METSÄTEHON katsaus

Metsäteho Review 4 A/1982

HARVESTING METHOD EXPERIMENTS WITH MAKERI MULTIPURPOSE LOGGING MACHINES IN THE FIRST THINNING OF A PINE STAND

By Harri Rumpunen

The study is a part of the project, financed by the Ministry of Trade and Industry, "Harvesting of energy wood in connection with the harvesting of industrial wood". Detailed information about the project will be published at a later date.

Makeri 33 T logging machines proved very suitable technically for first thinnings and were competitive in costs. Harvesting methods in which the additional raw material from branches and tops is recovered in the harvesting of industrial wood can be developed for both the harvester and the feller-buncher. The damage by the machines to growing stock was small, 1.7 % of the number of stems.

In developing the harvesting methods studied attention should be paid to the productivity of forest haulage which can be improved by increasing the bunch size in cutting.

First thinning was chosen as one of the targets of the study because of the relatively high proportion of additional raw material that it yields.

The purpose of the harvesting method experiments was to find serviceable mechanised harvesting methods for small-sized growing stock which would give technically a satisfactory recovery of additional raw material primarily for energy use at a cost that is competitive with those of the alternative short-wood methods. In addition, the possibility of improving with these machines through the short-wood harvesting method the generally poor harvesting profitability of the stand type was investigated.

INVESTIGATION MATERIAL

Work site

The study was conducted at the work site of Pellos Oy in Mäntyharju in September 1981. The stand was an approx. 30-year-old sown pine stand which had become partly regenerated naturally. It was relatively homogeneous as regards its growing stock and density. The selection of the trees to be removed was made by the logger and the Makeri operator in accordance with the instructions of the foremen.

According to the terrain classification for forest haulage, the experimental plots were chiefly of class 1. But they included class 2 plots because of gradient and stoniness. The investigation material comprised 888 stems.

TABLE 1 Growing stock data for the investigation stand

Growing stock	Stems/ha	%
Initial growing stock	2 250	100
Growing stock removed	1 200	53
- from the cutting area	830	37
- from strip roads	370	16 *)
Residual growing stock	1 050	47

*) About fourth of the growing stock removed from the strip roads came from connecting strip roads between the strip roads proper. The share of the connecting strip roads in the strip road network was above average because the investigation areas were small.

The mean diameter at breast height of the growing stock removed was 10.6 cm, mean height 10 m and mean volume 44 dm^3 (industrial wood), or 70 dm^3 with the additional raw material from branches and tops included. The yield was 52.8 solid m^3/ha harvested as industrial wood or 84 m^3(s)/ha harvested as whole-tree wood. The quantity of additional raw material was thus 59 % of the industrial wood yield.

Distribution of the removed growing stock by diameter class

Diameter class, cm	7	9	11	13	15	17+	
% of the number of stems	15	30	26	20	6	3	= 100

TABLE 2 Per-hour costs used in the comparison

Itemisation	marks/ gross effective hour	Gross effective time, months/year
Manual work	50*)	-
Makeri 33 T + feller-buncher	145	9
Makeri 33 T + harvester	155	8
Bruunett mini forwarder	160	11
Bruunett mini forwarder + grapple saw	175	11

*) marks/work-site hour

Workers, machines and methods

The man-work comparison cutting was performed by an experienced logger on the payroll of Pellos Oy who had been trained as a work instructor. The multipurpose logging machines and the forwarder were driven by operator instructors of the machine manufacturer and both of them had several years driving experience. On the whole, the operators were not familiar with the new trial working methods and actually did their first runs at the trial which might have an effect upon the output level of the machines.

Makeri 33 T basic machines were used both as harvester and as feller-buncher modifications. The forest haulage machine was the Bruunett mini forwarder. All the machines were new, manufacturer's demonstration machines.

The results and technical data of the earlier testing of the Makeri 33 T model were published in Finnish as an investigation report and the test report of Bruunett mini was published in English as Metsäteho Review 9 A/ 1979.

Fig. 1. Makeri 33 T harvester.
All photos by Metsäteho

Man-work was priced in the cost comparison in accordance with the duration (6.5 h) of the average working day and the average earnings of the worker studied. Gross earnings were increased by 53 % for indirect wage costs.

The gross-effective-hour costs of the machines were calculated by using, where applicable, the general cost bases. As there is little experience of Makeri machines in Finland, basic data derived from the best available information were used. The winter holdback because of the thick snow cover and the short shut-down during the summer because of the risk of stand damage by the harvester were taken into consideration in the annual gross effective times of the Makeri. All costs were calculated at the cost level for September 1981.

