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METHODOLOGY FOR THE CLASSIFICATION OF *Eucalyptus* CLONES FOR SOLID WOOD

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Resumo

Metodologia para classificação de clones de Eucalyptus para madeira maciça. O objetivo deste estudo foi desenvolver tabelas de pontuação baseadas na qualidade da tora e da madeira serrada e propriedades físicas e mecânicas para seleção de clones de *Eucalyptus* para produção de madeira maciça. Foram selecionados cinco clones, sendo três híbridos de *Eucalyptus grandis* x *Eucalyptus urophylla*, um clone de *Eucalyptus urophylla* e um clone de *Eucalyptus grandis*, com 10 anos de idade. Para a classificação do melhor clone, foram elaboradas duas tabelas de pontuação, uma levando em consideração o resultado da análise estatística e outra os valores absolutos. Com as tabelas foi possível classificar os clones quanto aos parâmetros analisados separadamente (qualidade das toras, qualidade da madeira serrada, rendimento em madeira serrada, propriedades físicas e propriedades mecânicas) e observar de forma mais clara alguns fatores que influenciam diretamente os resultados. O clone de *Eucalyptus grandis* (clone 4) apresentou os melhores resultados, enquadrando-se como de qualidade superior em relação aos demais para produção de madeira maciça. Dessa forma, as tabelas de pontuação que utilizaram a análise estatística ou valores absolutos se mostraram como ferramentas úteis e aplicáveis para a classificação qualitativa dos clones.
Palavras-chave: Propriedades físicas e mecânicas; qualidade da madeira; classificação da madeira; seleção de eucalipto.

Abstract

The aim of this study was to develop scoring tables based on log quality, sawn wood quality and physical and mechanical properties for the selection of *Eucalyptus* clones for the production of solid wood. Five clones were selected, being three hybrids of *Eucalyptus grandis x Eucalyptus urophylla*, a clone of *Eucalyptus urophylla* and a clone of *Eucalyptus grandis*, 10 years of age. For the classification of the best clone, two scoring tables were created, one considering the result of the statistical analysis and the other the absolute values. With the tables it was possible to classify the clones according to the analyzed parameters (quality of the logs, quality of the sawn wood, sawn wood yield, physical properties and mechanical properties) separately and to observe more clearly some factors that directly influence the results. The clone of *Eucalyptus grandis* (clone 4) presented the best results, being classified as of superior quality in relation to the others for the production of solid wood. Thus, the scoring tables using statistical analysis or absolute values proved to be useful and applicable tools for the qualitative classification of clones.
Keywords: Physical and mechanical properties; wood quality; classification of wood; selection of Eucalyptus.

INTRODUCTION

Brazil is one of the largest holders of planted forests in the world, with approximately 9.93 million hectares of forest plantations. Among the planted species, those of the genus *Eucalyptus* stand out, which occupy 7.53 million hectares of this total, concentrated mostly in the Southeast region of the country (IBA, 2022).

Through breeding and cultivation techniques, Brazil has achieved short crop turnover and high productivity rates. This increase in productivity allowed the use of wood on a large scale in the manufacture of solid wood products, contributing to the reduction in demand for native species from the Amazon. The *Eucalyptus* genus stands out for presenting quality wood, short growth cycles, speed of development of its trees, ease of implementation in large masses and also with specific genetic materials for different climatic conditions, resistance to diseases and with production of wood with specific properties for numerous purposes (WINK *et al*. 2013; BATISTA *et al*. 2015; LATORRACA *et al*. 2015), with application in the sawn wood, panels, floors, cellulose and energy industries.

With the availability of better quality raw materials, the use of *Eucalyptus* wood is growing for the production of products with greater added value, such as decorative EGP panels (*edge glue panel*) and for structural and closing use in civil construction, such as GLT panels (glued laminated wood), CLT (Cross-laminated timber) in addition to the use of solid wood in blocks, rafters, pillars and beams. These products require high quality and mechanical resistance, in addition to low cracking rates caused by growth stresses, reinforcing the need to select species that have these characteristics.

In order to achieve high quality raw materials, the genetic improvement of the *Eucalyptus* genus in Brazil is being increasingly refined. However, this was not always the case, since initially the main objective of the genetic improvement of *Eucalyptus* in Brazil was the volumetric productivity per hectare to produce cellulosic pulp, while the properties of the wood were little considered.

