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Research Article

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The Usability of Forest Tractors in the Activities of Extracting in Mountainous Terrain

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Abstract Extraction from compartment is the most difficult and costly part of forestry. Generally, the extraction is carried out by man and animal power or by agricultural tractors in flat areas. In mountainous forest areas with high slopes, special forests with drums are made with tractor cranes or air lines. Difficulties in supplying workers for production work in forests in mountainous regions, rising labor costs and safety reasons have necessitated the application of modern machinery and equipment instead of primitive production methods. In places where the labor force is insufficient and especially in the forests under the road, machine power is absolutely necessary. The rapid development of agriculture in recent years, and especially the removal of forest products from the compartment by forest tractors has provided new opportunities. This study was carried out on farm tractors and MB Trac 900 forest tractors which are used for uphill ground skidding in Zonguldak Forest Regional Directorate in Turkey. Time studies and volume measurements have been done during tractors work and productivity rates have been calculated as m^3/hour.

Keywords MB Trac, Forest harvesting, Productivity

1. Introduction

The work of carrying forest products to the nearest forest road from where they are cut down is called as extraction which is a step in harvesting operations. The process of harvesting consists of the following steps; felling, cutting the branches and the top, debarking, classification, skidding and transportation.

The purpose of extraction is to carry the raw material to the collection centers like landing, storage areas, and depots that are constructed by the roads by giving the least or no harm to the forest if possible in order to present the raw material to do use of human beings. Harvesting and transportation of logs especially on mountainous areas are extremely difficult, expensive, and time consuming operations.

In the terrain which is flat or almost flat, the logs are dragged by humans, animals or agricultural tractors. Dragging by tractors removes all the disadvantages of dragging by animals. Furthermore dragging by tractors is a method of extraction which is used when the animal force falls short to the work and when we want to reduce the harms of extraction by using dragging methods, in mountainous forests which have steep slopes, extraction works are applied by tractor winch by dragging the logs using a hauling cable or by making use of skylines [1-2].

Activities of extraction constitute the most difficult and the most expensive part of forestry works. In Turkey 72% of the logs that are produced by using extraction are carried by human power, 15% by animal power, 8% by tractor and 5% carried by skylines [3-4].

4% of the total industrial wood production in Turkish state forests is first class and second class logs and 96 % of these logs are third class [5]. One of the main reasons of this is the use of primitive methods in extraction activities.

Difficulties in finding suitable workers for harvesting in mountainous areas, rising cost of labour, huge losses in quality and work safety have required the application of methods that involve the use of modern machines and equipment [6-7-8]. Machine power is absolutely needed when the workforce is not sufficient, and it is also needed in order that the forests below the road level can be made use of. Farm tractors and forest tractors which have been developed technologically opened new horizons in extraction of forest products.

Menemencioğlu, in his study made in Ilgaz-Yenice Forest Enterprise has discovered that the average output is 6,236 m^3/h at a skidding distance of 100 m when a farm tractor is used and 4,967 m^3/h at a hauling distance of 50 m when a MB Trac 900 forest tractor is used [9].

In the study that has been made in Atrvin region on forest tractors by Erdaş and Acar it has been discovered that the output is 5,269 m^3/h in a terrain that has a slope of 70 % and a hauling distance of 69 m [10].

Activities of extraction that carried out by using different types of tractors in Eastern Black Sea Region have been studied by Acar and it has been found that the output is 6,328 m^3/h at a hauling distance of 50 m if a MB Trac 900 forest tractor is used [11].

This study has been made on MB Trac 900 forest tractors which are used for extraction activities in Karabük Forest Directorate while MB Trac 900 forest tractor were working, time studies and volume measurements have been made and output values have been calculated as m^3/h. Measures to be taken in order to increase the output in extraction by forest tractors have been negotiated.

2. Material and Methods

This study has been made on MB Trac 900 forest tractors which work within the borders of Karabük Forest Directorate. The measurements concerned with MB Trac forest tractors have been done during the extraction of the logs of scotch pine, crimean pine and fir.

