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Eucalyptus sp. sawn wood yields in the Los Palacios agroindustrial base unit, Pinar del Rio, Cuba

Incremento de los rendimientos de madera aserrada de Eucalyptus sp en la unidad de base agroindustrial Los palacios, Pinar del Rio, Cuba

Acrescentamento dos rendimentos de madeira serrada de Eucalyptus sp na Unidade de Basse Agroindustrial Os Palácios, Pinar del Río, Cuba

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ABSTRACT

The present study is developed in the areas of the Los Palacios Agroindustrial Base Business Unit, with the objective of increasing the yield of *Eucalyptus pellita* F Muell, and *Eucalyptus saligna* Smith sawn wood from the use of a combination of treatments to reduce the effect of growth stresses and sawing schemes. 200 logs of 4 m were used and through the two-factor ANOVA analysis, it was found that there are no significant differences between the species on the Cracking Index; considering also that the best results are obtained in logs stored with irrigation for *Eucalyptus saligna* and standing ringed trees for both species. From the application of the elimination method in the linear regression analysis, the conicity variable is excluded for the construction of the prediction model using the diameter of the logs as the only independent variable in the two equations obtained, which are characterized by presenting high coefficients of correlation, determination and low standard errors of estimation. Taking into consideration the sawing methods, it is defined that the best yields of sawn wood are obtained from alternative tangential sawing combined with the treatment of standing ringed trees.

Keywords: logs, splits, sawing, quality

RESUMEN

El presente trabajo se desarrolló en las áreas de la Unidad Empresarial de Base Agroindustrial Los Palacios, con el objetivo de incrementar los rendimientos de madera aserrada de *Eucalyptus pellita* F Muell y *Eucalyptus saligna* Smith a partir de la utilización de la combinación de tratamientos para reducir el efecto de las tensiones de crecimiento y los esquemas de aserrado. Se utilizan 200 trozas de 4 m y mediante el análisis ANOVA de dos factores, se comprobó que no existen diferencias significativas entre las especies sobre el Índice de rajadura; considerando además que los mejores resultados se obtienen en las trozas almacenadas con riego para *Eucalyptus saligna* y árboles anillados en pie para ambas especies. A partir de la aplicación del método de eliminación en el análisis de regresión lineal, la variable conicidad queda excluida para la construcción del modelo de predicción, utilizando como única variable independiente el diámetro de las trozas en las dos ecuaciones obtenidas que se caracterizan por presentar elevados coeficientes de correlación, determinación y bajos errores estándar de estimación. Teniendo en consideración los métodos de aserrado, se define que los mejores rendimientos de madera aserrada se obtienen a partir del aserrado tangencial alternativo combinado con el tratamiento de árboles anillados en pie.

Palabras clave: trozas, rajaduras, aserrado, calidad.

RESUMO

O presente trabalho desenvolve se nas áreas da Unidade de Basse Agroindustrial Os Palácios, com o objectivo de acrescentar os rendimentos da madeira serrada de *Eucalyptus pellita* F Muell y *Eucalyptus saligna* Smith partindo do emprego da combinação de tratamentos para reduzir o efeito das tensões de crescimento e os desenhos de serrado. Empregaram se 200 troças de 4m cada uma e mediante a analise ANOVA dos fatores, comprovou se que não existem diferenças entre as espécies sobre o índice da fissura~ considerando, embora disso, que os melhores resultados obtém se nas troças armazenadas com riscos para *Eucalyptus saligna* e as árvores aniladas em pé para ambas espécies. Partindo da aplicação do método da eliminação na análise de regressão linhal, a variável conicidade foi excluída para a construção dum modelo de predição, empregando como única variável independente o diâmetro das troças nas duas equações obtidas que caracterizam se por presentar levados coeficientes de correlação, correlação e baixos erros nos estandartes de estimação. Tendo em consideração os métodos de serrado se define que os melhores rendimentos de madeira serrada obtém se a partir do serrado tangencial alternativo, combinado com o tratamento das árvores aniladas em pé

Palavras chaves: troças, fissura, serrado, qualidade

INTRODUCTION

The forestry industry is a necessary tool to make sustainable forestry production a viable objective. It is also an agent for sustainable development in its own right, increasing the socio-economic benefits of the sector.