However, obtaining a qualitative identification of genetic material that brings together the best characteristics for a given product or purpose is a challenge for the forestry sector. In addition, Longue Junior and Colodette (2013) emphasize that, despite its great forestry vocation, Brazil still does not explore its entire productive potential, both for cultivation and for the use of wood-based products. Lima and Stape (2017) add that researches to evaluate new genetic materials are not routinely carried out, as the Eucalyptus sawn wood industry is not as large and organized as the pulp or charcoal industry and, in addition, the maturation time of the materials is fast. In this sense, the classification of wood for different uses is a source of investigation in the forest and timber sector, with interest for the industrial sector, addressing the classification by images, visual, superficial and mechanical (SUNDARAM *et al*., 2015; BREINIG *et al*., 2015; ROSA *et al*., 2020), including specific standards for classification, such as the American standard of the American Society for Testing and Materials – ASTM D 245 (2019).

In technological terms, characterization tests are conducted to check the quality of the wood, evaluating numerous properties of the material in order to select the most suitable raw material for specific purposes. Such a process requires time and skills to work with large databases, being a technical and scientific obstacle. In order to optimize the identification of the best clone/species for sawn wood quality, analysis of physical and mechanical properties may be tabulated and classified, defining with the final sum which material has the best characteristics. In this scenario, the scoring table appears as an alternative for the classification and selection of clones and/or forest species to indicate materials suitable for the production of solid and sawn wood.

Therefore, the objective of this work was to develop a score table to qualitatively classify clones and/or species according to the quality of the log and sawn wood, as well as physical and mechanical characteristics.

MATERIALS AND METHODS

Raw material

The clonal material used, belonging to the company ArborGen Tecnologia Florestal, came from an experimental clonal plantation located on the Santa Terezinha farm in the city of Mogi Guaçu, SP. According to the City Hall of Mogi Guaçu (2023), the city is located at 588 m above sea level, has a dry winter and rainy summer, with an average volume of rainwater of 1,162.7 mm/year, in addition to low soil, formed by sandy rocks and, in determined fractions, such as the coasts, they form basaltic outcrops.

Five clones were selected, being three hybrids of *Eucalyptus grandis x Eucalyptus urophylla* (clones 1, 3 and 5), a clone of *Eucalyptus urophylla* (clone 2) and a clone of *Eucalyptus grandis* (clone 4), with 10 years of age.

From each clone, five trees were cut down and three logs were drawn per tree; the first (2.5 m) intended for testing physical and mechanical properties and the rest, second and third wood logs (2.0 m) intended for measuring the top crack index of the logs (TCI log), sawn wood yield and sawn wood quality determination. Four disks (0.10 m, 2.5 m, 4.5 m and 6.5 m from the total height of the tree) were also removed from each tree, to determine the basic specific mass and the percentage of heartwood.

Tests performed

Log quality

The heartwood percentage was determined by measuring the total diameters (without bark) and the heartwood of each disc in a cross shape, used to determine the total areas of the disc and the heartwood for calculating the percentage, making the relation between the heartwood area and the disc area.

The top crack index of the logs was determined in the second and third logs of each tree, measuring the cracks in the fine and thick points, according to the methodology proposed by Lima *et al*. (2007).

Sawn wood yield

The sawn wood yield was determined by measuring the volume of the logs by the *Smalian* method and dimensions of the plancks (length, width and thickness) after splitting by the tangential method, then the volume of the plancks is compared to the volume of the logs.

The green gross yield (after pitsawing), the dry gross yield (after air drying up to 20% wood moisture content) and the green and dry net yield were determined, that is, discounting the cracks measured on the plancks after pitsawing and air drying.

Quality of sawn wood

The quality of the sawn wood was determined by measuring the bending, curving and top cracking index of the plancks (TCI planck). The analyzes were carried out after pitsawing (green) and after air drying up to 20% of the wood moisture content (dry), according to the Brazilian Technical Standard – NBR 14806 of the Brazilian Association of Technical Standards (ABNT, 2002). Forty plancks from each clone chosen at random were analyzed.