RESULTS AND CONCLUSIONS

Short-wood methods with a harvester

The Makeri harvester (methods H 1 and H 1 S) appeared to be very suitable technically for the preparation of approx. 3-m pulpwood in first-thinning conditions. The timber measuring precision was fully up to that for man-work and the delimbing result was slightly better than in power-saw delimbing. The approx. 60 % share in time expenditure of moving in the cutting area due to the way in which the machine works, had a decisive effect on productivity. The results point to the increased power effect of the new machine model. The faster moving speeds contributed very distinctly to the better productivity than was attained with the earlier machine model.

Judging by the test the share of moving can be reduced by handling two smaller-sized trees together (simulated method H 1 S). The result for both delimbing and bunching is still satisfactory. As no special instructions were given to the machine operator the bunch size was on average considerably smaller than in man-work cutting. The result was that in forest haulage the grab loads were small, loading was slower and the load more mixed. Hence, the load size was smaller and unloading was slower than in post-man-work transport. It would probably be beneficial to have the harvester make bigger bunches than in the test. Productivity of cutting would then decrease slightly, while that of forest haulage would improve.

Preparation of pulpwood by the Makeri harvester was in the test conditions undeniably competitive with man-work for in the handling of individual trees the unit costs of machine work were 13 marks and in the handling of 1 - 2 trees at a time 18 marks less than the unit costs of man-work.

TABLE 3 Harvesting methods. Strip road spacing 30 m, strip road width 4 m

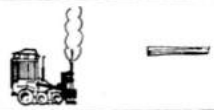
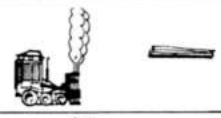
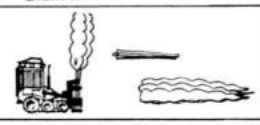
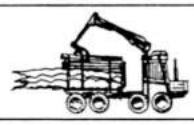
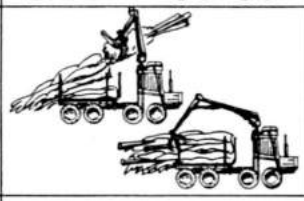
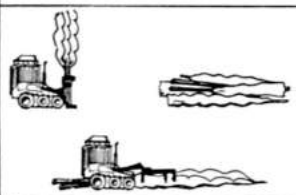
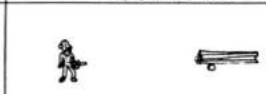
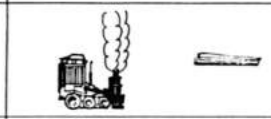
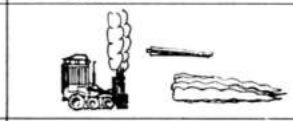
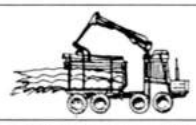
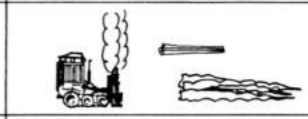
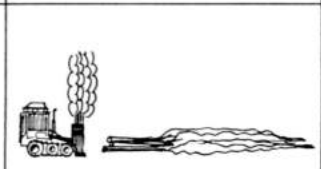
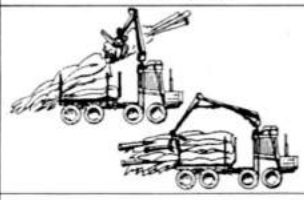
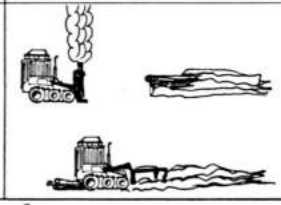
Symbol of the method	Cutting		Forest haulage	
M 1	MANUAL pulpwood of about 3 m into bunches alongside the strip road			FORWARDER haulage of pulpwood of about 3 m
H 1	HARVESTER pulpwood of about 3 m into bunches alongside the strip road, handling of trees singly			FORWARDER haulage of pulpwood of about 3 m
H 1S	HARVESTER pulpwood of about 3 m into bunches alongside the strip road, handling 1 - 2 trees at a time (simulated result)			FORWARDER haulage of pulpwood of about 3 m
H 2	HARVESTER butt end as pulpwood of about 3 m, top end as undelimbed part-tree of about 6 m, bunching separately alongside the strip road, handling 1-2 trees at a time			FORWARDER haulage of part-tree and pulpwood as a layered mixed load
H 3	HARVESTER butt end as a long log of about 6 m, top end as an undelimbed part-tree, bunching unsorted alongside the srip road, handling singly			FORWARDER haulage of long log and part-tree as a mixed load (not studied)
K 1	FELLER-BUNCHER felling-bunching of whole trees alongside the strip road, handling 2 - 4 trees at a time			FORWARDER haulage of whole trees (no time study)
K 1S	FELLER-BUNCHER felling-bunching of whole trees alongside the strip road, handling 2 - 4 trees at a time			FORWARDER + GRAPPLE SAW bucking into parts of about 6 m haulage of part-tree (simulated result)
K 2	FELLER-BUNCHER felling-bunching of whole trees and bucking into about 6-m part-trees into bunches alongside the strip road, handling 1 - 3 trees at a time			FORWARDER haulage of part-tree