Pupo *et al*. (2018), state that currently it is an objective of forestry policy to grow each year in wood production, mainly from plantations, alleviating the existing pressure on natural forests since the vast majority of species with high commercial value are distributed in these forests.

The demand for raw materials continues to increase and the supply of wood is even more limited, with the diversification of fast-growing species playing a fundamental role that, in addition to adapting to soil and climate conditions, are highly productive and have good quality wood, where the genus *Eucalyptus* stands out, coinciding in this aspect with (França *et al*. 2019).

However, according to Beltrame *et al.* (2016), the greatest technical limitation that this genre presents is the magnitude of the growth tensions, which is probably the most significant indicator, since high levels of tension (particularly longitudinal tensions) cause the defects that harm the most the performance and obtaining quality of sawn wood.

Growth tensions begin to be released from the moment of felling and appear as cracks at the ends of the logs. In sawn pieces, the remaining stresses also cause cracking and warping (França *et al.* 2019 and Silva *et al*., 2019) . Therefore, the general objective of the present study is to increase the yields of *Eucalyptus pellita* and *Eucalyptus saligna* from the use of a combination of treatments to reduce the effect of growth stresses and sawing schemes.

MATERIALS AND METHODS

Methodology

The investigation was carried out at the Rigo Fuentes band sawmill, belonging to the La Palma Agroforestry Company, specifically in the "Los Palacios" Agroindustrial Base Business Unit located in the Popular Council of San Diego de los Baños, Los Palacios Municipality, Province of Pinar del Río, Cuba.

Los Palacios municipality is located in the south-eastern part of the province of Pinar del Río. It limits to the North with the municipalities of La Palma, to the South with the waters of the Gulf of Batabanó, to the West with the Consolación del Sur municipality and to the East with San Cristóbal, the territory extends from the elevations of the Guaniguanico Mountain Range to the south coast bathed by the Caribbean Sea and has a territorial area of 764.51 km^2.

The Agroindustrial Base Business Unit ¨Los Palacios¨ is located in the mountainous area of the municipality and has a forestry heritage of 12,249.60 hectares, with 199 workers, distributed in six brigades to attend to everything related to Forestry use and Forest industry.

Two species of genus *Eucalyptus* are used: *Eucalyptus pellita* and *Eucalyptus saligna* in plantations that cover 373.6 hectares of the 1451.70 hectares that constitute established plantations of the Forest Heritage of the Los Palacios Municipality.

Determination of the number of samples used in the research

Simple random sampling was used based on the use of 100 trees, with the diameter ($D_{1.30}$) as variable of interest; according to the methodology proposed by Aldana *et al.* (2010) and Álvarez *et al.* (2020); which use the following equations Equation 1 and 2:

$$n=\frac{t^2 s_x^2}{E^2} \qquad (1)$$

$$E=(LE*\overline{X}) \qquad (2)$$

where: n = number of samples; t^2= Student 's t-statistic squared; LE= limit of permitted sampling error.

The sample consists of 200 logs of 4 m length of each species, with a diameter between 21 and 30 cm. This number was divided into groups of 50 to apply the different treatments to reduce the rates of cracking of the logs and increase the sawn wood yields

Determination of the efficiency of the sawing process of Eucalyptus pellita and Eucalyptus saligna depending on the sawing schemes and treatments to reduce growth stresses

From the combination of three treatments to reduce the effect of growth stresses on the quality of the logs; combined with the application of different sawing methods, proposed by Pedro *et al.* (2014), cited by Juizo *et al.* (2018); Carvalho *et al.* (2019) to increase the efficiency of the *E. pellita* and *E. saligna* sawing process. The treatments are the following:

Treatment of stored logs with irrigation (T1)

This treatment consists of keeping the logs subjected to irrigation for 4 times a day, with the aim of maintaining a high humidity gradient in the wood to reduce the effect of internal growth stresses and at the same time make the sawing of the logs easier, according to (Pupo *et al*., 2018).