Physical properties

The basic density was determined in two opposite wedges of each disk, using the hydrostatic balance method, following NBR 11941 (ABNT, 2003).

The apparent density at 12% humidity was determined following the guidance of the Pan American Standards Commission – 461 (COPANT, 1972), and the retraction of wood according to the Pan American – 462 (COPANT, 1972).

Mechanical properties

The making of the specimens and the tests of static bending, compression parallel to the fibers, Janka hardness and shear parallel to the fibers, followed the specifications of Pan American standard 555 (COPANT, 1972), Pan American standard 464 (COPANT, 1972), Pan American standard 465 (COPANT, 1972) and Pan American standard 463 (COPANT, 1972), respectively.

Statistical analysis

The data were analyzed for normality using the *Shapiro Wilk* test and the homogeneity of the variances using the *Levene* test. The results were evaluated by a simple analysis of variance (ANOVA) and later the *Tukey* test was performed to compare averages at a level of 5% significance of error. To analyze the influence between the tests, *Pearson's* correlation was used.

Methodology for the classification

For the classification of the best clone, two scoring tables were elaborated considering the result of the statistical analysis and another based on absolute values. Thus, the better the result obtained through statistics, the better the score attributed to the clone. However, when there was an overlap between two clones, fractional values were used, as shown in Table 1.

Table 1. Methodology for assigning scores for the classification of the best clone and/or species, considering statistical analysis.
Tabela 1. Metodologia para a atribuição de notas para a classificação de melhor clone e/ou espécie, considerando a análise estatística.

Statistical analysis	**Score**
A	5.0
Ab	4.5
B	4.0
Bc	3.5
C	3.0
Cd	2.5
D	2.0
De	1.5
E	1.0

A scoring table was also prepared considering the absolute values in which the highest score (5) was attributed to the best value of the property and the lowest score (1) to the worst value. When two or more clones had the same average value, the same score was assigned.

RESULTS

Table 2 shows the average values obtained per clone for each parameter evaluated. For all tests it was possible to perform statistical analysis, with the exception of the wood yield for not having enough repetitions to perform the *Tukey* test. Thus, the wood yield is found only in the scoring table considering the absolute values.

Table 2. Average values of physical, mechanical and quality properties of the wood of *Eucalyptus* clones.
Tabela 2. Valores médios das propriedades físicas, mecânicas e de qualidade da madeira dos clones de *Eucalyptus*.

