ECONOMIC ANALYSIS OF MEASURES TO CARE CULTURES OF BLACK PINE (Lat. Pinus Nigra)

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ABSTRACT

Cleaning the lower (ground) parts of a tree branch is an important measure of the breeding in terms of technology and economics. This measure of care is provided by the high quality of the first tree and reciprocal to the higher income. The authors examine the technical and technological components, and economic effects, highlighting the specificity of the translation results in a tree, in particular.

Key words: cutting, black pine, branch, economy.

Introduction:

The branches and nodes as their remains are usually determinant of the log quality. Natural pruning is slow, especially in thin cultures. Dead branching grown and as a result there are the protruding nodes or cavity in the stem, cutting material and others.

There are four categories of the nodes (the remains of a branch) in the central part of the tree, more precisely in the tree trunk, such as the remains of the living branches, remnants of dead branches, remnants of dead and rotting branches, and finally a kind of cylindric cavity as a result of the rotting remains of branches.

The second and third category belong to the so-called protruding nodes, which significantly reduce the quality of sawn timber and veneer. The fourth category largely downgrade the assortments. These residues may be overgrown branches to healthy wood mantle, to give the illusion of of high log quality (roundwood). Care of trees in order to obtain higher quality logs and later assortments, is the fact that the lower parts of the trees clean of branches successively with the growth of the tree. It is worth to clean the terrestrial part of the stem length of 25-30% of the length of the tree. On this part of the tree should not be allowed to come to the dying and ingrowing of dead branches.

The quality of timber is only one reason for cleaning the lower parts of the tree branches. Also, technological aspect of this problem is the significant. Non-forest actions: cutting, production, drawing of the trunks are lighter, if pruning of lower branches had been performed. Pruning of branches must be done sooner at least in preparing assortments, so cleaning the tree, the branches is inevitable and it is better to do it as soon as possible. According to this, there are a number of questions raised, such as which trees should be cleaned of branches? To what extent? When to clean? What are the economic effects?

Materials and methods:

The research area is forest management area Kragujevac. This area consists of forestry unit in Gornji Milanovac and one in Kragujevac as well. Concrete measures of black pine cultures were done in the area of Gruža-Lepenica-Jasenica forest, which belongs to forestry unit of Kragujevac.

Gruža-Lepenica's forest is spread in the area of 3250 ha. 300 ha are black pine cultures. That's almost 10 percent. It should be mentioned that these are mostly black pine cultures.

Fig-1: Study area (In Picture-1), shown in red are experimental fields where research has been conducted)**

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The subject of the research are technical-technological aspects and economic factors of justification and appropriateness of pruning of the lower parts of the tree branches. The research related to forest plantations of pine, logically, is significant for all species.

Concerning techno-economic factors are the most important effect, i.e., labor productivity, being understood that in the given circumstances and in time, the most efficient technique was applied. The economic factors primarily include the costs of pruning of the branches of the tree, and the profitability of investment funds, especially considering that the investment has been carried out over a longer period of time.

**image taken from the web site, GOOGLE - EARTH,**

Depending on the planned patrols while performing two procedures of pruning, before main (final) cutting, depending on quality habitats, per 1 ha. There are, on average, 500 trees in its final cutting totally 200 trees. These trees should be pruned in a timely manner and treat them as future trees. It is useful to cut the pieces off about 20% of the trees, in order to compensate the losses from the various lines of reasoning (windbreaks, et al.) Pruning of all of the branches of trees, particularly in the planted rows so called - growing below 4000 seedlings per ha., can be reasonable out of the reasons already mentioned (technological benefits), but the quantification of these differences is very complex and is a separate issue. The aim of the research implicitly stems from the case study. These are the main technical-technological and economic factors for justification of pruning of the branches of trees, especially the creation of methodologically sound basis for the consideration of this complex problem.

The research that is presented in this paper are namely first 2.5 m of a tree, measured from the log (practically from the ground). To prune the tree which height exceeds 2.5, specialized the mechanized or manual means are necessary. With regard to the methodology of research is largely solved this problem.

With regard to the subject or content of research, experimental research were applied, statistical data processing, recording, and economic analysis, and comparing costs with the effects of the investment.