TABLE 4 Results of the harvesting method tests in average conditions of the investigation stands. Forest haulage distance 350 m

Itemisation	Method							
	M 1	H 1	H 1 S	H 2	H 3	K 1	K 2	K 1 S
CUTTING								
Recovered, m^3/tree	0.044	0.044	0.044	0.063	≈0.060	0.070	0.070	0.070
- as pulpwood of about 3 m	0.044	0.044	0.044	0.035	≈0.040	-	-	-
- as undelimbed part-tree	-	-	-	0.028	≈0.020	0.070*)	0.070	0.070
Handling on average, trees at a time	1.0	1.0	1.2	1.2	1.0	2.1	2.1	2.1
Productivity, trees/ effective hour	26	94	106	100	88	158	85	158
FOREST HAULAGE								
Average size of bunch, solid m^3	0.48	0.29	0.31	0.32	forest haulage not studied		0.35	0.35
Average load size, m^3 (s)	6.7	6.5	6.5	5.3			4.5	4.5
Relative productivity	132	100**)	105	89	-	-	92	77***)
Expenditure of time, gross effective hour / ha								
- in cutting	59	14	13	13	15	8	16	8
- in forest haulage	6	8	8	13	-	-	14	16

*) As whole tree
**) 100 = 6.6 solid m^3 / gross effective hour
***) Bucking of whole trees by grapple saw during loading

TABLE 5 Unit costs of cutting and forest haulage in the investigation stand. Forest haulage distance 350 m

Symbol of the method	Pine pulpwood of about 3 m				
	CUTTING	marks/m^3(s)	FOREST HAULAGE	marks/m^3(s)	Total, marks/m^3(s)
M1		55		18	73
H1S		37		23	60
H2		28		23	51
	Undelimbed part-tree of about 6 m *)				
	CUTTING	marks/m^3(s)	FOREST HAULAGE	marks/m^3(s)	Total, marks/m^3(s)
H2		26		32	58
K1S		15		34	49
K2		27		26	53

*) Per solid m^3 recovered, including thus branches and tops

Fig. 2. Bruunett mini forwarder. Unloading of pulpwood and part-wood from layered mixed loads is fast

Fig. 3. The Makeri 33 T feller-buncher. The machine can buck whole trees to make them transportable part-trees on the ground alongside the strip road

Part-tree methods with a harvester

The method in which 1 - 2 pulpwood logs (about 3 m) were made of the butt end of the tree and the top was left as undelimbed part-tree of a target length of 6 m (H 2) was technically successful with the harvester. However, the bunching of tops can be speeded further by developing the working method. Raw material lots suited solely for industrial use and those mainly for energy use can be separated already in the cutting phase. Thus, compared with harvesting methods based on whole-tree chipping, additional treatment of raw material intended solely for industrial use is obviated. After-treatment by means of, for instance, screening is a difficult problem to solve economically.

The raw material yield of the stand was more than 40 % higher than the yield from harvesting by the short-wood method. The share harvested as short wood (pulpwood) decreased by only about 20 %, however, or one approx. 3-m pulpwood log on average per stem was harvested as the part-tree top. The unit costs of cutting per m^3(s) harvested [an average of 28 marks/m^3(s)] were under 75 % of the costs of short-wood harvesting by the Makeri harvester and only a half of the unit costs [55 marks/m^3(s)] of manual cutting. The cost distribution in Table 5 (p. 4) for pulpwood and part-trees was made from the time expenditure shares of the different work phases and the yields of different types of raw material. The result is another one if the division is made by, for instance, pricing pulpwood in accordance with the Makeri's short-wood cutting (H 1 S). The cutting costs of part-trees would then be about 17 marks/m^3(s).

In the harvesting method, layered mixed loads were used for forest haulage to enlarge the load size by compacting the part-trees with pulpwood. No technical difficulties arose in forest haulage, unloading was fast and presented no problems. However, the load size did not increase to the level anticipated from earlier experiments; the part-trees were compacted relatively little. Moreover, as the mixed load method requires loading-hauling twice from the same strip, and thus slows the loading operation, the productivity of forest haulage with method H 2 was relatively small.

For the further development of the method it might be useful if the harvester were to make bigger bunches. This would enlarge the pulpwood grab loads to be placed on the part-trees, improve the compacting of part-trees and, presumably, increase the load size.