Parameter		Clone 1	Clone 2	Clone 3	Clone 4	Clone 5
Log quality	TCI log (%)	0.70 c (27.25)	0.47 b (26.46)	0.20 a (31.09)	0.23 a (30.72)	0.20 a (26.47)
	% heartwood (%)	70.47 a (3.35)	68.1 a (3.35)	65.21 b (6.09)	70.08 a (3.01)	58.84 c (9.09)
Sawn wood yield	Green gross yield (%)	50.12	51.01	48.42	51.91	49.91
	Dry gross yield (%)	48.09	48.23	46.35	49.46	47.72
	Green net yield (%)	39.43	41.75	44.97	46.93	44.37
	Dry net yield (%)	37.13	38.65	42.02	42.96	40.92
Physical properties	Tangential retraction (%)	7.60 a (15.20)	9.56 b (7.75)	8.01 a (10.42)	8.58 ab (2.50)	8.20 a (8.80)
	Radial retraction (%)	4.40 a (27.53)	6.52 b (9.77)	4.76 a (27.98)	5.44 ab (8.44)	4.87 a (11.18)
	Longitudinal retraction (%)	0.15 ab (69.14)	0.22 b (26.71)	0.08 a (47.55)	0.13 ab (89.64)	0.12 ab (69.38)
	Volumetric retraction (%)	12.15 a (18.16)	16.31 b (6.63)	12.85 a (14.34)	14.15 ab (4.23)	13.19 a (8.34)
	Anisotropy coefficient	1.78 a (13.14)	1.48 a (13.35)	1.77 a (21.33)	1.59 a (8.15)	1.69 a (10.09)
	Basic density ($g.cm^{-3}$)	0.473 d (9.67)	0.595 a (4.72)	0.492 cd (6.96)	0.534 b (4.35)	0.511 bc (5.68)
	Apparent density ($g.cm^{-3}$)	0.510 c (13.87)	0.684 a (10.41)	0.527 c (12.20)	0.615 ab (6.08)	0.572 bc (3.88)
Mechanical properties	Compression parallel to fibers (MPa)	36 c (6.64)	47 a (5.84)	36 c (8.23)	42 b (10.37)	40 b (9.95)
	Static bending (MPa)	67 b (20.88)	91 a (18.72)	62 b (14.01)	90 a (21.46)	71 b (11.93)
	Parallel shearing of fibers (MPa)	8 b (16.90)	11 a (12.10)	10 a (12.93)	11 a (13.82)	11 a (9.28)
	Longitudinal hardness (N)	3697 cd (16.96)	4639 ab (13.44)	3499 d (17.72)	5042 a (8.90)	4199 bc (13.39)
	Radial hardness (N)	2554 bc (22.76)	3567 a (14.83)	2169 c (14.46)	3724 a (10.76)	2975 b (23.17)
	Tangential hardness (N)	2847 bc (24.14)	3442 ab (24.35)	2542 c (36.91)	3700 a (13.57)	3202 ab (16.40)
Quality of sawn wood	Green bending (mm/m)	0.57 a (107.82)	0.35 a (210.84)	0.61 a (127.88)	1.04 b (58.24)	1.02 b (61.91)
	Dry bending (mm/m)	3.08 a (49.85)	3.68 ab (51.38)	4.34 b (46.90)	3.40 ab (40.11)	3.66 ab (40.45)
	Green curving (mm/m)	1.46 a (91.50)	2.09 a (96.21)	1.91 a (117.94)	3.12 b (62.55)	3.73 b (65.83)
	Dry curving (mm/m)	5.37 a (46.29)	6.21 ab (50.27)	7.58 b (34.12)	6.38 ab (34.37)	7.69 b (33.37)
	TCI green planck (%)	21.33 c (52.56)	18.15 c (58.69)	7.13 a (81.43)	9.60 ab (62.01)	11.11 b (72.07)
	TCI dry planck (%)	22.79 b (50.98)	19.87 b (50.03)	9.34 a (71.68)	13.14 ab (57.41)	14.25 ab (72.61)

Note: averages followed by the same letter on the line do not differ statistically by the Tukey test at the 95% probability level. Values in parentheses refer to the coefficient of variation.
Legend: TCI: top crack index.

Table 3 presents the scores attributed to all tests performed for the clones, considering the results obtained in the statistical analysis. According to the analyzed variables, it may be seen that clone 4 had the highest sum, therefore better quality for the production of solid wood. Also noteworthy is clone 2, with the second largest sum with just 1.5 points less compared to the first. Clone 1 had the lowest value, so the wood quality was lower among the evaluated clones.

In view of the observed values, the order of qualitative classification of the clones would be: Clone 4; Clone 2; Clone 5; Clone 3; Clone 1. In this sense, the hybrid clones denoted inferior quality of the wood in relation to the clones of pure lines.

Table 3. Classification of clones based on statistical analysis of physical, mechanical properties and wood quality.
Tabela 3. Classificação dos clones com base na análise estatística das propriedades físicas, mecânicas e qualidade da madeira.

	Parameter	Clone 1	Clone 2	Clone 3	Clone 4	Clone 5
Log quality	TCI log (%)	3	4	5	5	5
	% heartwood (%)	5	5	4	5	3
	Subtotal	8	9	9	10	8
Physical properties	Tangential retraction (%)	5	4	5	4.5	5
	Radial retraction (%)	5	4	5	4.5	5
	Longitudinal retraction (%)	4.5	4	5	4.5	4.5
	Volumetric retraction (%)	5	4	5	4.5	5
	Anisotropy coefficient	5	5	5	5	5
	Basic density (g.cm^{-3})	2	5	2.5	4	3.5
	Apparent density (g.cm^{-3})	3	5	3	4.5	3.5
	Subtotal	29.5	31	30.5	31.5	31.5
Mechanical properties	Compression parallel to fibers (MPa)	3	5	3	4	4
	Static bending (MPa)	4	5	4	5	4
	Parallel shearing of fibers (MPa)	4	5	5	5	5
	Longitudinal hardness (N)	2.5	4.5	2	5	3.5
	Radial hardness (N)	3.5	5	3	5	4
	Tangential hardness (N)	3.5	4.5	3	5	4.5
	Subtotal	20.5	29	20	29	25
Quality of sawn wood	Green bending (mm/m)	5	5	5	4	4
	Dry bending (mm/m)	5	4.5	4	4.5	4.5
	Green curving (mm/m)	5	5	5	4	4
	Dry curving (mm/m)	5	4.5	4	4.5	4
	TCI green planck (%)	3	3	5	4.5	4
	TCI dry planck (%)	4	4	5	4.5	4.5
	Subtotal	27	26	28	26	25
	Total	**85**	**95**	**87.5**	**96.5**	**89.5**