Treatment of stored logs with ring at the ends (T2)

It consists of making a 30 cm ring at each end of the logs, deepening 1/3 of the diameter, taking into account what was proposed by Pupo *et al.* (2018).

Pattern (T3)

Logs stored under normal conditions for comparison.

Girdling of standing trees (T4)

It consists of making a ring 30.0 cm wide above the felling height of the trees, deepening 1/3 of the diameter with the objective of cutting off the circulation of the sap, eliminating the cambium of the tree, until reaching the desired depth, for which it was necessary to wait three months (Neto, 2017 and Pupo *et al.*, 2020). Next, a four-meter-long log is obtained located above the felling height and containing the ringing made.

The logs were transferred from the logging area to the Agroindustrial Base Business Unit "Los Palacios" where all the treatments were mounted. As an index of determining the effect of the methods applied to reduce growth stresses on *Eucalyptus wood sp* The Cracking Index is taken as a reference.

Determination of crack index

In the development of the treatments, the quantification of the cracks produced in the logs due to the release of growth stresses in terms of length (LG), depth (PG), width (AG) and number (NG). These data were processed with the facilities of the Microsoft Excel system where the means of each of the quantified parameters were determined (Figure 1), as well as the log cracking index (IRT), according to the treatment and species, using the equation used by Beltrame *et al.*, (2015) (Equation 3)

$$IR = 200\left[\frac{\sum_{i=1}^{n} a_i C_i}{\pi D^2}\right] \quad (3)$$

log splitting index, %; a_i - maximum opening of the crack (i = 1...n), cm; C_i - size of the crack (pith-cortex), cm; D - average cutting diameter, cm.

For the construction of the models that allowed the prediction of the Cracking Index, the standard sample (T3) was taken, with the IR as dependent variables and the diameter in the center of the log and the conicity of the logs as independent variables. The selection of both variables is based mainly on conceptual or theoretical foundations (Hair *et al.*, 1999). To adjust the crack index estimation models, multiple linear regression was used, using the stepwise method.

After the time established in the applied treatments had concluded, the samples were transferred to the Martín González sawmill where the second phase of the research was carried out.

Due to the particularity of *Eucalyptus sp* regarding the high internal growth stresses and their subsequent defects in the sawn wood, two sawing schemes were applied to the samples, called (A)- tangential sawing with successive cuts and (B)- tangential sawing with alternative cuts, as represented in Figure 1; agreeing with Carvalho *et al.* (2019).

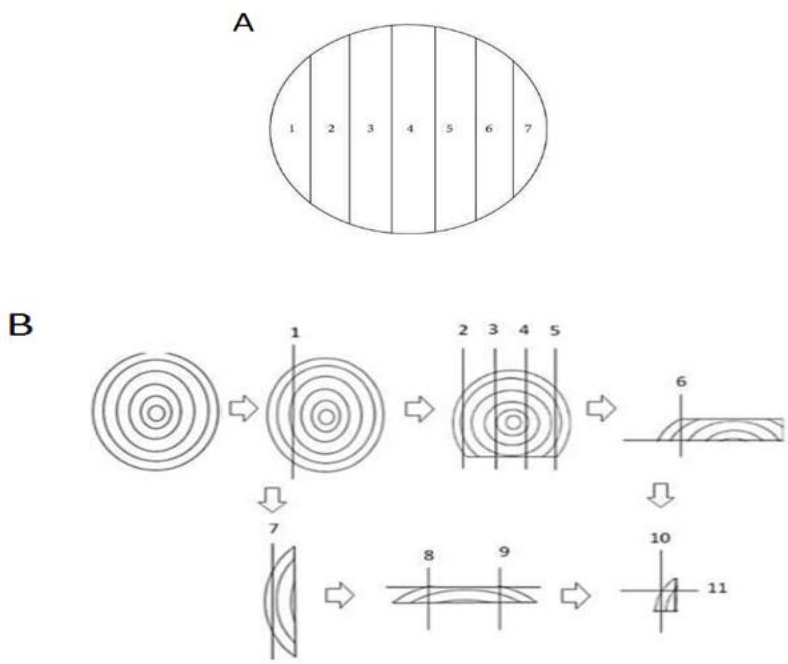

Figure 1. *- Sawing methods. A- Tangential sawing with successive cuts. B- Alternative tangential sawing.*

