Bucking accuracy of alder and oak logs harvested in coppice stands during and after growing season

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Abstract: Bucking accuracy of alder and oak logs harvested in coppice stands during and after growing season. The wood from coppice trees is considered to be of a lower quality compared with the wood from seed trees. The main disadvantage of coppice trees are shape defects, including single- and multilateral swipe. In coppice stands alder usually grow in a group of several stems from one stool. Swipe usually makes it difficult to process the wood using a harvester. The aim of the paper was to determine the accuracy of the bucking of alder and oak logs during and after the growing season using two different harvesters. The study was carried out on two plots of alder and oak, 31 y.o. and 55 y.o., respectively. The pulp wood was bucked with an intended length of 2.50 m and a tolerance of ±0.05 m. Measurement of the log length was carried out using a Spencer tape with an accuracy of 1 cm. In total, 404 alder and 373 oak logs were measured. The accuracy of the bucking was high for both the tested species. Unexpectedly, a high bucking accuracy of the alder and oak logs was observed from the coppice forests. The alder logs were bucked during and after the growing season at a similar level of accuracy (mean log length: 252.4 and 252.4 cm, respectively). The majority of the alder logs which did not fulfill the requirements were too long. The oak logs were bucked during and after the growing season at a different level of accuracy (mean log length: 252.0 and 253.8 cm, respectively). For both species, the most accurate log bucking was achieved during the growing season. Moreover, the length accuracy of the alder logs was better than that of the oak logs. Indeed, 27% of the oak logs were too long when processed after the growing season. Most of the logs had the expected length, while the logs which were too short were the least represented (less than 10% for each species). The use of harvesters in selected stands made it possible to produce logs of the proper length during and after the growing season.

Keywords: wood quality, harvester head, mechanized logging

INTRODUCTION

Forest management in Poland focuses on the high forest system. Stands of seed origin provide timber of a high quality, meeting the current demand from the timber sector. Forests cover almost one third of Poland, with 7 094 696 ha under the management of the State Forest National Forest Holding. By providing a large variety of wood and non-wood products, as well as other services, coppice forests are of special importance (Suchomel et al. 2011). In recent decades, in some parts of Europe, the management of coppice forests has been abandoned due to socioeconomic changes (Suchomel et al. 2012). Coppice forests occur in Poland very occasionally and they are considered a less important forest management type (Nicolescu et al. 2017). The total area of coppice in Poland amounts to 21 477.57 ha and almost 89% belongs to the State Forests. The oldest and the biggest coppice area (about 3 thousand hectares) is located in Pogórze Kaczawskie (Sudety Mountains) in the South of Poland. These Quercus petraea coppices were created in the first half of twentieth century. The remaining stands make up one of the rarest forest areas in Poland and are now excluded from utilisation (Szymura 2010). The quality of the wood from coppice trees is considered to be lower compared to the quality of the wood from seed trees. The main disadvantages of coppice trees are shape defects, including single- and multilateral swipe. Coppice trees are also susceptible to rotting, particularly in the bottom part of the stem due to the high risk of
pathogenic fungal growth in the stool and root systems after harvesting the previous generation.

The use of harvesters in Poland is constantly growing (Moskalik et al. 2017, Mederski et al. 2016a, Mederski et al. 2016b), and their use is not restricted to coniferous stands. The development of a logging machine fleet also results in harvesting in mixed stands, although it still sporadically occurs in pure deciduous stands. One of the species felled and processed with harvesters is Black alder (Alnus glutinosa Geartn.). Alder in its generative form has a trunk which resembles the conifer species. In coppice stands, alder usually grows in a group of several stems from one stool. This research study examined whether it was possible to harvest coppice alder trees. For comparison, oak (Quercus robur) coppice trees were selected. The oak stand where the sample plot was established underwent a silvicultural treatment in a particular way: after a tree has been browsed during early growth by game animals, it grows in a form of candelabrum with many lateral shoots (epicormic growth (Lazdina et al. 2017)). This distorted stem is cut off and then the rapid growth of a new, straight stem appears with one leading shoot. After several years, such trees do not differ phenotypically from trees obtained from planting.

A factor which may limit the mechanized harvesting of coppice is weather conditions, particularly on wet sites. Logging is conducted throughout the year, which may cause the increased risk of certain secondary defects from the group of discoloration defects. Different temperatures and variable bark adhesion during and after the growing season may also influence log quality (Simonov 1984). Wood quality is a complex of different factors and wood defects. One of the parameters taken into account is the length of logs which must match the intended length. It was hypothesized that the accuracy of the bucking of the coppice alder and oak logs may be less accurate during the growing season due to lower bark adhesion. The aim of the paper was to determine the accuracy of the bucking of alder and oak logs during and after the growing season.

