Factors affecting productivity of Vimek 404 T5 harvester in pre-commercial thinning & Fields of application of Kranman Bison 10000 and other small forwarders

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Agris Zimelis, Santa Kalēja, Per Olof Johansson, Andis Lazdiņš, Gints Spalva, Guntis Saule, Gatis Rozītis, Guna Petaja
Latvia State Forest Research Institute “Silava”
e-mail:santa.kaleja@silava.lv

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LSFRI Silava
Riga street 111
Salaspils LV-2169, Latvia
Phone: +37167942555, e-mail: inst@silava.lv
www.silava.lv
Study sites
Typical study sites

<table>
<thead>
<tr>
<th>ID</th>
<th>Stand type</th>
<th>Dominant species</th>
<th>Area. ha</th>
<th>Number of trees per ha</th>
<th>D&lt;sub&gt;13&lt;/sub&gt;. cm</th>
<th>H. m</th>
<th>Growing stock. m³ ha&lt;sup&gt;-1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>601-186-12</td>
<td>Vacciniosa</td>
<td>Pine</td>
<td>3.4</td>
<td>1 917</td>
<td>11</td>
<td>12</td>
<td>138</td>
</tr>
<tr>
<td>601-186-16</td>
<td>Vacciniosa</td>
<td>Pine</td>
<td>3.3</td>
<td>2 925</td>
<td>16</td>
<td>16</td>
<td>575</td>
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<tr>
<td>602-28-19</td>
<td>Oxalidosa</td>
<td>Spruce</td>
<td>1.9</td>
<td>2 354</td>
<td>11</td>
<td>8</td>
<td>167</td>
</tr>
<tr>
<td>602-32-8</td>
<td>Myrtilloso-</td>
<td>Spruce</td>
<td>1.3</td>
<td>3 350</td>
<td>9</td>
<td>11</td>
<td>199</td>
</tr>
<tr>
<td></td>
<td>sphagnosa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>602-46-29</td>
<td>Hylocomiosa</td>
<td>Spruce</td>
<td>0.7</td>
<td>2 300</td>
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<td>10</td>
<td>120</td>
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<tr>
<td>602-74-7</td>
<td>Oxalidosa</td>
<td>Birch</td>
<td>2.7</td>
<td>4 233</td>
<td>10</td>
<td>12</td>
<td>285</td>
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<tr>
<td>711-358-5</td>
<td>Oxalidosa</td>
<td>Spruce</td>
<td>3.5</td>
<td>1 104</td>
<td>9</td>
<td>12</td>
<td>62</td>
</tr>
</tbody>
</table>
Why small harvester?

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Numerical values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>In production since 2011, continuously improved from model to model</td>
</tr>
<tr>
<td>Price</td>
<td>Basic setup 180000 €</td>
</tr>
<tr>
<td>Operating weight</td>
<td>4 100 kg</td>
</tr>
<tr>
<td>Engine output</td>
<td>36.4 rpm. min.(^{-1}) or 44.7 kW</td>
</tr>
<tr>
<td>Dimensions</td>
<td>Length 3.35 m, width 1.84 m</td>
</tr>
<tr>
<td>Crane max. reach</td>
<td>4.3 m</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>4-4.5 L hour</td>
</tr>
<tr>
<td>Felling head</td>
<td>Keto Forst</td>
</tr>
</tbody>
</table>
## Summary of study results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Spring trials</th>
<th>Summer trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extracted trees</td>
<td>13993</td>
<td>8073</td>
</tr>
<tr>
<td>Extracted amount, m³</td>
<td>1109</td>
<td>350</td>
</tr>
<tr>
<td>Average tree D_{1.3}, cm</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Average stem volume, m³</td>
<td>0.08</td>
<td>0.04</td>
</tr>
<tr>
<td>Average productivity</td>
<td>6.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Average productivity without driving</td>
<td>6.9</td>
<td>5.4</td>
</tr>
</tbody>
</table>
Average productivity of harvesting depending from dimensions of trees

\[
f(x) = -0.0024x^3 + 0.0837x^2 - 0.0925x
\]
\[R^2 = 0.9894\]

\[
f(x) = -0.0023x^3 + 0.0920x^2 - 0.2593x
\]
\[R^2 = 0.9854\]
Comparison of productivity of different harvesters and felling heads
Impact of forwarder on prime cost of harvesting

