УДК 630

IMPACT OF FORWARDING CONDITIONS ON PRODUCTIVITY OF FORWARDER KRANMAN BISON 10000

Kaleja S.,[1] assistant, Mg.silv., Lazdiņs A.[1], senior researcher, Dr. silv.,
Johansson P. O.[2], independent expert, Mg.silv.,
Spalva G.[1], assistant, Mg.silv., Skola U.[3], stud.
[1]Latvian State Forest Research Institute "Silava"
(Salaspils, Republic of Latvia), santa.kaleja@silava.lv, andis.lazdins@silava.lv
[2](Kingdom of Sweden), andis.lazdins@silava.lv
[3]Latvia University of Agriculture
(Jelgava, Republic of Latvia), andis.lazdins@silava.lv

ВЛИЯНИЕ УСЛОВИЙ ПОДВОЗКИ ЛЕСОМАТЕРИАЛОВ НА ПРОИЗВОДИТЕЛЬНОСТЬ ФОРВАРДЕРА KRANMAN BISON 10000

Калэя С.[1], ассистент, маг. лесов., Лаздинш А.[1], вед. научный сотрудник, д-р. лесов.,
Ёханссон П. О.[2], независимый эксперт, маг. лесов,
Спалва Г.[1], ассистент, маг. лесов., Скола У.[3], студ.
[1]Латвийский Государственный Лесохозяйственный исследовательский институт «Силава»
(Саласпилс, Латвийская Республика)
[2](Королевство Швеция)
[3]Латвийский сельскохозяйственный университет
(Елгава**,** Латвийская республика)

The aim of this study is to investigate potential uses of Kranman Bison 10000 6WD forwarder in thinning under normal and difficult forwarding conditions, to determine productivity, average load size and forwarding costs. In normal forwarding conditions productivity of forwarding increase by 11%. The average forwarded load is 2.0 m³ and the average load capacity is 80%, accordingly. Prime cost of chainsaw-prepared roundwood is 8.7 € m⁻ ³,but, when using harvester for preparing roundwood, itis possible to reduce the prime cost by about 2.9 € m⁻ ³.

Key words: forwarding conditions, soil bearing capacity, forwarding productivity.

Introduction.

Roundwood forwarding is one of forestry operations and it is necessary to assess how it is influenced by various factors. Productivity of forwarding is affected by characteristics of the forest area, bearing capacity, weather conditions, technological and technical conditions. Bearing capacity of soil in the harvest site and in the forwarding road outside the harvest site has a significant impact on forwarder movement, but this factorcan beadapted. When making forwarding roads, forest site type should be taken into account. Increased fertilizations lowers the bearing capacity of soil [6; 3].

Forwarding conditions are classified according to the terrain classification system in particular countries. [4] According to the guidelines of Joint stock company "Latvia's State Forest" there are four types of forwarding conditions instate forests. Forwarding conditions in forest types *Cladinoso-callunosa, Vacciniosa*, *Myrtillosa* and *Hylocomiosa* are characterized as good, with good bearing capacity of soil, forwarding can be done for all seasons. Forwarding conditions in forest types *Oxalidosa, Aegipodiosa, Callunoso-sphagnosa, Vaccinioso-sphagnosa, Myrtilloso-sphagnosa, Callunosa mel.,and Vacciniosa mel.* are characterized as average, with moderate bearing capacity of soil. Forwarding is possible throughout the whole year, when tracks are mounted. Forwarding conditions are bad in forest types *Myrtillosoi-polytrichosa, Drypteriosa, Myrtillosa mel., Mercurialosa mel., Callunosa turf. Mel., Vaccin-*

iosa turf. Mel., Myrtillosa turf. Mel. and *Oxalidosa turf. Mel.,* characterized by weak bearing capacity of soil. Forwarding is possible only by mounting tracks and putting low-grade roundwood into forwarding roads and forwarding roads outside a stand to improve the bearing capacity. Forwarding conditions in forest types *Sphagnosa, Caricoso-phragmitosa, Dryopterioso-caricosa* and *Filipendulosa* are characterized as extreme with very bad bearing capacity of soil. Forwarding can be done only when forwarders are equipped with tracks on the rear and front axle or soil is frozen or dried out. [2; 6; 3]

Reduction of soil damage in forwarding is one of the criteria for sustainable forest management as well have direct impact on the forwarding productivity. Incorrect evaluation of forwarding conditions and forwarding techniques can not only have a significant impact on the environment, but also increase forwarding costs. Choices of properly equipped forwarder can prevent risks outlined above [4].