Source: Pedro et al. (2014) cited by Juizo et al. (2018) y Carvalho et al. (2019)

25 logs per treatment were processed to define the yields and quality of the sawn wood for the *Eucalyptus species* investigated. Sawn wood yields are obtained from the following mathematical expression, coinciding with Leyva *et al.*, (2017) Equation 4.

$$R_v = \left(\frac{Vma}{Vt}\right) * 100 \quad (4)$$

Where: r_v - Total volumetric yield, (%); vma - Volume of sawn wood, (m^3); Vt - Volume of wood in logs (m^3)

The volume of total sawn wood in each log in the sawmills was determined based on the linear measurements obtained from sawn wood according to the expressions set out below Equation 5:

$$Vma = \sum_{i=1}^{n}(a_i * g_i * l_i) \quad (5)$$

Where: Vma - volume of sawn wood from a log, m^3; a_i, g_i, l_i - width, thickness and length of the piece *i* obtained from a log or group of logs, m; n- number of sawn pieces of a log

The calculation of the raw volume of each log was carried out using the Smalian formula, taking into consideration studies developed by (Casagrande *et al.*, 2019), as shown in the following equation (Equation 6):

$$Vmb = ((g_1 + g_2)/ 2) * L \quad (6)$$

Where: Vmb, volume of wood in bolus (m^3); g_1: basal area at the fine end (m^2);

g_2: basal area at the thick end (m^2); L, length of the log (m).

Statistical analysis

The variables length (LG), depth (PG), width (AG) and number of cracks (NG) were analyzed to know if the theoretical assumptions were met (normal distribution and homogeneity of variances). A two-factor ANOVA was carried out, taking into account the behavior of each dependent variable in each methods or treatments applied in the investigated species, with the exception of the specific case of number of cracks that does not meet the theoretical assumptions since it does not follow a normal distribution and logarithmic transformations were applied.

Through the Duncan test at a level of 5 % probability of error, the existence of significant differences between the methods or treatments applied in each of the quantified variables was determined.

It has been made besides an analysis of variance to define differences between the species investigated and the methods or treatments applied to reduce the magnitudes of cracks (number, width, length and depth of cracks) and the Log Cracking Index (IRT) through an HSD Tukey test considering a value of P= 0.05

A paired samples t-analysis was used in the validation process of the regression models obtained for the prediction of the Cracking Index in the investigated logs.

RESULTS AND DISCUSSION

Analysis of treatments to reduce the effect of internal growth stresses in Eucalyptus pellita and Eucalyptus saligna wood

Figure 2 shows the behavior of the number of cracks per treatment depending on the species. Observing that the standard sample is the one with the greatest number of cracks, considering that no treatment has been applied to these logs to reduce the effect of growth stresses on the development of cracks at the ends; which directly affects the effectiveness of the mechanical transformation process of these logs in volume and quality of the processed wood; coinciding with Braz *et al*. (2017) (Figure 2).