Within experimental studies production trials to establish the duration of the cleaning of the branches of the tree (the processing time) were conducted and the three variants were studied:

1) pruning of all trees with a chainsaw at usual technique work.
2) pruning of only selected trees (trees of the future) using new techniques which proved the most productive during the experiments, and
3) pruning of all the trees by using new techniques.
4) common technique, characterized by cutting off the branches with a chainsaw, a new technique while the branches are cut off in one direction in one operation, from top to bottom, like some kind of grass cut. The recording cuts duration (the processing time) was calculated by flow method, and recorded a digital chronometer.

Time for branch pruning was recorded specifically for every tree trunk, in the order that is encountering most of the situation on the ground, with the time for preparation, including a waste of time, the transition from tree to tree. This means that the end of the operation on one tree simultaneously start operations in the second (next) tree. Delays and surrender are recorded separately.

This mode results in an apparently high variability of the obtained time. This is due to the loss, the transition of any time-diameter dependence and the like. However, detailed recording are neither rational nor necessary. The aim of the research showed that the applied mode was sufficiently reliable which was demonstrated by statistical analysis. Upon completion of the recording of pruning duration, the recording leaves were calculated, statistical and regression analysis was made, depending on the duration of the cuts in diameter of trees in breast height (D 1,3).

The economic analysis as part of a research method includes:
- establishing labor costs (calculation)
- analysis of the effect of investments in pruning of branches, based on the costs, including interest rates and higher prices of the assortments of a higher quality.

The specificity of the method of research, characterized by originality compared to similar research, is the reduction of the effect on one (average) tree, so that it can receive a response which is related to the different categories of tree of various sizes, age and others.

Results and discussion:

The experimental part of the research was carried out in the department 65, section g, - management unit of, Gružansko-Lepenička-Jaseničke forests, known by the name Popovac - Serpentinite geological base of the slope is 15% , the altitude of 500 m, with 2,000 trees per hectare. Increment of the study is lv = 4.8 m3 / ha. Diameter of the trees is from 8 to 18 cm, the average diameter is Ds = 13 cm. The exposure is south-south-east-S-SE. For pruning of the branches proportionately easy saw - Stihl 024, weight 4.6 kg power of 2.3 kW is applied.
Tab. 1. Important recording results of statistical analysis:

<table>
<thead>
<tr>
<th>Variant</th>
<th>No. of records</th>
<th>Regression equation</th>
<th>Coeff. of regression</th>
<th>Req. number of records</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>67</td>
<td>y=26.09 x X 0.26707</td>
<td>1.26</td>
<td>45</td>
</tr>
<tr>
<td>A2</td>
<td>85</td>
<td>y=21.26 x X 0.217039</td>
<td>0.74</td>
<td>41</td>
</tr>
</tbody>
</table>

Explanation:

Variant A1. -Pruning of all the trees by usual technique, (first experimental field)

Variant A2. -Pruning of all the trees by using new techniques, (second experimental field)

Y- duration of pruning in seconds per tree.

X- trunk diameter at breast height D 1.3

Regression coefficient indicates an increase in the duration of pruning for each tree diameter (interval of D1,3 = 6-18 cm).

Considering the above mentioned removing of the time for transition, the duration of a tree-pruning obtained relatively small correlation coefficient, based on average per diameter degrees: for a variant A1 the correlation coefficient =0.70 …for a variant, A2 the correlation coefficient = 0.50.

Regression coefficients is calculated according to the formula:

\[ Kr = \frac{Y_{18} - Y_{8}}{10} \]

According to variant B, which refers to pruning of only selected trees by using new techniques was carried out only a trial recording (21 trees) and on the basis of the obtained regression equation:

\[ Y = 0.72 X + 33 \]

Which shows that the coefficient of regression is \( Kr = 0.72 \).

Measured time (s) per tree, depending on the diameter of the tree (X) in breast height on the previous three regression equations are shown in Table 2. The economic analysis as the average value of the duration of cost-pruning, values D1,3 = 12 cm were used from the Table 2.