The aim of this study is to investigate potential uses of Kranman Bison 10000 6WD forwarder in thinning under normal and difficult forwarding conditions and to determine productivity, average load size and forwarding costs.

Materials and Methods.

The study was conducted in stands (25.8 ha) representing fertile *Hylocomiosa* (45% of the total area or 11.6 ha), *Myrtillosa mel.* (28% of the total area or 7.2 ha), *Myrtillososphagnosa* (20% of the total area or 5.1 ha) and *Myrtillosa turf.mel.* (7% of the total area or 2.0 ha) site types in central part of Latvia nearby Jelgava in forests of *Forest Research Station territory.*

Study of forwarding was carried out with small weight six-weel Kranman Bison 10000 6WD forwarder, of the payload of 2.5 t. In this study forwarding productivity data were obtained in stands, where roundwood was prepared with a chainsaw and Vimek 404 T5 harvester, working in normal and difficult forwarding conditions. "Normal forwarding conditions" mean that soil bearing capacity is good and moist areas are not crossed, whereas "difficult forwarding conditions" mean that bearing capacity of soil is moderate or weak, moist areas are crossed and it is necessary to strengthen forwarding roads with harvesting residues. Detailed work studies are done of forwarding 455 m³ round wood. Most of the forwarded roundwood (335 m³ or 74%) was prepared with Vimek 404 T5 harvester and the rest (120 m³ or 26%) was prepared with a chainsaw. The average length of forwarding distance in this study was 286 m. Forwarding operations were implemented in July – September, 2016. Prime cost calculation of forwarding was done according to calculation models used similar studies carried out previously [1]. Average indicators of forwarding in calculation are used. In order to determine the significance level of data T-test was used.

Results.

Within the study Kranman Bison 10000 forwarder had worked 250 hours in total. 230 loads were forwarded during the study, including 63 loads from areas, harvested with a chainsaw, and 167 loads from areas, harvested with Vimek 404 T5 harvester. The average forwarded load is 2.0 m³ (the maximum load is 2.5 m³, therefore the average load capacity is 80%).

The average forwarding time per load is 33 minutes of productive time (productive time percentage is 94% from total engine hours of the machine). When forwarding roundwood from areas, harvested with a chainsaw, 31.1 min per load were spent but when forwarding from areas, harvested with Vimek 404 T5 harvester, 33.2 min per load were spent. On average loading and unloading take 15.4 and 5.7 min per load, accordingly. Statistically significant differences were not identified when comparing working time consumption for forwarding depending on the harvesting method.

Statistically significant differences can be observed in operations related to movement (driving time on average makes up 30% of total time), but these differences can be explained with length of the forwarding distance and location of pails, therefore movement elements are not included wheno assessing statistical differences of harvesting methods.

Productive working time in normal and difficult forwarding conditions are, respectively, 95% and 98% of the total working time. The average speed of the forwarder was 55.3 m min^{-1}, in normal forwarding conditions 63.6 m min^{-1} (average load 1.88 m^3) and 46.9 m $min.^{-1}$ (average load 1.94 m^3) in difficult forwarding conditions. The speed of the forwarder in normal forwarding conditions was considerably higher than in difficult forwarding conditions. When forwarding roundwood from areas with normal forwarding conditions, 28.9 min per load were spent, but forwarding from areas with difficult forwarding conditions required 32.1 min per load. On average loading and unloading in normal and difficult forwarding conditions takes, accordingly, 13.7 and 5.3 min and 13.5 and 5.4 min per load. The differences are not statistically significant. In normal forwarding conditions the average length of forwarding distance was 417 m, but in difficult forwarding conditions – 235 m, respectively.

Forwarding of 1 m^3 on average takes 16 minutes of productive working time. Comparing average productive time for forwarding of 1 m^3 depending on the harvesting method, no statistically significant differences were identified.

Analyzing work elements, statistically significant differences ($p = 0.00002 < 0.05$) were observed in working time consumption required for roundwood gripping at loading. Time consumption was 9% less, when roundwood was prepared with a chainsaw, comparing with roundwood, prepared with harvester. Differences ($p = 0.003 < 0.05$) were observed in working time consumption required for inserting round wood in the load. Time consumption was 29% less, when inserting chainsaw-prepared roundwood which is explained with more convenient placement of roundwood. There are statistically significant differences ($p = 0.002 < 0.05$) in working time consumption required for roundwood gripping at unloading – it was 10% less for chainsaw-prepared round wood. Statistically significant differences ($p = 0.002 < 0.05$) were also found in time required for roundwood unloading. Time required for unloading of roundwood that was prepared of harvester was 7% less. It could be explained with layout of roundwood in load. Driving during unload required 40% less time when chainsaw-prepared roundwood was unloaded ($p = 0.01 < 0.05$).