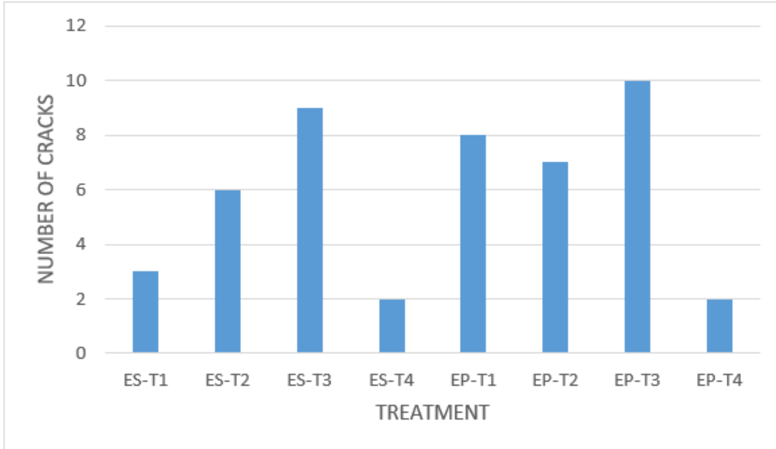

Figure 2. *- Number of cracks. EN- Eucalyptus saligna, Eucalyptus pellita, T1-Treatment 1, T2-Treatment 2, T3-Treatment 3, T4-Treatment 4*

In Figures 3 and 4, it can be seen that the best results were obtained in the treatments of logs stored with irrigation (T1) and in standing ringed trees (T4) for *E. saligna* Smith and in standing ringed trees (T8) for *E. pellita* (Figure 3 and 4).

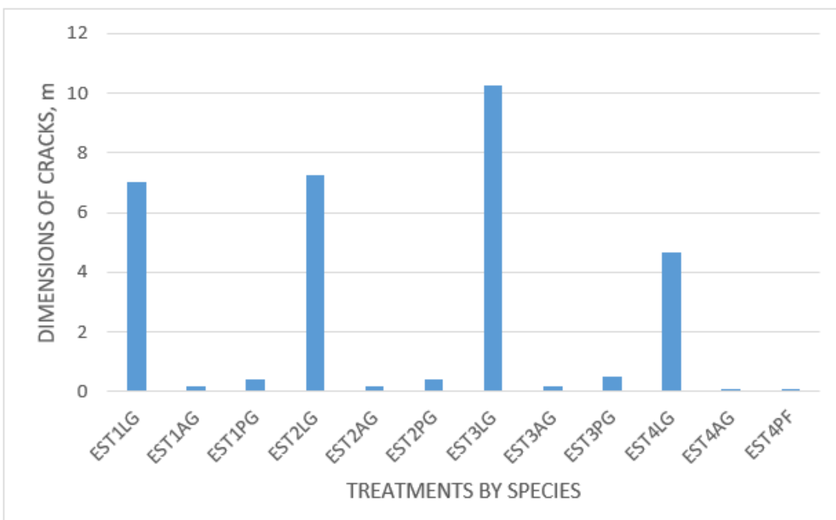

Figure 3. - *Dimensions of cracks by treatment. EN- Eucalyptus saligna, T1-Treatment 11, T2-Treatment 2, T3-Treatment 3, T4-Treatment 4, LG-Length of cracks, AG-Width of cracks, PG-Depth of cracks*

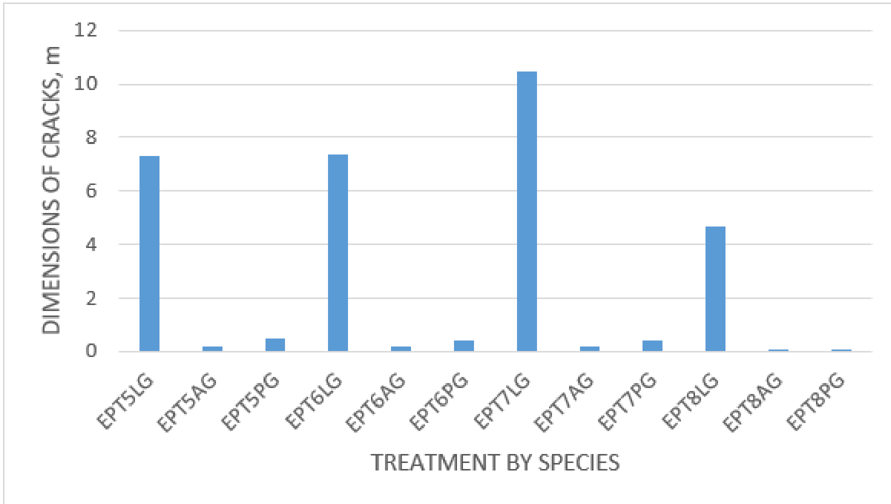

Figure 4. *- Dimensions of cracks due to treatment in Eucalyptus pellita. T5-Treatment 5, T6-Treatment 6, T7-Treatment 7, T8-Treatment 8, LG-Length of cracks, AG-Width of cracks, PG-Depth of cracks*

