Comparing the effectiveness of harvester use for thinning operations in beech and birch stands of 4th age class

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Forest engineering: Making a positive contribution
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Species structure of stands in Poland (%, 2014)

33% until 2050!

Broadleaved 30.4%

Coniferous 69.6%

- Pine
- Spruce
- Fir
- Other
- Oak
- Birch
- Beech
- Alder
- Hornbeam
- Aspen
- Poplar
- Other

Birch 7,4
Beech 5,7
Number of harvesters in Poland

40 mln m³/year

Moskaik
Grodecki
Kusiak
Sowa
Kusiak
Zabierek
Mederski

10
21
67
157
170
350
368 (450)

Objectives of the research:

1) operational productivity,
2) time consumption for delimbing and cross-cutting,
3) trunk use for logs.
Materials and methods

1. Stand measurements

For 60 trees with visible numbers:
- upper diameter of the top log
- total log length

2. Work time recording

3. Wood measurement
### Results

**Operational productivity**

<table>
<thead>
<tr>
<th>Beech</th>
<th>Birch</th>
<th>Difference [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.75 m³ h⁻¹</td>
<td>17.54 m³ h⁻¹</td>
<td>11</td>
</tr>
</tbody>
</table>

**Spearman's correlation coefficient (p<0.05)**

- Beech $r = 0.8772$
- Birch $r = 0.5041$

![Graph showing operational productivity vs timber volume](image)

**Equations**

- Beech: $y = -337.9x^2 + 137.3x - 0.105$
- Birch: $y = -25.09x^2 + 38.23x + 6.427$
# Species characteristics

<table>
<thead>
<tr>
<th>Average data</th>
<th>Beech</th>
<th>Birch</th>
<th>Difference [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [years]</td>
<td>61</td>
<td>63</td>
<td>3</td>
</tr>
<tr>
<td>Wood hardness [MPa]</td>
<td>78</td>
<td>48</td>
<td>-62</td>
</tr>
<tr>
<td>Dbh [cm]</td>
<td>15,6</td>
<td>20,8</td>
<td>33</td>
</tr>
<tr>
<td>Height [m]</td>
<td>15,3</td>
<td>19,5</td>
<td>27</td>
</tr>
<tr>
<td>Tree crown length [m]</td>
<td>8,8</td>
<td>8,3</td>
<td>-6</td>
</tr>
<tr>
<td>Merchantable timber volume of a tree [m³]</td>
<td>0,21</td>
<td>0,30</td>
<td>43</td>
</tr>
</tbody>
</table>
Results
Delimbing and cross-cutting

Spearman's correlation coefficient (p<0.05)
Beech $r = 0.7224$  Birch $r = 0.6152$
Results
Trunk utilization

<table>
<thead>
<tr>
<th>Average data</th>
<th>Beech</th>
<th>Birch</th>
<th>Difference [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper diameter of the top log [cm]</td>
<td>10,0</td>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>

Spearman's correlation coefficient (p<0.05)
Beech $r = 0.6250$    Birch $r = 0.7186$

$y = -0.033x^2 + 1.419x - 3.147$    $y = 0.016x^2 - 0.343x + 9.796$
## Results

Trunk utilization cont.

<table>
<thead>
<tr>
<th>Average data</th>
<th>Beech</th>
<th>Birch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total log length from a single tree [m]</td>
<td>9,6</td>
<td>12,3</td>
</tr>
<tr>
<td>% of tree height</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>% of tree crown length</td>
<td>35</td>
<td>13</td>
</tr>
</tbody>
</table>

**Spearman's correlation coefficient (p<0.05)**

- Beech $r = 0.5847$
- Birch $r = 0.3667$

**Equations**

- Beech: $y = 0.017x^2 - 0.091x + 6.189$
- Birch: $y = -0.009x^2 + 0.653x + 2.919$
Results
Trunk utilization cont.

Spearman's correlation coefficient (p<0.05)
Beech $r = 0.7205$  Birch $r = 0.5300$

Total log length from a single tree [m]

Tree height [m]

- Beech
  - Poly. (Beech) $y = 0.035x^2 - 0.205x + 3.826$
- Birch
  - Poly. (Birch) $y = -0.014x^2 + 0.971x - 0.513$
Conclusions

1) Beech and birch harvesting is possible using the tested machine with acceptable productivity.

2) The bigger average volume of the birch trees (compared to beech) had a significant impact on harvester productivity.

3) The birch branches were more problematic for delimbing.

4) The amount of merchantable timber volume left after harvesting depends not only on harvester head capabilities but also on operator motivation.
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