Table 4 shows the sums related to the scoring table using the absolute values. Clone 4 with the highest summation and clone 2 with the second highest summation stand out, with a difference of 13 points. It is also observed that the lowest sum, or with the lowest quality, was clone 1, with 26 points below the best clone.

Table 4. Classification of clones with absolute values of physical, mechanical properties and wood quality.
Tabela 4. Classificação dos clones com em valores absolutos das propriedades físicas, mecânicas e qualidade da madeira.

	Parameter	Clone 1	Clone 2	Clone 3	Clone 4	Clone 5
Log quality	TCI log	2	3	5	4	5
	% heartwood	5	3	2	4	1
	Subtotal	7	6	7	8	6
Wood yield	Green gross yield	3	4	1	5	2
	Dry gross yield	3	4	1	5	2
	Green net yield	1	2	4	5	3
	Dry net yield	1	2	4	5	3
	Subtotal	8	12	10	20	10
Physical properties	Tangential retraction	5	1	4	2	3
	Radial retraction	5	1	4	2	3
	Longitudinal retraction	2	1	5	3	4
	Volumetric retraction	5	1	4	2	3
	Anisotropy coefficient	1	5	2	4	3
	Basic density	1	5	2	4	3
	Apparent density	1	5	2	4	3
	Subtotal	20	19	23	21	22
Mechanical properties	Compression parallel to fibers	2	5	2	4	3
	Static bending	2	5	1	4	3
	Parallel shearing of fibers	3	5	4	5	5
	Longitudinal hardness	2	4	1	5	3
	Radial hardness	2	4	1	5	3
	Tangential hardness	2	4	1	5	3
	Subtotal	13	27	10	28	20
Quality of sawn wood	Green bending	4	5	3	1	2
	Dry bending	5	2	1	4	3
	Green curving	5	3	4	2	1
	Dry curving	5	4	2	3	1
	TCI green planck	1	2	5	4	3
	TCI dry planck	1	2	5	4	3
	Subtotal	21	18	20	18	13
Total		**69**	**82**	**70**	**95**	**71**

DISCUSSION

Regarding the quality of the logs, it is observed that clone 4 had the highest sum, being close to clones 2 and 3. Clones 1 and 5, on the other hand, had the lowest totals, but still, with values similar to clones 2 and 3. Considering that all the clones were submitted to the same silvicultural treatments, one may attribute the statistical differences observed to the intrinsic characteristics of each species/clone (Table 3).

As for physical properties, clones 4 and 5 stood out with superior performance, while clone 1 showed the lowest sum, mainly due to the low scores attributed to the basic and apparent density.

In the sums for the mechanical properties, it is observed that clones 2 and 4 showed higher values than the others, because they are the clones with higher densities, a variable with great influence on the mechanical properties. This fact is confirmed by Pearson's strong correlation between the grades attributed to basic density and the subtotal of mechanical properties with R: 0.9368 and R^2: 0.8821.

For the quality of the sawn wood, clone 3 received the best scores and consequently the highest sum. However, it is observed that the difference between the highest and the lowest sum was only three points, indicating a certain homogeneity when evaluating all the parameters of quality of sawn wood. This fact may also be observed in the statistical analysis of the variables log quality and physical properties.

When each parameter is analyzed separately, there are significant differences between clones (Table 2). However, when the values of the sums of the set of parameters of each variable are observed, there is an effect of compensation of the properties, with minimal differences between the sums of each clone (Table 3). This effect may be observed for the variables log quality, physical properties and quality of sawn wood.