The results presented in Figures 3 and 4 made it possible to show a reduction in the dimensions of the magnitudes of the cracks, which is a consequence of a greater release of growth stresses; agreeing with Müller *et al.* (2017) and Silva *et al.* (2017).

These results were demonstrated through a two-factor ANOVA taking into account the behavior of each dependent variable in each test or treatment carried out for each species.

When analyzing the behavior of each variable independently, it is summarized that in the variable number of cracks (NG) the interaction between the factors (treatments and species) is seen and the best treatments without significant difference between them are the treatments of stored logs with irrigation (T1) and standing ringed trees (T4) for *E. saligna,* where values of 3.25 cm and 2.0 cm respectively were obtained and in standing ringed trees (T4) for *E. pellita* with an average value of (1.66 cm) (Table 1).

In the case of the variable crack length (LG) there were no significant differences between the species or between the treatments. The treatment of logs stored with irrigation (T1) with 7.04 cm in *E. saligna* and 7.29 cm in *E. pellita* does not differ statistically from the treatment logs stored with a ring at the ends (T2) with 7.26 cm in *E. saligna* and 7.35 cm in *E. pellita*, indicating that the release of growth stresses were more evident in the appearance of cracks at the ends of the logs.

However, there is a significant difference between the treatment of standing ringed trees (T4) with the other treatments and the pattern (T3), considering this as the most effective to reduce cracks at the ends of the logs for both species with minimum values obtained of 4.65 cm in *E. saligna* and 4.67 cm in *E. pellita* (Table 1).

Table 1. *- Means of each variable in the different treatments evaluated*

›ecies	Treatments	NG	LG cm	AG cm	P.G. cm
Eucalyptus saligna	**1**	3.25d	7.04b	0.018a	0.045a
	2	6.25c	7.26b	0.017a	0.043a
	3	9.00ab	10.28a	0.019a	0.048a
	4	2.00d	4.65c	0.010b	0.010b
Eucalyptus pellita	**1**	8.00bc	7.29b	0.020a	0.049a
	2	7.50bc	7.35b	0.018a	0.043a
	3	10.25a	10.48a	0.020a	0.044a
	4	1.66d	4.67c	0.011b	0.010b

Note: Values with the same letter show that there are no significant differences between the treatments for P < *0.05.*

This is a consequence of the fact that ringing causes the death of the trees, losing moisture, reducing the effect of drying stresses. Another reason is the partial release of growth stresses, causing a decrease in the magnitude of the cracks.

Silva *et al.* (2017) obtained average cracking values by applying the treatment of standing ringed trees in *E. europhylla* (26.73 cm) much higher than those obtained in the present investigation. The width (AG) and depth (PG) of the cracks show similar behavior as in the previous variable. With minimum values obtained of (0.011 cm) in *E. saligna* and (0.010 cm) in *E. pellita* in the treatment of standing ringed trees, reaffirming its effectiveness.

Analysis of the determination of the Cracking Index

Through the two-factor ANOVA analysis, it was verified that there are no significant differences between the species on the Cracking Index; also considering the existence of a significant effect of the treatment factor on the Cracking Index (Table 2).

Table 2. - *Results of the analysis of variance for the log cracking index*

Variance analysis					
Fountain	**Sum of squares**	**Gl**	**Middle Square**	**F**	**P**
Testing	0.415184	3	0.138395	27.40	0.0000
B: Species	0.00300312	1	0.0030012	0.59	0.4482
A x B	0.403344	3	0.0134448	2.66	0.0709
Residue	0.121225	24	0.00505104		
Total	0.579747	31			

Pupo *et al.* (2018 y 2020), establish that the presence of cracks is a consequence of the presence of growth stresses and that is why the application of different treatments aims to reduce their effect, which develops with marked significance in the genus *Eucalyptus*, coinciding in this sense with Silva *et al.* (2019).