Harvesting cost, € m⁻³

- Vimek 404 T5 + Kranman Bison 10000
- Vimek 404 T5 + John Deere 810E
- Vimek 404 T5 + Logbear F4000
Conclusions & recommendations

- In spring harvesting productivity was significantly higher, mostly because of better visibility (no foliage on deciduous trees).
- No impact of scarification (micro-relief) was found; however, productivity grows faster in artificially regenerated stands with increase of tree dimensions.
- Harvesting with 2 “ghost tracks” between strip-roads significantly decreased productivity, it is recommended to use 1 “ghost track”.
- Productivity on poor soils is higher in comparison to rich soils, probably due to thicker branches and longer crown.
- Cost of Vimek 404 T5 harvester working hour is 44 €, it is heavily affected by utilization rate and assumptions on personnel costs.
- Vimek 404 T5 is more efficient than conventional harvesters in pre-commercial and the 1st thinning, final felling (if D_{1.3} < 20 cm) and cleaning operations (ditches, abandoned farmlands).
- Combination with small forwarder (Vimek 610 or Logbear F4000) is more efficient than combination with middle class forwarder because of narrow strip-roads and high productivity values at large number of assortments.
Field trials with Kranman Bison 10000
700 hours of monitoring data in 2016
Specifications

- Kranman Bison 10000 6WDIs in production since 2015 as upgraded version on 8000 6WD model.
- Price of basic setup 40 584 €, cost of setup used in studies 60 000 €.
- Forwarder can be equipped with tracks, simple heater and even air conditioner in cabin.
- Width 1.55 m, length up to 6.10 m, weight 1.52 tonnes, load capacity 2.5 m³.
- Crane length 3.3 m (can lift up to 400 kg at full extend).
- Fuel consumption 2 L per hour (0.5 L m⁻³).
Summary of study results

- Width of corridors – 2-2.5 m.
- Average load – 2.0 m³.
- Average driving distance – 235 m.
- Time consumption: loading in – 13.5 min., loading out – 5.4 min. per load.
- Average productivity – 3.9 m³ per work hour (15% less in extreme conditions).
- Driving speed – 47 m min.⁻¹ (heavily affected by presence of ruts and large stumps).
- Forwarding cost at 1172 productive hours per year – 7.14 € m⁻³.
- Total harvesting & forwarding cost:
  - mechanized harvesting with Vimek 404 T5 – 16.2 € m⁻³;
  - harvesting with chainsaw – 18.6 € m⁻³.
Impact of driving distance and utilization rate on prime cost of roundwood
Potential impact of load transfer on forwarding cost

- Kranman without load transfer
- Kranman with load transfer
- Additional cost due to load transfer

Driving distance, m

Forwarding cost, € m⁻³

Additional cost due to load transfer, € m⁻³
Fields of application of Kranman Bison 10000 and similar forwarders

- The main advantages of Kranman Bison 10000 are small fuel consumption, small weight (*can operate on organic soils*), mobility (*can be transported with ordinary pickup*), manoeuvrability (*2.5 m wide corridor is enough*).
- The main disadvantages – small load and crane lifting capacity, limited space, vibration and noise pressure in cabin.
- Forwarder is recommended for small felling sites with small trees, including thinning, sanitary fellings and final felling.
- Optimal setup – team of 3-4 workers with chainsaws and Kranman Bison 10000 forwarder, pickup and trailer. Optimal utilization rate – at least hours annually (3372 m³).
- In state forests 30 teams (*90-120 workers and 30 small forwarders*) can take over motor-manual operations in thinning.