Table 4 shows that, as for the quality of the logs, that the sums had little variation, especially due to the clones that received higher scores for the percentage of heartwood being the same ones that received lower scores for the top crack index of the logs. Even so, clone 4 obtained the best sum when compared to the others. The reason is due to the assignment of the second best score for the two parameters evaluated, showing their homogeneity in log quality.

In the yield of sawn wood, there are great differences between the sums, with clone 4 and clone 1 having the largest and smallest sum, respectively. This fact is due to the sawmill layout being developed for small diameter logs and clones 4 and 1 have the smallest (20.58 cm) and largest (29.86 cm) average diameter at breast height (DBH), respectively, in the same way as Cunha *et al*. (2015), when evaluating the gross yield after the break-down, concluded that statistically the elevation of the diametric class reduced the lumber yield, and differently from Anjos and Fonte (2017) who found higher yields for trees with larger average diameters regardless of the species. The net yield considers the crack in the plancks and clone 4 presented a good score in this regard, contributing to the best score.

There was little variation for physical properties, probably due to the clones that obtained better scores for retractions receiving lower scores for the anisotropy coefficient and for densities. These results are due to the fact that the basic density directly influences the values found in the retractions, as reported by 'Schulgasser & Witztum 2015', species with higher density have greater volumetric variation. The sum of the scores for mechanical properties showed higher variations, with emphasis on clones 4 and 2 with higher values, followed by clone 5. Clones 4 and 2 received the two highest scores (5 and 4) for all tests performed, while clone 3 received the lowest score in 66% of the tests, unlike clone 4, for example, which received the highest score in 66 % of tests. It is noted that again the clones with higher densities stood out for the mechanical properties, being evidenced by the strong correlation of Pearson with R: 0.8850 and R^2: 0.7832.

In the quality of the sawn wood, little variation was observed between the sum of the clones, except for clone 5, which received the lowest score, due to its maximum score being three (3). Clone 1 performed well for the deformations of the wood, receiving high marks; however, when the cracks were evaluated after splitting and after drying, it was responsible for the highest indexes, interfering negatively in its quality, receiving the lowest marks. The highest rates of cracks in the boards are probably due to the clone having the highest percentage of cracks in its logs, as observed by Müller *et al*. (2019). Even so, this clone showed the best quality in sawn wood, similar to clone 4.

The scoring tables using statistical analysis or absolute values proved to be an important tool for the qualitative classification of clones/species for obtaining solid wood, presenting the same classification sequence of the five clones. The tables are an easy to determine the best clone/species based on a set of evaluated properties, optimizing the technical-scientific process. Looking more broadly, the application of this type of table may be expanded to evaluate and classify wood for other purposes, such as in the energy, paper, cellulose and furniture industry, among others.

CONCLUSIONS

- The use of tables for classifying wood based on its properties allows identifying the best clone for use as solid wood.
- Density, log and board splitting rates were the factors that most influenced the subtotals and final sum of the classification tables.
- Pure line clones (2 and 4) have better qualities for solid wood production.

- Clone 4 had the best score in the two analyzed tables, being classified as of superior quality for the production of solid wood.
- The statistical analysis score tables and absolute values show the same order of classification of the clones and can be used to optimize the identification of the best clone/species for wood quality.

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REFERENCES

ANJOS, R.A.M. dos; FONTE, A.P.N. Rendimento em madeira serrada de espécies de Eucalyptus. **Revista de Ciências Agroveterinárias**, Lages, v.16, p.26-32, 2017.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). **NBR 14806**: madeira serrada de eucalipto – Requisitos. Rio de Janeiro. 2002.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). **NBR 11941**: madeira – determinação da densidade básica. Rio de Janeiro. 2003.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM). **ASTM D245-06**, Standard Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber, ASTM International, West Conshohocken, PA, 2019.

BATISTA, D.C.; KLITZKE, R.J.; ROCHA, M.P. Qualidade da secagem convencional conjunta da madeira de clones de três espécies de Eucalyptus sp. **Ciência Florestal**, Santa Maria, v.25, n.3, p.711-719, 2015.