Table 3 shows the existence of significant differences between the applied treatments, where T4 (girding of standing trees) is the one with the best performance with the lowest cracking index (0.15) in *E. saligna* and (0.26) *E. pellita,* although in the other treatments applied a tendency to decrease in relation to the pattern can be seen (Table 3) and coinciding with Beltrame *et al.* (2015).

Table 3. - *Comparison of the averages of the Cracking Indices of the logs according to the treatments applied*

TREATMENTS	IRT (%) *E. saligna*	IRT (%) *E. pellita*
1	0.32b	0.37b
2	0.29c	0.29c
3	0.56a	0.48a
4	0.15d	0.26da

Values with the same letter show that there are no significant differences between the treatments for P > 0.05.

In studies carried out on different clones of *Eucalyptus sp* by Beltrame *et al.* (2015), the average value obtained is 0.46% although in some of them the results were between 0.14 and 0.34 %, very similar to those obtained in the present investigation.

Mathematical modeling of the influence of the diameter and taper variables on the prediction of the Cracking Index of logs

It is very important to determine the effect of the characteristics of the tree on the wood values, in order to provide information for the selection of the models, which is why the log variables diameter and taper (CON) are used and to determine the degree of this relationship between the variables used in the estimation of the cracking indices in the logs was constructed in the correlation matrix shown in Tables 4 and 5.

As can be seen in Tables 4 and 5, the correlation coefficients of the variables used to estimate the cracking index in the two species studied are significant, which demonstrates the high degree of relationship between them (Table 4 and Table 5).

Table 4. - Pearson parametric correlation matrix for *Eucalyptus pellita*

	Diameter	GO	WITH
DIAMETER Pearson correlation	1	-.857 **	-.0.45
Sig. (bilateral)		,000	.757
N	fifty	fifty	60
IR Pearson Correlation	-.857 **		.201
Sig. (bilateral)	.00		
N	60	fifty	fifty
WITH Pearson correlation	-.045	.184	1
Sig. (bilateral)	.757	.201	
N	fifty	fifty	fifty

***The correlation is significant at the 0.01 level (two-tailed)*

Table 5. *- Pearson parametric correlation matrix Eucalyptus saligna*

	Diameter	GO	WITH
DIAMETER Pearson correlation	1	-.857 **	-.0.45
Sig. (bilateral)		,000	.757
N	fifty	fifty	60
IR Pearson Correlation	-.857 **		.201
Sig. (bilateral)	.00		
N	60	fifty	fifty
WITH Pearson correlation	-.045	.184	1
Sig. (bilateral)	.757	.201	
N	fifty	fifty	fifty

*Note: **The correlation is significant at the 0.01 level (two-tailed)*

Using the independent variables (diameter and taper of the logs) with the greatest relationship with the dependent variable (IR), prediction equations for the log splitting index are obtained for the *E. saligna* and *E. pellita* and the compared models are seen in Table 6, with their respective correlation coefficients r, determination (r^2) and standard error of estimation (s), obtaining a set of results that denote that there is a linear correlation between the cracking index of the logs, and the variables under study, reporting that there is an r square of 0.715 for *E. saligna* and 0.806 for *E. pellita*; which is considered strong. From the application of the elimination method in the linear regression analysis, the conicity variable is excluded for the construction of the prediction model (Table 6).

Table 6. *- Models to determine the log cracking index*

SPECIES	REGRESSION MODELS	R	R^2	YES
E. saligna	IRT= 1.474-0.046(Diameter)	0.845	0.715	0.09155
E. pellita	IRT= -0.606+0. 047(Diameter)	0.898	0.806	0.07087

The two equations constructed to determine the splitting index in logs have high correlation and determination coefficients and low standard errors of estimation. However, the best behavior is found in the model that corresponds to *E. pellita*, which has the best fit (the independent variables explain 89% of the dependent variable) and the lowest value of the standard error of estimation.