MATERIALS AND METHODS

The study was carried out on two plots with two species: alder and oak harvested in northern Poland (alder in the Forest District of Zaporowo, in Olsztyn Regional Directorate of the State Forests; oak in the Forest District of Kwidzyn, in Gdańsk Regional Directorate). The tests were carried out during the growing season (the period when the trees had leaves) and after the growing season (when the trees had no leaves).

Plot no 1:
Black alder, early thinning, 31 years old.
Timber was harvested using a Preuss 84 V.II harvester equipped with a Kesla 20 RH II head
The operator had 4 years of experience.

Plot no 2:
Oak, late thinning, 55 years old.
Timber was harvested using a Valmet 901.3 harvester equipped with a Valmet 350.1 head.
The operator had 7 years of experience.

After cutting and delimbing, the trees were bucked in accordance with the rules set by the forest administration. The hardwood logs were cut from the bottom, middle and top sections of the tree trunks. The pulp wood was bucked with an intended length of 2.50 m and a tolerance of ±0.05 m. Measurement of the log length was carried out using a Spencer tape with an accuracy of 0.01 m. Statistical measures of position (mean, minimum, maximum and median) as well as Mann-Whitney U tests were completed using R 3.3.1 software (R Core Team 2017).
RESULTS AND DISCUSSION

In total, 404 alder and 373 oak logs were measured. The alder and oak trees cut during and after the growing season were from homogenous stands (tab. 1).

Table 1. Biometric parameters of cut trees

<table>
<thead>
<tr>
<th>Species</th>
<th>Biometric parameters</th>
<th>During growing season</th>
<th>After growing season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alder</td>
<td>Mean DBH [cm]</td>
<td>14.7</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>Mean height [m]</td>
<td>17.4</td>
<td>17.0</td>
</tr>
<tr>
<td>Oak</td>
<td>Mean DBH [cm]</td>
<td>18.6</td>
<td>18.1</td>
</tr>
<tr>
<td></td>
<td>Mean height [m]</td>
<td>17.5</td>
<td>17.6</td>
</tr>
</tbody>
</table>

The accuracy of the bucking was high for both the tested species. During and after the growing season the logs of the alder were bucked at the same level of accuracy (p=0.74), with the mean log lengths of 252.4 cm (tab. 2). The range between the minimum and maximum values in the alder logs was smaller after the growing season than during the growing season (24 and 37.5 cm, respectively).

Table 2. The bucking accuracy of alder logs

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</thead>
<tbody>
<tr>
<td>During season growing</td>
<td>252.4</td>
<td>233.1</td>
<td>270.6</td>
<td>252.2</td>
<td>285</td>
</tr>
<tr>
<td>After season growing</td>
<td>252.4</td>
<td>242.0</td>
<td>266.0</td>
<td>252.0</td>
<td>119</td>
</tr>
</tbody>
</table>

The majority of the alder logs not fulfilling the requirements were too long. This observation was more evident after the growing season, with 13% considered too long (fig. 1). In addition, more alder logs were found to be too short after the growing season (3%) (fig. 1).

Figure 1. Share of alder logs

During and after the growing season the oak logs were bucked at a different level of accuracy (mean log length: 252.0 and 253.8 cm, respectively, table 3; table 4), p<0.01. The length differences were significantly bigger for the oak logs than for the alder logs: 51.0 cm during the growing season and 42.0 cm after the growing season. The logs from both the alder and oak were bucked with an expected extra length of 2-4 cm.
Table 3. The bucking accuracy of oak logs

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>During growing season</td>
<td>252.0</td>
<td>228.0</td>
<td>279.0</td>
<td>252.0</td>
<td>207</td>
</tr>
<tr>
<td>After growing season</td>
<td>253.8</td>
<td>236.0</td>
<td>278.0</td>
<td>254.0</td>
<td>166</td>
</tr>
</tbody>
</table>

Table 4. Mann-Whitney U Test for oak logs during and after growing season

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sum of ranks Oak</th>
<th>Sum of ranks</th>
<th>U</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log length</td>
<td>37052.5</td>
<td>32698.5</td>
<td>11170.5</td>
<td>-5.808</td>
<td>0.00001</td>
</tr>
</tbody>
</table>

In addition, as regards the oak logs, more of the logs which did not fulfill the requirements were too long: 27% of the logs harvested after the growing season were too long (fig. 2). In contrast to the alder logs, more oak logs were found to be too short during the growing season (5% compared to 3.6%) (fig. 2).