In these studies, MB Trac 900 forest tractors which belong to Forest Directorate and which have been hired out to peasants. MB Trac 900 forest tractors work by pulling forest products upwards till the roads using a cable. MB Trac 900 forest tractors have a motor power of 85 PS (63 kW) and 6360 kg weight. The cable which is used to pull the forest products is 12 mm and it's 100 meters long. The tractor has two tambours; however, only one tambour has been used during the measurements (Figure 1).

Figure 1: Extracting by MB Trac forest tractor using a cable

For the extraction works done by forest tractor using a cable, two different study forms have been used in order to be evaluated in the analyses to be done. During the studies chronometer, tape measure, clinometer, caliper and compass have been made use of.

Statistical evaluation of the measurements has been made on computer by making use of SPSS statistical software and Microsoft Excel.

In the working area, the time that is spent in each phase of the process of carrying the trees to the forest roads from where they have been cut has been measured and noted on the study forms that have been prepared before. At the same time, the width and length of the products have been measured and noted down and later volume calculations have been done, Furthermore, skidding distance, slope, skidding, direction have also been noted down. The slope when pulling the products upwards by a cable has been considered as (+), and it has been considered as (-) when pulling the products downwards.

Permanent time measuring technique has been used as the time measuring method. In this method, the chronometer has been turned on as the work began and at the end of each phase as well as at the end of the work the figures have been noted down. Later time spent for each phase has been calculated. While working with MB Trac 900 forest tractors, time spent for pulling empty hooks, loading, pulling the products by cables and unloading has been calculated.

The total output which has been obtained from the skidding works with cables has been calculated as follows since loading-unloading work occupy a great deal of time in total cycle time [10-11];

$$\text{Output (IM)} = \frac{60 \text{ X OUH}}{(YS + BS) + [(AIS + KCS) \text{ X } (IM / MM)]} \quad (1)$$

IM : Desired Distance (m)
YS : Loading Time (min)
OUH : Average Volume of Products Skidded Each Time (m^3)
BS : Unloading Time (min)
AIS : Descending Time of the Empty Hook (min)
KCS : Pulling Time of the Cable (min)
MM : Average Present Distance (m)

Desired Distance (IM) in the study and evaluation in other words pulling distance of the cable with a forest tractors has been taken as 50 m and output calculations have been done accordingly. In the skidding works with forest tractors using cables time measurements have been done for 60 skids in total.

The means and standard deviations of the measurements were calculated, and correlation and regression analyzes were performed to reveal the relations between the factors being examined and output as degree and quantity.

3. Results and Discussion

The average values that have been obtained as a result of the evaluation of the measurements done during skidding process of the products with MB Trac 900 forest tractors using cables in the region are given in Table 1. In skidding works with MB Trac 900 forest tractors, average output has been found to be 7.47 m^3/h at a distance of 50 m by using output formula (1). This output value is high compared to other research in Turkey. This results from studying in the regions which are rich in terms of the amount of forest and production rate. It was observed that one log was transported on average at a volume of 0.88 m^3 each time.

Table 1: Average Values of Working with MB Trac 900 Forest Tractor

Factors	Measurement	Mean	Standard Deviation
Diameter (cm)	60	50.93333	±17.10076
Length (m)	60	4.616667	±2.081734
Volume (m^3)	60	0.881185	±0.44988
Skidding distance (m)	60	45.7500	±21.26956
Slope (%)	60	62.66667	±10.10398
Pulling the empty hook (sec)	60	53.61667	±27.24036
Loading time (sec)	60	48.66667	±40.5315
Dragging by cable (sec)	60	249.9333	±100.7687
Unloading time (sec)	60	130.300	±54.10044
Total time (sec)	60	481.8167	±336.7847
Output (m^3/h)	60	7.471142	±4.383919

Bigger pieces of logs can be carried by MB 900 Trac forest tractors in contrast to carrying by animals and agricultural tractors. MB Trac forest tractor can also extract products from the compartment in the form of the whole tree. Thus, skidding with forest tractors enable people to produce first and second class long logs.