BREINIG, L.; LEONHART, R.; BROMAN, O.; MANUEL, A.; BRÜCHERT, F.; BECKER, G. Classification of wood surfaces according to visual appearance by multivariate analysis of wood feature data. **J Wood Sci**, v. 61, p. 89 – 112, 2015.

MÜLLER, B. V.; PEREIRA DA ROCHA, M. P.; KLITZKE, R. J.; CUNHA, A. B.; SILVA, J. R. M.; FRANÇA, M. C.; NICOLETTI, M. F. Qualidade da madeira serrada de cinco espécies de *Eucalyptus* resistentes à geada. **Ciência da Madeira**, Pelotas, v. 10, n. 1, p. 57-70, 2019.

COMISSION PANAMERICANA DE NORMAS TECNICAS. **COPANT.** Caracas. 1973.

CUNHA A.B.; BRAND M.A.; SIMÃO R.L.; MARTINS S.A.; ANJOS R.A.M.; SURDI P.G.; SCHIMALSKI M.B. Determinação de rendimento de matéria-prima de *Eucalyptus benthamii* Maiden & Cambage por meio de diferentes métodos de desdobro. **Revista Árvore**, Viçosa, v. 39, n. 4, p. 733-741, 2015.

INDÚSTRIA BRASILEIRA DE ÁRVORES (**IBÁ**). Relatório 2022. Disponível em: < https://iba.org/datafiles/publicacoes/relatorios/relatorio-anual-iba2022-compactado.pdf>. Acesso em: 24 fev. 2023.

LIMA, I.L.; GARCIA, J.N.; STAPE, J.L. Influência do desbaste e da fertilização no deslocamento da medula e rachaduras de extremidade de tora de *Eucalyptus grandis* Hill ex-Maiden. **Cerne**, Lavras, v. 13, n. 2, p. 170 – 177, 2007.

LIMA, I.L.; STAPE, J.L. Caracterização da madeira serrada em clones de Eucalyptus. **Pesquisa Florestal Brasileira**, Colombo v. 37, n. 89, p. 55-62, 2017.

LATORRACA, J. V. de; DIAS JÚNIOR, A. F.; SILVA, G. C.; PACE, J. H. C.; CARVALHO, A. M. de. Anelamento e vaporização de toras visando otimização do processo de secagem da madeira eucalipto. **Revista Brasileira Ciências Agrárias**, Recife, v.10, n.2, p.273-279, 2015.

LONGUE JÚNIOR, D.; COLODETTE, J. L. Importância e versatilidade da madeira de eucalipto para a indústria de base florestal. **Pesquisa Florestal Brasileira**, Colombo, v. 33, n.76, p. 429-438, 2013.

PREFEITURA DE MOGI GUAÇU, 2023. Disponível em <https://www.mogiguacu.sp.gov.br/cidade.html#:~:text=O%20solo%20%C3%A9%20pobre%2C%20formado,as%20encostas%2C%20formam%20afloramentos%20bas%C3%A1lticos.> Acesso em 13 de fevereiro de 2023.

ROSA, T.O.; VIEIRA, H.C.; TEREZO, R.F.; CUNHA, A.B.; SAMPAIO, C.A.P.; ZANGALI, C., ROSA, G.O.; WALTRICK, D.B. Classificação visual e mecânica da espécie *Cryptomeria japonica* D. Don para utilização em madeira laminada colada. **Ci. Fl.**, Santa Maria, v. 30, n. 2, p. 451 – 462, 2020.

SCHULGASSER, K.; WITZTUM, A. How the relationship between density and shrinkage of wood depends on its microstructure. **Wood Science and Technology**, v. 49, n. 2, p. 389 – 401, 2015.

SUNDARAM, M.; ABITHA, J.; MAL MATHAN RAJ, R.; RAMAR, K. Wood species classification based on local edge distributions. **Optik**, v. 126, n. 21, 2015.

WINK, C.; REINERT, D. J.; MÜLLER, I.; REICHERT, J. M.; JACOMET, L. A idade das plantações de *Eucalyptus* sp. influenciando os estoques de carbono. **Ciência Florestal**, Santa Maria, v. 23, n. 2, p. 333-343, 2013.