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RESEARCH CONCERNING THE NUMBER AND SURFACE OF THE KNOTS DETECTED ON BLACK POPLAR (POPULUS NIGRA L.)

E.C. DAVID[1] A. CIUBOTARU[1]

Abstract: *The article presents the correlations between the numbers of knots, respectively the total area of knots detected on a tree, reported at the base diameter. After applying the statistic analysis, the results showed coefficients of correlation of 0.69 and 0.83. The regression was verified with Fisher test. The significance of the regression coefficient was tested using Student t test.*

Key words: *number of knots, the total area of knots, regression coefficient.*

1. Introduction

The knots are inevitable defects of the trees. They can restrict the use of wood. Many authors were concerned of wood defects, recalling in their work the knots. The most significant manuscripts were: [1], [3-7] and [10].

Regarding the use of the wood, there was consulted Romanian standard ASRO EN 1316-2 (November 2001, [13]), which is identical to the European Standard EN 1316-2 (February 1997, [12]). According to them, poplar wood can be classified into three categories of quality, namely: the class of exceptional quality (Po-A), the second class (Po-B) and the third class which includes logs and balls from which more than 40% from wood is usable. Thus, in the first class is allowed a single apparently healthy knot with less than 20 mm diameter, or a covered knot with a diameter less than 60 mm, reported to the minimum length of the piece. In the second class there are allowed two apparent knots with diameter less than 40 mm, or two apparent dry knots with a diameter of less than 20 mm, or a healthy knot with diameter less than 40 mm and a dry knot with diameter of less than 20 mm (related to the minimum length of the piece). The third class is the most permissive. In this class there are admitted both types of knots (with a diameter less than 60 mm and larger).

The article presents the correlations between the base diameter and the total number of the knots, and between the base diameter and the total surface of the knots detected on each tree.

A similar study was conducted by [9], who analyzed the knots detected on pine trunks. Also, there was determined an average diameter and the sum of diameters for each category of knots. The study showed the distributions between the

[1] Dept. of Forest Exploatation, *Transilvania* University of Braşov.

elements presented above and the height at which the knots were detected. There were established equations of regression between the average diameter, the maximum diameter and for each category the height of occurrence of the knot.

Two other authors researched the relationship between the diameters of the knots and their location. The researches were performed on spruce [2].

2. Materials and Methods

The research was conducted in the Feldioara town Braşov County, in the alignment of black poplar in Vadul Roşu.

Research methodology began with a detailed documentation on the chosen topic followed by field work statistical analysis of data and finally the interpretation of the results.

The field work involved the measurement of biometric characteristics of the trees, the identification and measurement of the knots. Field equipment consisted of a dendrometric roulette and two devices: Criterion RD 1000 and TruPulse TM 200.

After execution of field work, the data were centralized in an Excel file. For each tree there were determined the total number of knots and total surface of knots detected on a single tree. Because most part of the knots had a larger size than the other, the knots were likened as rectangles and the surface was determined by the rectangle formula.

Subsequently there were summed the areas for all knots detected on a tree and an average surface for each category of diameters was calculated.

For the statistical analysis of data there was used the simple linear regression. For this purpose there were consulted specific publications ([8] and [11]).

3. Results and Discussions

3.1. The correlation between the base diameter and the total number of knots detected on black poplar tree

To highlight the link between the base diameter and the total number of knots detected on an individual, the trees were grouped into categories of diameters from 2 to 2 cm and from 4 to 4 cm.

The first way of grouping leads to a value of 0.55 for simple correlation coefficient, and for the second modality the simple correlation coefficient is 0.69. This is why the regression table (Table 1) corresponds to the second classification of diameters (from 4 to 4 cm).

As shown in Table 2, the simple correlation coefficient is 0.69, indicating a connection of average intensity between the base diameter and number of knots detected.

The categories of diameters Table 1

The categories of diameters [cm]	The average number of knots detected on a tree	The categories of diameters [cm]	The average number of knots detected on a tree
32	16	56	15
36	15	60	22
40	18	64	24
44	17	68	22
48	17	72	21
52	14		

Table 2

Table of regression for the variation in the number of knots detected on a tree, depending on the base diameter

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.687					
R Square	0.471					
Adjusted R Square	0.413					
Standard Error	2.566					
Observations	11					
ANOVA						
	df	***SS***	***MS***	***F***	***Significance F***	
Regression	1	52.821	52.821	8.025	0.020	
Residual	9	59.238	6.582			
Total	10	112.059				
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***
Intercept	9.263	3.273	2.830	0.020	1.859	16.666
X Variable 1	0.173	0.061	2.833	0.020	0.035	0.312

The regression was tested with Fisher test for the probability of transgression of $\alpha = 5\%$ and $n–k–1$ (9) and k (1) degrees of freedom. It appears that the regression is significant because $F_{exp} = 8.025$ is higher than $F_{teor} = 5.12$.