In the multiple regression process, dependent variable total time (Y) and independent variables were taken as diameter, slope, length, volume and hauling distance at 0.05 significance level. As a result of using stepwise solution technique which is involved is SPSS package programme, it has been found that slope and volume as independent variables aren't useful for the regression model. So, regression equation has been written as follows;

Y=-348,200 + 9,085 x diameter + 5,822 x distance + 18,811 x length

The coefficient of determination of the model has been found to be R^2=0,481. Diameter (XDiameter), dragging distance of the cable (XDistance) and length (XLength) variables explain the total time (Y) by 48%. A simple linear correlation operation has been made and correlation coefficients have been found by using SPSS statistical package programme in order to discover the relations between the total time and other variables (Table 2).

Table 2: Correlations between the Total Time and the Other Variables

Variables	Diameter	Length	Volume	Distance	Slope
Total time	0.543**	0.217	0.446**	0.489**	-0.013
** P<0.01					

In the table it can be seen that there is a meaningful relation between the total time and diameter, volume and distance at an importance level of 0.01. In skidding works, as the diameter and volume of the logs increase and as the distance gets longer, the total time also increases and thus the output values decrease. Also it has been discovered that there isn't a significant relation between the total time and length and slope at an importance level of 0.01. That the length of the logs and slope values don't have an effect on the total time and output has also been discovered. The graphics of the relations that are meaningful have been prepared as follows using Microsoft Excel.