Technical-technological component of the problems associated with pruning of a tree relies primarily down to the choice of means, techniques and the establishment of the processing time. In this study, chainsaw as most suits the purpose was elected, based on its weight and strength. In this respect, there is no doubt that the progress is possible, and it mainly consists in the fact that choosing the optimal tool is the most important, taking into account all the aspects: technological, technical, economic and others. The total production time (given in Table 2 and the corresponding regression equations) are a sound basis for further analysis. Thus, all technical aspects are not all covered completely. In order to reduce the negative consequences of work with a chainsaw (vibration and noise), it is necessary to choose the best possible organizational form of work. For example, an organizational form (1M + 1R), where the two employees work together during the day, and alternate. While the one is working with the chainsaw, the other is using hydraulic scissors or hand tools.
Tab. 2. Dependence of the duration of the pruning and the diameter in the breast height of the tree:

<table>
<thead>
<tr>
<th>D 1,3</th>
<th>A1</th>
<th>A2</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>42,1</td>
<td>31,4</td>
<td>37,4</td>
</tr>
<tr>
<td>7</td>
<td>43,9</td>
<td>32,4</td>
<td>38,1</td>
</tr>
<tr>
<td>8</td>
<td>45,5</td>
<td>33,4</td>
<td>38,8</td>
</tr>
<tr>
<td>9</td>
<td>46,9</td>
<td>34,4</td>
<td>39,5</td>
</tr>
<tr>
<td>10</td>
<td>48,3</td>
<td>35,0</td>
<td>40,3</td>
</tr>
<tr>
<td>11</td>
<td>49,5</td>
<td>35,8</td>
<td>41,0</td>
</tr>
<tr>
<td>12</td>
<td>50,7</td>
<td>36,5</td>
<td>41,7</td>
</tr>
<tr>
<td>13</td>
<td>51,8</td>
<td>37,1</td>
<td>42,4</td>
</tr>
<tr>
<td>14</td>
<td>52,8</td>
<td>37,7</td>
<td>43,2</td>
</tr>
<tr>
<td>15</td>
<td>53,8</td>
<td>38,3</td>
<td>43,9</td>
</tr>
<tr>
<td>16</td>
<td>54,7</td>
<td>38,8</td>
<td>44,6</td>
</tr>
<tr>
<td>17</td>
<td>55,6</td>
<td>39,3</td>
<td>45,3</td>
</tr>
</tbody>
</table>

The economic justification of the pruning the lower parts of trees can be expressed per 1 ha of forest plantations, totally for the whole area or per tree unit. In the first two cases the costs of those parts that do not depend directly on the number of trees per hectare must adequately taken into account. The third case is an original feature of these studies from the methodological point of view. It provides the analysis of the role of certain categories of trees depending on the time of their pruning, sizes and others. Consideration of the justification of pruning of an average tree, according to the plan, the time of the final thinning and care measure are illustrated.

Taking into account that the experimental research was conducted the pruning of the first 2.5 m of a trunk, calculated from the stump (practically from the ground) in a single procedure, in one way and one tool, and the one can ask the question of expediency of investment funds irrespective of subsequent investments, which would follow a few years later, and that would be applied by analogy and the additivity system exposed to the methodology analysis. Pruning of a tree, in terms of the research, is economically justifiable, in the following case:

\[ T_{nk} < R_v \]

When the TNC tree pruning costs of a certain category together with interest on the invested assets, from the time of the investment, up to the moment of cutting, the RV represents the difference value in the present case, the first tree length 2.5 m of pruned tree and the tree of the same value, assuming the pruning was not performed. Pruning cuts \( (T_{nk}) \) can be calculated by the formula:

\[ T_{nk} = T_n \times 1.0 \times p \times N \]

When \( T_n = \) immediate or direct pruning cost, increased by multiplying the coefficients of total (overhead) costs, \( 1.0p = 1 + p/100 \) where, \( p \) is the percentage of invested funds, and the \( N \), the number of years of amounting (the time elapsed from the time of pruning until the time of cutting, expressed in years).

Direct costs (\( T_n \)) obtained by calculation of pruning cost showed in € per working day (shift), increased by multiplying the ratio of common costs and divided by standard preparation (number of trees per day). Calculation of costs (K) was performed by well-known methodology (Nikolić 1981). In this calculation the following basic values and norms are taken into account such as:

- retail chainsaw price : 3200 dinars
- the number of working hours a day: 6 hours
- Duration of engine blades: 2000 working hours
- Chain saw maintenance: 100% of depreciation.
- Retail chain price: 200 dinars, sprocket: 250 dinars, rails 400 dinars, duration of the chains: 120 hours (in operation), duration of sprocket and the guide: 360 operating hours.