When analyzing forwarding work time depending on forwarding conditions, more productive work time was spent for forwarding of 1 m^3 round wood in difficult forwarding conditions than in normal conditions, but differences are not statistically significant. Statistically significant differences ($p = 0.0007 < 0.05$) were observed in forwarder driving speed, however contrary to the expectations the average forwarder speed was higher in difficult forwarding conditions. This is due to a longer flat stage in forwarding distance, which allowed to significantly increase the average speed.

Summaryof the main forwarding productivity indicators depending on working method shows that unloading productivity was 7 m^3 per productive hour, when forwarding chainsaw-prepared roundwood, and 8 m^3 per productive hour – with harvester prepared round wood. Loading productivity was 21 and 20 m^3 per productive hour, respectively, and driving speed was 59.0 and 43.5 m $min.^{-1}$.

Summary of the main forwarding productivity indicators depending on forwarding conditions shows that unloading productivity in difficult forwarding conditions was 8 m^3, but in normal forwarding conditions was 9 m^3 per productive hour. Loading productivity was 21 and 21 m^3 per productive hour, respectively, and driving speed was 63.6 and 46.9 m min^{-1}.

Study results prove that the best application of Kranman Bison 10000 is forwarding small stands or individual trees, when logging with a chainsaw. Forwarder can work on soils

with weak bearing capacity, however productivity can be significantly hindered by stumps and uneven terrain.

Prime cost of a Kranman Bison 10000 working hour with a 5% rate of return is 20 € (prime cost of a productive working hour is 24 €). Roundwood forwarding prime cost, when working 1172 productive hours annually, is 7.14 € m^{-3}. Average costs of forwarder are 28.7 thousand € annually, including personal costs 46%.

If harvesting is carried out with a chainsaw and forwarding – with Kranman Bison 10000, the prime cost of round wood is 23.6 € m^{-3}, including 18.6 € m^{-3} harvesting and forwarding. If harvesting is carried out with Vimek 404 T5 harvester and forwarding – with Kranman Bison 10000, the prime cost of round wood is 20.7 € m^{-3}, including 16.2 € m^{-3} of harvesting and forwarding.

Forwarding prime cost is significantly influenced by forwarding distance and machine utilization rate (average annual working hours). Forwarding prime cost significantly increases, when forwarder works less than 1000 hours annually.

The study was implemented with in the scope of the JSC funded research project 'Research program on forest biofuel and mechanization of forest operations' (agreement No 5-5.9_003v_101_16_47).

REFERENCES

1. Lazdiņš, A. Sortimentu struktūras ietekme uz kopšanas un pievešanas ražīgumu lapkoku audzēs (Impact of assortment structure on productivity of harvesting and forwarding in deciduous stands) / Salaspils: Latvian State Forest Research Institute "Silava", 2013. 60 p.

2. Liepa, I., Miezīte, O., Luguza, S., Šulcs, V., Straupe, I., Indriksons, A., Dreimanis, A., Saveļjevs, A., Drēska, A., Sarmulis, Z., Dubrovskis, D. Meža tipoloģija (Typology of forest) / Jelgava: Latvian Agricultural University Faculty of Forestry, 2014. 118 p.

3. Sarmulis, Z., Saveļjevs, A. Meža darbi un tehnoloģijas (Forest works and technologies) / Jelgava: Latvian Agricultural University Faculty of Forestry, 2015. 146 p.

4. Tiernan, D., Zeleke, G., Owende, P.M.O., Kanali, C.L., Lyons, J., Ward, S.M. Effect of Working Conditions of Forwarder productivity in Cut-to-lenght Timber Harvesting on Sensitive Forest Sites in Ireland / Biosystems Engineering (87), 2004. pp 167-177.

5. Usitalo, J. Introduction to Forest Operations and Technology / JVP Forest Systems, 2010. 287 p.

6. Vadlīnijas pievešanas apstākļu noteikšanai (The guidelines for determination of forwarding conditions) / Riga: JSC "Latvian State Forest", 2015. 4 p. http://www.lvm.lv/images/lvm/Profesionaliem/Me%C5%Beizstr%C4%81de/Pielikumi/Pievesanas_apstaklu_noteiksanas_vadlinijas_v.03.pdf.