The aim of the other harvester part-tree method tested (H 3) was to speed the handling time for individual trees by preparing one approx. 6-m pulpwood long log of the stem of the butt and feeding the top parts, with delimbing knives open, through the feeding rolls into same pile.

However, the handling time in the test was slower than in the previous method and as the share of the additional raw material recovered in the method was slightly smaller and furthermore the raw material assortments were unsorted after cutting, there appeared to be no advantage in using the method. Because of this, study of forest haulage was also omitted.

Part-tree methods with a feller-buncher

The study showed that felling-bunching of whole trees alongside the strip road by a Makeri feller-buncher (K 1) is a technically good cutting method. Productivity rose perceptibly due to the multi-stem handling of the trees and unit costs were low as all the additional material from the branches and top was recovered.

Although all the timber after cutting is bunched alongside the strip road, forest haulage of whole trees is impossible in first-thinning conditions. Difficulties arise already in the loading phase because of the lack of handling space and the considerable projection of the load beyond the rear of the tractor makes driving difficult and damages the growing stock. For these reasons no time study was conducted for this method.

From an earlier Metsäteho investigation material the results were also calculated for a method in which whole tree bunches are bucked during loading into 5-7-m long part-trees (single bucking) by a grapple saw (K 1 S) on the loader of the forwarder. According to the results, the unit costs of forest haulage are then quite high, but due to economical felling-bunching the unit costs of the whole harvesting phase would be the lowest of the methods studied. However, the results should be regarded as only indicative.

The material used was based on the bucking of the grab loads on the ground beside the forwarder. It is essential for the development of the method to discover whether the bucking can be performed above the load space so that re-loading of the other half of the bunch would be obviated.

The feller-buncher can also be used for the bucking of whole trees into part-trees (K 2) suitable for forest haulage. The machine then collects a bunch of 2-3 trees, moves it to the strip road and puts it down. The machine then advances, leaving the butts between the tracks around the middle of the stems, bucks the bunch on the ground and lifts the tops by reversing onto the butts

and collects the part-trees into a bunch alongside the strip road. The bucking takes up a considerable amount of time and reduces productivity to approx. a half of that in the felling-bunching of whole trees. The method is serviceable, however, when no grapple saw is available or investment in one is not considered economical. It is worthy of note that the grapple saw raised the per-hour costs of the forwarder used in this study by about 9 % and this applies even when the saw was not needed in haulage.

The advantage of all the part-tree methods studied which are based on the feller-buncher is recovery of the additional raw material — also the branches of the butt ends — of the entire stand. However, distribution into industrial use and energy use must be performed after the harvesting and the costs that this may entail are not seen in the comparison.

Harvesting damage

In the stand in which the Makeri experiments were conducted, 1.7 % of the residual stock was damaged. The damage was not specified by method. Two-thirds of the damage was to roots and the remainder to stems within 1-m height in the butt.

A similar damage incidence has been measured for the Makeri in earlier investigations; some studies, however, have reported considerably greater damage percentages. In those cases the studies were without exception on marked stands which obliged the machine operator to remove trees even when they were located inconveniently for the machine. Selection of trees by the operator is not only economical and conducive to an adequate work result, but also very important for avoidance of harvesting damage.

Post-Makeri forest haulage caused no further harvesting damage, apart from the damage when testing transport of whole trees that had not been bucked. The projection of the load beyond the rear of the forwarder bent standing trees at curves to an extent equivalent to an estimated 2.5 - 3.0 % of the residual growing stock per hectare.

GENERAL CONCLUSIONS

Judging by the harvesting method tests, Makeri multipurpose logging machines are noteworthy alternatives in the harvesting of first thinnings both by the short-wood method and part-tree methods in which the aim is to combine harvesting of additional wood raw material suitable for energy use with the harvesting of industrial wood.

The moving in the stand of the current model of the basic machine has increased in speed and its terrain capability has improved.

It is also possible to handle two trees at a time with the harvester and, with the feller-buncher, even bunches of 4 - 5 trees in first thinnings. Both permit several different alternatives in bunching, sorting and, partly, also in bucking.

In developing these methods the most important consideration will be improving the productivity of forest haulage. The bunching-on-the-cutting-area cutting methods combined with forest haulage using a medium-sized forwarder with a long-reach loader are alternatives that require study.

Organisational problems may occur with the use of Makeri machines, although cost competitiveness will stand the 2 - 3-month shut-down due to snow in the winter. The most economic alternative appears to be providing the basic machine with both a harvester and a felling-bunching device. The selection of suitable types of work site will then widen and shut-downs will be shorter in certain conditions. The per-hour costs of a machine unit thus equipped would be 170 marks for an annual use of 9 months.

METSÄTEHO

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ISSN 0357-4326

HELSINKI 1982 PAINOVALMISTE