- Consumption of fuel: 0.0067 liters per tree.
- Consumption of chain oil is 0.5 of a fuel consumption
- Fuel price of 3.3 dinars per lit., and lubricants 10 dinars per litre.
- Costs of worker transport, food, lodging, wages, bonus and personal protection devices, 22 dinars per employee.
- Income (wages) for a worker, including all contributions, based on 208 working days a year, is 108 din per worker.
- Interest rate of the funds for the purchase of chainsaws: 2 dinars per day (12% of interest)

Based on the mentioned direct costs are 207 din per day, and \( Tu = 207 \times 1.5 = 310.5 \) dinars per day, and the 1.5 ratio of common costs (the constant). It should be noted here that in forestry practice these works are not often burdened by the common costs.

If the previous costs are divided by performance \( (U) \) measured by the number of trees per day, the costs per tree are provided. \( (Tn) \) is then

\[
Tn = \frac{Tn}{U}
\]

Performance \( (In) \) depend on the effective working time \( (Te) \) and operation time \( (ti) \) and \( Te = 382.5 \) minutes is generally calculated a day (Nikolic, 1993) and the time for production is given in Table 2. In the text, the data of the stumps of D1,3 = 12 cm are taken into account (since the average tree diameter is from 6 to 18 cm). A new operation technique is marked with A, and pruning of a the selected trees with B.

Based on the given time of production, the performance was calculated by the formula:

\[
U = \frac{Te \times 60}{ti}
\]

Since -Te is expressed in minutes a day, and ti-time of production. By substituting the appropriate production time, the performance is obtained the following:

Variant A2, the performance of \( U = 382.5 \times 60 / 36.5 = 629 \) trees per day, and

Variant B, the performance of \( U = 328.5 \times 60 / 41.7 = 550 \) trees a day.

When the corresponding value is substituted in the form of costs \( (Tn) \), it is obtained

Variants A2: \( \frac{310.5}{629} = 0.5 \) dinars per tree.

Variants B2: \( \frac{310.5}{550} = 0.56 \) dinars per tree.

When analyzing the economic feasibility of pruning of the branches of the tree, it is necessary to start from the appropriate plan (model) for development and thinning forest plantations. All costs amounted for tree pruning should be compensated with the different values of those trees, which, considering the time for cutting and dimensions of round timber assortments, regardless of tree pruning. One practical model is shown in Table 3 where the pruning costs should be compensated by 800 trees per hectare or any number below 800 in the same column, if they are pruned, only for a certain number of trees corresponding to the designed model.

Pruning of the branches of the trees is best done after the first thinning. In so-called rare planting orchards, the first thinning is carried out depending on the worthiness, starting from 15 years of age, remaining about 2000 trees. If all the trees are pruned, the costs by \( -Tn \) variant, A2 then increased to 2000/800 = 2.5 times. More specifically, they precisely amounted to 0.5 x 2.5 = 1.25 din per tree. Consequently, variant B, when recorded performance amount to approximately 500 trees per hectare, the costs \( Tn \) be increased to 800/500 = 1.6 times, or more precisely they would amount to 0.56 x 6 = 0.9 dinars per tree.
Tab 3: Basic indicators of a model for development forests and elements of economic analysis.

<table>
<thead>
<tr>
<th>E</th>
<th>n</th>
<th>Ne</th>
<th>Ns</th>
<th>D1,3 cm</th>
<th>V (m³)</th>
<th>Difference in money</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A2 Per 1 tree.. per ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tnk. per ha... Tnk per ha</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>40</td>
<td>800</td>
<td>200</td>
<td>31</td>
<td>0,19</td>
<td>27,6</td>
<td>5520</td>
</tr>
<tr>
<td>65</td>
<td>50</td>
<td>600</td>
<td>150</td>
<td>35</td>
<td>0,24</td>
<td>72,0</td>
<td>10800</td>
</tr>
<tr>
<td>75</td>
<td>60</td>
<td>450</td>
<td>110</td>
<td>38</td>
<td>0,28</td>
<td>84,0</td>
<td>9240</td>
</tr>
<tr>
<td>90</td>
<td>75</td>
<td>340</td>
<td>90</td>
<td>41</td>
<td>0,33</td>
<td>99,0</td>
<td>8910</td>
</tr>
<tr>
<td>110</td>
<td>95</td>
<td>250</td>
<td>250</td>
<td>45</td>
<td>0,4</td>
<td>120,0</td>
<td>30000</td>
</tr>
<tr>
<td>TOTAL</td>
<td>800</td>
<td>64470</td>
<td>43008</td>
<td>30969</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In case of cutting (pruning) only about 500 trees per hectare or less than that, the cost should not be increased, but the subject of the analysis would be the only the ones related to the number of trees, including the final cutting.

