. *Agro@ mbiente On-line*, 230-237. http://dx.doi.org/10.18227/1982-8470ragro.v8i2.1891

Lorenzi, H. (2016). *Árvores brasileiras: manual de identificação e cultivo de plantas nativas arbóreas do Brasil* (5ª ed.). Nova Odessa: Plantarum.

MAPA. (2015*). Descritores mínimos de feijão* (*Phaseolus vulgaris* L.). Recuperado de https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/protecao-de-cultivar/agricolas

Mccabe, W. L.; Smith, J. C., & Harriot, P. (1993). *Unit operation of chemical engineering* (5ª ed.). Singapura: McGraw-Hill.

Mohsenin, N. N. (1986). *Physical properties of plant and animal materials* (2ª ed.). New York: Gordon and Breach.

Citation (APA): Nogueira, A. da S., Carvalho, L. R., de., Silva, L. M., Silva, L. S., da., & Sales, N. de L. P. (2023). Morphometry of seeds of *Lachesiodendron viridiflorum* (Fabaceae). *Brazilian Journal of Production Engineering*, 9(4), 44-54.

Morais-Costa, F., Soares, A. C. M., Bastos, G. A., Nunes, Y. R. F., Geraseev, L. C., Braga, F. C., Lima, W. S., & Duarte, E. R. (2015). Plants of the Cerrado naturally selected by grazing sheep may have potential for inhibiting development of *Haemonchus contortus* larva. *Tropical Animal Health and Production*, 47, 1321-1328. https://doi.org/10.1007/s11250-015-0866-8

Pessoa, Â. M. S., Santos, Â. G., Ribeiro, M. L. F., & Silva-Mann, R. (2012). Influência da maturação de frutos na germinação, vigor e teor de óleo de sementes de *Jatropha curcas* L. *Scientia Plena*, 8(7). https://www.scientiaplena.org.br/sp/article/view/407

Souza Silva, D., Viera de Freitas, D., & Pereira Dias, D. (2022). Biometria e qualidade fisiológica de sementes de *Hymenaea stigonocarpa*. *Revista Agrotecnologia*, 13(1).

Queiroz, L.P. (2023). *Lachesiodendron* in Flora e Funga do Brasil. Jardim Botânico do Rio de Janeiro. Recuperado de https://floradobrasil.jbrj.gov.br/FB605431

Ribeiro, P. G., Luckow, M., Lewis, G. P., Simon, M. F., Cardoso, D., de Souza, É. R., Silva, A. P. C., Jesus, M. C., Santos, F. A. R., Azevedo, V., & Queiroz, L. P. (2018). *Lachesiodendron*, a new monospecific genus segregated from *Piptadenia* (Leguminosae: Caesalpinioideae: mimosoid clade): Evidence from morphology and molecules. *Taxon*, 67(1), 37-54. https://doi.org/10.12705/671.3

Roberts, E. H. (1973). Predicting the storage life of seeds. *Seed Science and technology*, 1, 499-514.

RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA. Recuperado de http://www.rstudio.com/.

Sahay, K. M. & Singh, K. K. (1994). *Unit operations of agricultural* processing (2ª ed.). New Delhi: Vikas Publishing House Pvt.