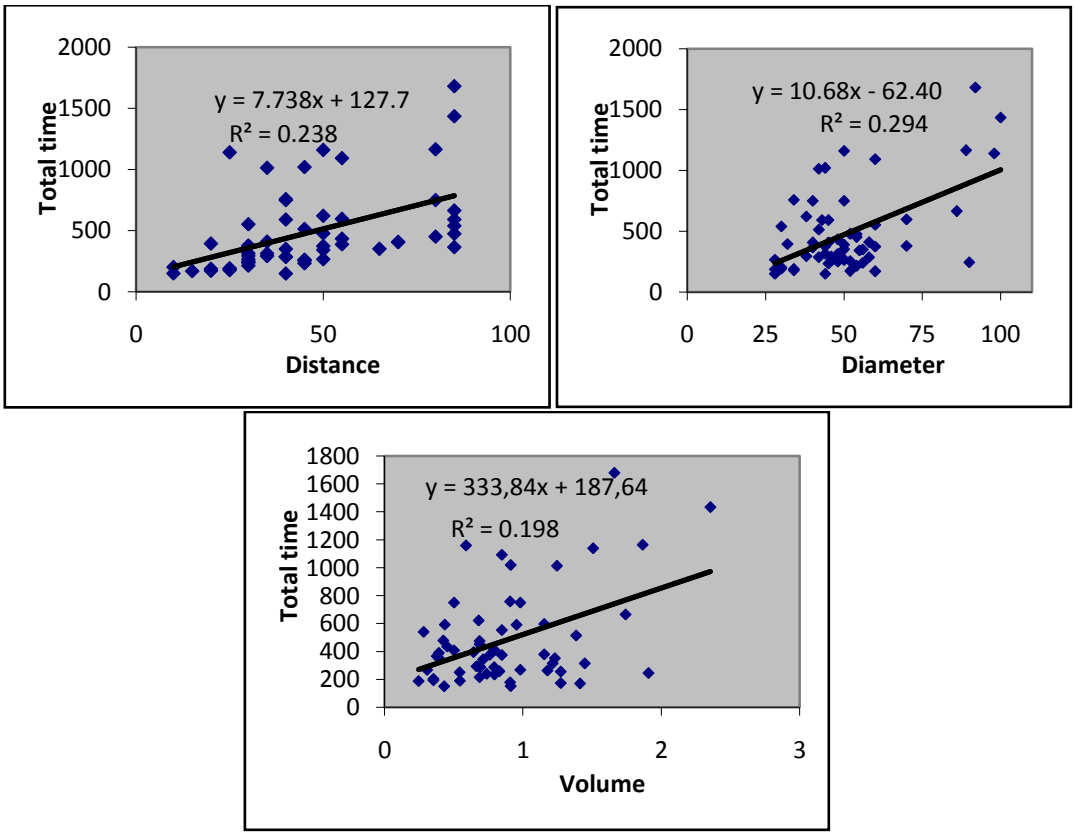

Figure 2: The relations between the total time and distance, diameter and volume

The time of each phase obtained as a result of the evaluation of time studies in the process of skidding works with MB Trac forest tractor has been shown in table 3.

Table 3: Distribution of the time of work phases in skidding work with forest tractor

Work phase	Time	%
Pulling the empty hook (sec)	53.61667	11.11189
Loading (sec)	48.66667	10.08602
Dragging by cable (sec)	249.9333	51.79784
Unloading (sec)	130.300	27.00427

As it is seen in the table 3, dragging the logs by cable occupies 51% and unloading occupies 27% of the total work time at a distance of 45 meters. By reducing the time spent on dragging and unloading, the total work time can be reduced and output can be increased.

Dragging the logs by cable may take more time due to choosing inappropriate routes and as a result of this, obstruction of several factors. The logs being dragged by the cable are obstructed by trees, branches, roots and soil. This leads to loss of time and breaking off the cable. The logs to be dragged should be lopped and their barks should be removed before they are dragged. Obstruction of the log by tree trunks and roots can be prevented by choosing an appropriate route. Also, obstruction of the logs by branches that were cut before can be prevented by carrying these branches away from the route. If the both ends of the logs are made round, obstruction of the log by soil can be prevented. The logs which are stuck can be moved by using simple manual devices such as sapie, lever and twist hook.

Since the workers in loading place have difficulty in communicating with their colleagues in unloading station, a great deal of time is lost. With a good communication among workers, dragging of the logs which are stuck can be stopped immediately and breaking off the cable can be prevented. The time losses can be reduced and breaking off the cable can be prevented when a worker communicates between the operator and the loading place right next to the tractor during the dragging process.

The main reasons of the fact that unloading takes a long time are putting the logs by the road, narrowness of the forest roads and absence of temporary stowage areas by the roads. The forest roads should always be kept open. Moreover, while stowing the logs by the road in fill parts, the logs may roll down and this poses a great danger for the workers below the road. Unloading time can be reduced by employing experienced tractor operators and by preparing the stowage area before starting the work.

4. Conclusions

In skidding works with MB Trac forest tractors, the average output has been found to be 7.47m^3/h at a distance of 50 m. Each time, a log the volume of which is 0.88 m^3 has been carried on average. In skidding works with MB Trac forest tractor, it has been seen that the logs can be produced as a whole tree and first and second class logs can also be produced.

In skidding works with MB Trac forest tractors, it has been discovered that dragging by cable phase occupies 51% and unloading phase occupies 27% of the total work time and these two phases come first and second in the time table.

Moreover, in skidding works with MB Trac forest tractors, as the diameter and volume of the log and the distance increase, total work time increases and this leads to a decrease in output. It has been discovered that changes in the length of the logs and slope don't have considerable effect on the total work time and output.

Instead of primitive skidding methods using manpower and animal power, skidding method using forest tractors which has a high rate of output and which has the capacity to produce high quality logs must be preferred. Before dragging the logs by forest tractors, their branches must be cut, barks must be removed and their both ends must be made round. Some manual devices such as sapie, lever and twist hook in order to move the logs that are stuck. There must be a worker near the tractor to help the operator and workers in the loading place communicate during skidding. The dragging route must be chosen and cleaned with care before starting the work so that no log is stuck. Tractor operator must be chosen from experienced persons and stowage areas must be determined and prepared before hauling.

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