For calculating the required volume of trees, used as tables of wood mass (Bezak, 1992) Explanation: E - Age culture (years), n -number of years of being under the interest rate (E-15), not-number of trees per hectare in the E year, Ns- number of trees being cut, V-volume logs .2.5 m of length (pruned part of the branch)

Module given in Table 3. Is based on the following:

- in each operation, the thinning is cut with 25% of the existing number of trees.
- Time of invested funds under investment rate, n = E-15, since the pruning was done in the 15 years of age.
- Difference in price of tree log classified as "L" " T", 145 dinars per m³.
- Costs for pruning per one tree (Tnk) have been calculated on the basis of costs and related interest, calculated together with an interest rate of 5% per year.

This example (Table 3) shows the importance (burden) of interest rates as a key factor which determines the economic feasibility of investing in tree pruning of the branches.

The results of the analysis show that under the circumstances of economic development the variant B stems from the basic settings. Then it can be seen that the justified investing is in pruning all the trees, except for those in the final cuts. This leads to the importance of determining the rotation. Data analysis shows a very great complexity of the problem but also the importance of the analysis, the necessity models, etc., considering nonvalorized pruning utility. In terms of methodology, pruning of long pieces stem from the one discussed in this paper (2,5m), presented also in this paper. Any pruning operation results in a corresponding increase in cost and quality on treated trees. This operation with branch at bigger height per unit is more expensive, and assortments are thinner, so it is logically to conclude that the profitability of each subsequent pruning is less.
Fig-2: Cultures of black pine where has not been done care measures

Fig-3: Cultures of black pine where have been done care measures

Conclusion

Pruning of the lower parts of the tree off the branches is invested in higher quality of logs. Taking into account that the branches are the most important quality factor, pruning, as a rule, ensures the highest quality of the first and possibly every second tree, and has a relatively significant share in the volume of the trunk.

By improved quality of the first log (a part timely prunned off the branches) provides a significant difference in price, and in proportion to the value. Pruning of trees off the branches is economically approving when the aforementioned difference value greater than the funds invested in pruning, including the interest rate.

The cost of pruning the branches of the tree depends on operation type, prior branch pruning, the cost for the worker wages, depreciation of tools, fuel and other. These expences are calculated, practically calculated per tree, but they have to take into account only the trees, to get a higher quality assortments, regardless of the pruned tree number. This means that only a certain number of trees must be "burdened" by all pruning costs.

The immediate cost cuts (tn) is amounted with the interest rate, giving the total cost:

\[ tn_k = tn \times 1.0 \times pn \]
These costs, provided that the branch pruning is economically approving, should be less valuable than the value of the part of the trunk which is pruned of branches. It should also be respected that, what was not quantified are all the benefits of tree-pruning.

The number of years of amounted with the investment rate depends on the model (plan) development of forest plantations. In the example in Table 3, various categories of trees depending on the pruning arrangement are revealed, and thus the economic justification for the branch pruning can be established for each category of a particular tree.

The studies have shown that pruning of the first 2.5 m of a trunk is economically justified in certain circumstances, if the interest rate to 5% and, if incorporated into into the development plan, with the calculated difference of 145 dinars per m3, the thinnest logs, and 300 dinars per m3 for others. In respect to the positive difference between the difference value and the cost, it can be counted with a little higher interest rate of 5%. The maximum interest rate can be calculated from the previous equation solution by 'P' if it is put that the differences in value is equal to the pruning costs. (Rv = TNk).

However, there are very legitimate reasons for the use of smaller interest. For example, at an interest rate of 3% per annum in the same conditions the effects of investment in pruning are of great importance.

One of the factors of nonvalorized pruning of the branches of the tree and higher quality of assortments of those trees that have reached dimensions that correspond to the logs as assortments (the first several thinning).

A problem of pruning is the one that is resolved in the whole although very complex, could be useful in practice, and also as the basis for all research. Any pruning, done periodically, on the one hand make the costs, yet on the other hand receives the quality assortments with pruned stump. In each case, pruning is a very important issue in forestry and logging, if we want to get quality that is and later the more expensive varieties, although it is true to some extent.

References:

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