Validation of the regression models obtained

Tables 7 and 8 show the comparison between the prediction of the IR variable in 50 % of new samples to validate with the real values of that variable, obtaining accuracy in the behavior of the proposed model as no significant difference was found between the real and estimated value of the models for *E. saligna* and *E. pellita* (Table 7).

Table 7. - *T test for validation of the proposed model for IR in Eucalyptus saligna*

	Paired differences							
	Half	**Standard deviation**	**Mean standard error**	95% confidence interval of the difference		**t**	**gl**	**Yeah. (bilateral)**
				lower	**Superior**			
Pair 1 IR-Unstandardized Predicted value	.00173255	.079642299	.01592860	-.03114246	.03460756	.109	24	.914

Table 8. *- T test for validation of the proposed model for IR in Eucalyptus pellita*

	Paired differences							
	Half	**Standard deviation**	**Mean standard error**	95% confidence interval of the difference		**t**	**gl**	**Yeah. (bilateral)**
				lower	**Superior**			
Pair 1 IR-adjust	.06958	.22310	.04554	'022562	.16279	,1,506	23	.146

The validation of the model guarantees its precise use in social practice for the prediction and control of the incidence of crack formation and its implication on the quality of the bolo wood and its influence on the yields and quality of the sawn wood.

Analysis of sawn wood yields based on the proposed sawing methods

Taking into consideration the experienced sawing methods, it was possible to establish that in the results presented in Table 9, the best yields were obtained for both species with the use of the sawing method with alternative tangential cuts and in the treatment of standing ringed trees where the lowest crack index values are obtained (Table 9).

Table 9. *- Yields of sawn wood for Eucalyptus sp.*

Treatments	**GO-** *E. saligna* %	**GO** *E. pellita* %	**Rend -** *E. saligna* **CTCS** %	**Rend -** *E. saligna* **CTA** %	**Rend -** *E. pellita* **CTCS** %	**Rend -** *E. pellita* **CTA** %
Storage with irrigation	0.32	0.37	46.34	49.98	45.75	46.95
End banding of logs	0.29	0.29	47.25	50.65	47.88	51.55
Pattern	0.56	0.48	42.19	44.14	43.21	42.76
Girdling of standing trees.	0.15	0.26	48.19	51.87	49.10	52.55

Note*: IR- Crack index, CTCS- Tangential cut with successive cuts, CTA-Alternative tangential cut.*

Anjos and Fonte (2017), in *E. grandis* and *E. dunnii* obtained yield values between 41.07 % and 43.85 %, 36.71 % and 41.02 % respectively, also lower than those obtained, although in *E. saligna* it obtained values between 43.87 % and 47.46 %, the latter very similar to the results obtained in both species with the use of the tangential sawing scheme with successive cuts, applying the ringing treatment at the ends of the logs.

Also, Carvalho *et al*., (2019), in *Eucalyptus sp* obtained yield values of 47.08 % similar to the previous result and 53.43 % higher than those obtained. Melo *et al.* (2016), in studies carried out with native species, obtained yield results of 49.0 %, similar to those obtained in this research.

Demonstrating the need to take these approaches into consideration to obtain the best results in relation to the efficiency of the primary transformation process in sawmills for logs of *E. saligna* and *E. pellita*.

The simulation model is based on the solution of the two-dimensional cutting problem in an irregular space that could be extended to a third dimension. In its computational implementation, the algorithm uses the commercial information of the required wood orders to optimize the sawing pattern for a specific log.

CONCLUSIONS

Taking into consideration the experienced sawing methods, it can be established that the best yields are obtained for both species with the use of the sawing method with alternative tangential cuts combined with the treatment of standing ringed trees.

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***Conflict of interests*:**

The authors declare not to have any interest conflicts.

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The authors have participated in the writing of the work and analysis of the documents.