Confidence interval for the coefficient of the base diameter is between ± 0.1385.

Regression equation that can determine the variation of the number of detected knots according to the base diameter for black poplar is:

$$y = 9.263 + 0.173x, \quad (1)$$

where: y - the number of knots; x - the base diameter.

In Table 3 the significance of the regression coefficient using the Student test is checked. For $f = n–k–1$ degrees of freedom (9) and the transgression probabilities of 5%, 1% and 0.1%, there is a direct correlation between the base diameter and the number of knots. The diameter has a significant influence on the total number of knots.

3.2. The correlation between the base diameter and the total surface of the knots detected on one black poplar

All the analysed trees were classified into categories of diameters from 2 to 2 cm. For each tree there was calculated a total surface of all the knots detected, and for each category of diameters there was calculate an average value for the surface (Table 4).

Table 3

The significance of the variable coefficient "diameter" from regression equation

Features	**Coefficients**	**Standard error**	**Experimental *t***	**Theoretical *t***			**The signification**
				5%	**1%**	**0.1%**	
f = 9 degrees of freedom							
Free term	9.263	3.273	2.830	2.262	3.250	4.781	–
The diameter	0.173	0.061	2.833				* (significant)

The simple correlation coefficient ($r = 0.83$) indicates a strong connection between the base diameter and the total area of the detected knots (Table 5).

The classification of trees related to the categories of diameters Table 4

The categories of diameters [cm]	**The total surface of knots detected on a tree**	**The categories of diameters [cm]**	**The total surface of knots detected on a tree**
30	690.80	54	2269.12
34	1005.06	56	1656.04
36	997.54	58	1810.21
38	1600.23	60	2462.94
40	1393.32	62	2106.42
42	1249.83	66	2422.51
44	1228.45	68	1737.60
46	1453.12	70	4344.98
48	1547.24	72	3899.89
50	1443.42	74	4531.81
52	1187.49		

Table 5

Table of regression for the variation of the total surface of knots detected on a tree, according to the base diameter

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.832					
R Square	0.692					
Adjusted R Square	0.676					
Standard Error	611.092					
Observations	21					
ANOVA						
	df	***SS***	***MS***	***F***	***Significance F***	
Regression	1	15947799.507	15947799.507	42.706	0.000	
Residual	19	7095228.270	373433.067			
Total	20	23043027.777				
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***
Intercept	-1581.144	557.180	-2.838	0.011	-2747.335	-414.954
X Variable 1	67.493	10.328	6.535	0.000	45.876	89.109

R2 determinative factor shows that the variation of the total surface of knots is due to the base diameter in proportion of 69%, and due to other factors not taken into study in proportion of 31%.

According to the Fisher test the regression is significant because F_{exp} = 42 706 is greater than $F_{teor} = 4.38$, for the probability of transgression α = 5% and $n–k–1$ (19), respectively $k = 1$ degrees of freedom.

The confidence interval for the base diameter coefficient varies between ± 21.26.

The variation of total surface of the knots according to the base diameter of the tree can be estimated with the next equation of regression:

$$y = -1581.144 + 67.493x, \quad (2)$$

where: y - the total surface of knots (cm^2); x - diameter of the tree (cm).

The influence of the coefficient of the base diameter was tested with the t Student test for the probabilities of transgression 5%, 1% and 0.1% and for $f = 19$ degrees of freedom (Table 6).

It is noted that the basic diameter has a very significant influence on the total surface of the knots. There is an indirect but very strong correlation between the variables.

Table 6

The significance of the base diameter coefficient from the equation of regression

Features	**Coefficients**	**Standard error**	**Experimental *t***	**Theoretical *t***			**The signification**
				5%	**1%**	**0.1%**	
f = 19 degrees of freedom							
Free term	-1581.144	557.180	-2.838	2.093	2.861	3.883	–
The base diameter	67.493	10.328	6.535				*** (very significant)

4. Conclusion

From the data presented above the following conclusions resulted:

- simple correlation coefficient ($r = 0.69$) indicates a moderate relationship between the base diameter and the number of knots;
- regression equation that can determine the variation of the number of detected knots according to the base diameter for black poplar is:

$$y = 9.263 + 0.173x,$$

where: y - the number of knots; x - diameter of the tree;

- simple correlation coefficient between the total area of the knots detected on a tree and the tree diameter ($r = 0.83$) indicates a strong intensity of the connection;
- total area of the knots is very significantly influenced by the tree diameter, there is an indirect very strong correlation between the two variables;
- as a consequence of the Fisher test, it is noted that in both cases the regressions are significant (F_{exp} larger than F_{teor});
- regression equation that can determine the variation of the total surface of knots with the base diameter for the black poplars trees is:

$$y = -1581.144 + 67.493x,$$

where: y - the total surface of knots (cm^2); x - diameter of the tree (cm).

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