![Figure 2. Share of oak logs](image)

Bucking was more accurate during the growing season for both species. Presumably the better weather conditions, affecting the occurrence of dry and non-iced bark, had some influence on the results. The harvester head measuring wheel was better able to fit to the surface of the processed tree in the growing season, making the measurement more accurate. Generally, the accuracy of the bucking of the coppice alder and oak may be considered unexpectedly accurate. Most of the logs met the requirements for medium-sized timber/pulpwood. There was, however, a difference in the accuracy of the bucking between the species. The alder logs were bucked with a better accuracy than the oak logs. An important observation is that the logs of both species which did not meet the requirements were for the most part too long. Such logs are more acceptable to customers in wood processing when compared to logs which are too short (Karaszewski et al 2016a, Karaszewski et al 2016b).

In coppice, the felled stems are often small enough to be easily handled manually with simple/low specification mechanized forestry systems (Magagnotti and Schweier 2017). When a proper harvesting system is not introduced in aged coppice stands, the potential for providing wood products remains unutilized. At a time when the demand for wood and wood-based products is constantly rising, a possible solution to this problem could be the introduction of small- and medium- sized harvesters in coppice stands (Tsioras 2016). The results obtained showed that a higher level of mechanization may be introduced to coppice stands. However, the costs of logging may increase in comparison to logging with tools already in use on the farm (tractors, trailers, horses, etc.) (Tsioras 2016).
CONCLUSIONS

The following conclusions can be drawn from the research:

- For both species, the most accurate log bucking was achieved during the growing season.
- Unexpectedly, a high bucking accuracy was observed for the alder and oak logs from the coppice forests.
- The length accuracy of the alder logs was better than that of the oak logs. 27% of the oak logs were too long when processed after the growing season.
- Most of the logs had the expected length, while logs which were too short were the least represented (less than 10% for each species).
- The use of harvesters in selected stands made it possible to produce logs of the proper length.
- The growing season did not negatively impact log measurements by harvester.

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Streszczenie: Jakość wyrzynki olszowych i dębowych sortmentów z drzew odroślowych w trakcie i po sezonie wegetacyjnym. Narastający odpływ pracowników fizycznych powoduje konieczność coraz szerszego stosowania maszynowego pozyskiwania drewna. Harwestery wkraczają do drzewostanów mieszanych i liściastych, w tym do drzewostanów pochodzenia odroślowego. Jakość sortmentów pozyskiwanych z olszowych i dębowych drzewostanów odroślowych, zwłaszcza dokładność wyrzynki, może być pogorszona ze względu na występujące wady pni, głównie krzywizny. Celem pracy było określenie dokładności wyrzynki drewna olszowego i dębowego z drzewostanów odroślowych pozyskanego w sezonie wegetacyjnym i poza nim. Zakres prac objął ocenę dokładność wyrzynki sortmentów. Walki pozyskano z drzewostanów: olszowego w wieku 33 lat oraz dębowego w wieku 55 lat. Zastosowano dwa harwestery z różnymi głowicami. Ocenę dokładności wyrzynki wykonano mierząc walki taśmą mierniczą. Łącznie zmierzone 777 walków. U obu badanych gatunków stwierdzono wysoką dokładność wyrzynki walków. Walki olszowe pozyskane w trakcie i po sezonie wegetacyjnym zostały wycięte z taką samą dokładnością. średnia długość walków wyniosła 252,4 cm. Długość długości walków olszowych była lepsza w stosunku do walków dębowych. średnia długość walków dębowych w trakcie sezonu wegetacyjnego wyniosła 252,0 cm, a po sezonie 253,8 cm. Po pozyskaniu walków dębowych po sezonie wegetacyjnym stwierdzono 27% zbyt długich walków. Stwierdzono, że pozyskiwanie w sezonie wegetacyjnym może wpływać na uzyskiwanie sortmentów bliższych do średniej oczekiwanej. Zbyt krótkie walki wystąpiły najrzedniej (poniżej 10% dla obu gatunków). W wyniku analizy danych stwierdzono, że pozyskiwanie drzew odroślowych harwesterem oraz manipulacja surowca bez względu na porę roku są technicznie możliwe i nie przynosi to zwiększonych negatywnych konsekwencji dla dokładności wyrzynki.

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