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Full Length Research Paper

Productivity of MB Trac 900 tractor at beech stands on mountainous areas in Blacksea region

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Research of productivity of MB Trac 900 tractor in beech stands was performed in the area of Golkoy Local Forest Enterprise within the Ordu Forest Administration in Turkey. Timber was skidded uphill by MB Trac 900 tractor in felling area. Time study of a cycle was carried out by using collected data and by statistical analysis. In this study, skidding distance ranges between 55 and 105 m. Hourly productivity are 14.400 m³/h for skidding distance of 55 m, 8.700 m³/h for skidding distance of 105 m. The cost of skidding are 3.5 and 9.6 $/m³ at different distance. Average load volume for every cycle was found 1,490 and 2,130 m³, respectively.

Key words: MB Trac 900, skidding, productivity, cost, time study.

INTRODUCTION

Ground skidding system is the process of moving timber from the felling area to roadside or landing. In the Blacksea region located in north of Turkey, timber extraction with skidding vehicle is the most common system and also the one that tends to cause the erosional problems. Rubber tires tractors are used on the more gentle slopes and on skid roads on steeper terrain. Crawler tractors are used on steeper topography to skid direct to the landing (Gholami and Majnounian, 2008).

Due to the combined use of tractors and trucks for primary and secondary transportation of roundwood, forest harvesting had to rely on a network of forest and public roads. Forest roads are expected to reduce the distance and costs of wood extraction and strip roads and skid trails to reduce winching and mobility of loaded vehicles on mountainous terrain of higher or lower slope (Sabo and Porsinsky, 2005).

The production of timber is still one of the most important forestry practical. The productivity of skidding tractor of a forest depends on various ecological factors and their positive and negative effects. There are some factors that have impact on productivity, these factors are; machine and equipments type, forest conditions, weather conditions and operators. The operator has a large influence on productivity for most types of forest work (Gullberg, 1995). Harvesting and transportation of woods on mountainous areas are extremely difficult, expensive and time consuming operations (Eroglu et al., 2009). Primary transportation methods are of three types in Turkey's forestry, they are; human power, animal power and mechanization. Ground skidding by hand (man and gravitation) is applied in small forest areas for extraction of small amount of timber and big amount of fuel wood over short distances. Animal skidding, mainly by horses and oxes, is used for pre-skidding for bunching distance between 20 and 100 m. Mechanical skidding is carried out by ground based forestry vehicles (Ozturk and Senturk, 2007).

Time studies are very important for productivity studies in forest engineering. The different methods and equipments are used in time studies and measurements (Gullberg, 1995; Acar, 1997; Aykut, 1972). Time studies and ergonomic evaluation were conducted with the aim of determining the possibility of using a forest machine in forest harvesting operations (Johansson, 1997).

The aim of this paper is to research some exploitation characteristics of articulated MB Trac 900 tractor in skidding in beech stands. The structure of total consumed times are established as well as daily output standards for different skidding distance and time standards of pulling, choking and winching.

MATERIALS AND METHODS

MB Trac 900 tractor technical features

Tractor is designed for skidding timber on skid roads and skid trails as well as off road. Tractor MB Trac 900 is a four-wheel drive vehi-

Table 1. Main technical characteristics of MB Trac 900 (Ozturk, 2001).

Features	MB Trac 900	Features	MB Trac 900
Machine Power	85 HP (63 kW)	Vinch Mark	CG2M2ZD
Weight	6000 kg	Cable Diameter	12 mm
Drawing Power	72.9 HP (53,7 kW)	Cable Length	100 m
Speed	30/40 km/h	Cable Speed:	
Cylinder	4 cylinder	-540 tour	33/61 m/min
Cylinder Capacity	3780 cm³	-1000 tour	19/35 m/min
Cooling System	Water Cooling	Lift up Power	2000 daN
Speed - front	25 - 40 km/h	Depot Capacity	120 lt
Speed - back	20 km/h	Machine Type	OM 314

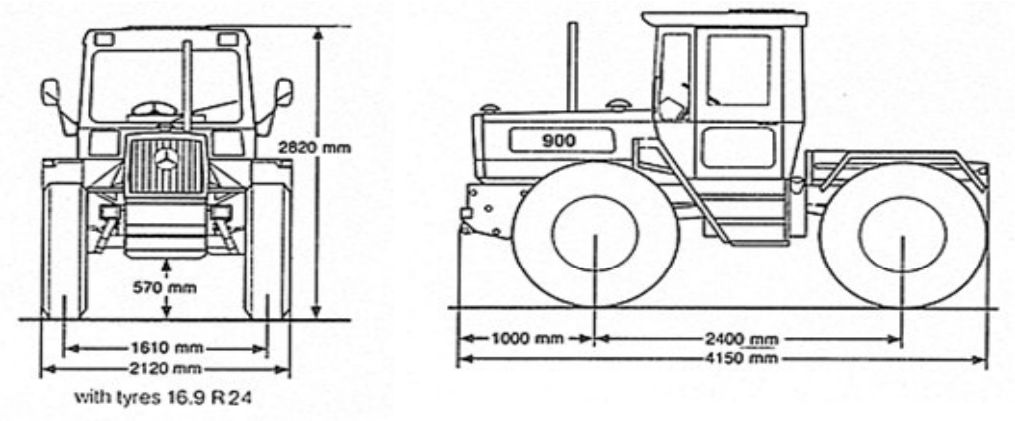

Figure 1. The features of MB Trac 900.

cle. The main technical characteristics of the tractor are shown in Table 1 and Figure1.

Location of research

The research of the extraction of beech timber by tractor MB Trac 900 was carried out in mountainous area of Golkoy Local Forest Enterprise within the Ordu Forest Administration. Golkoy Local Forest Enterprise manages a forest area of 47847 ha. The compartment number of research area is 67 and stand age was 40. In the section of an area 25 ha, beech is dominating. The road density of this area is 9.60 m/ha. Figure 2 show the maps of the investigated subcompartment. The mean slope of research area is 30%. The altitude of region is between 1200 and 1500 m.

Two tractors roads were scheduled for skidding of the tractor from the felling site landing. Along skid roads, soil was loamy. Skidding for every skid road is uphill. The forest road was used as the landing site as wood assortments were stocked along the road at both sides.

Data collection

Performance of MB Trac 900 tractor performance was investigated by time and work study method. Time consumptions of the duration of working components were researched by repetition method and records were taken throughout the whole working day. The distance of skidding was measured by use of a measuring tape, the slope gradient of the terrain and strip roads was measured by clinometer and the load data were collected by measuring the diameter and length of each piece of timber under bark using a caliper.

The measurement data were entered into computer files from the record sheets so as to make them available for data processing. Data processing covered the control and selection of data, classification of recorded times and calculation of the achieved work productivity. Statistical data processing was carried out by use of a computer with the application of the software package Microsoft Excel 2003 and SPSS 11.00.

This study tries to measure the impact of the following independent variables to “total cycle time” (total time). In here, the total time is chosen as a dependent variable whereas; unloaded tractor travel, pulling out of cable, Hookup, Winching, Loaded tractor travel, Unhook and Delay time were selected as independent variables. Beyond that, variables such as skidding distance, load volume and load number were also chosen as independent variables.

The definitions of both dependent and independent variables and how to measure them are summarized below.

Dependent variable

t = total time: which is measured as time at scale level variable and the measurement unit is minute.

Independent variables

a = unloaded tractor travel: This phase is started when the tractor is ready to move the loading area. Then, ends of this phase when

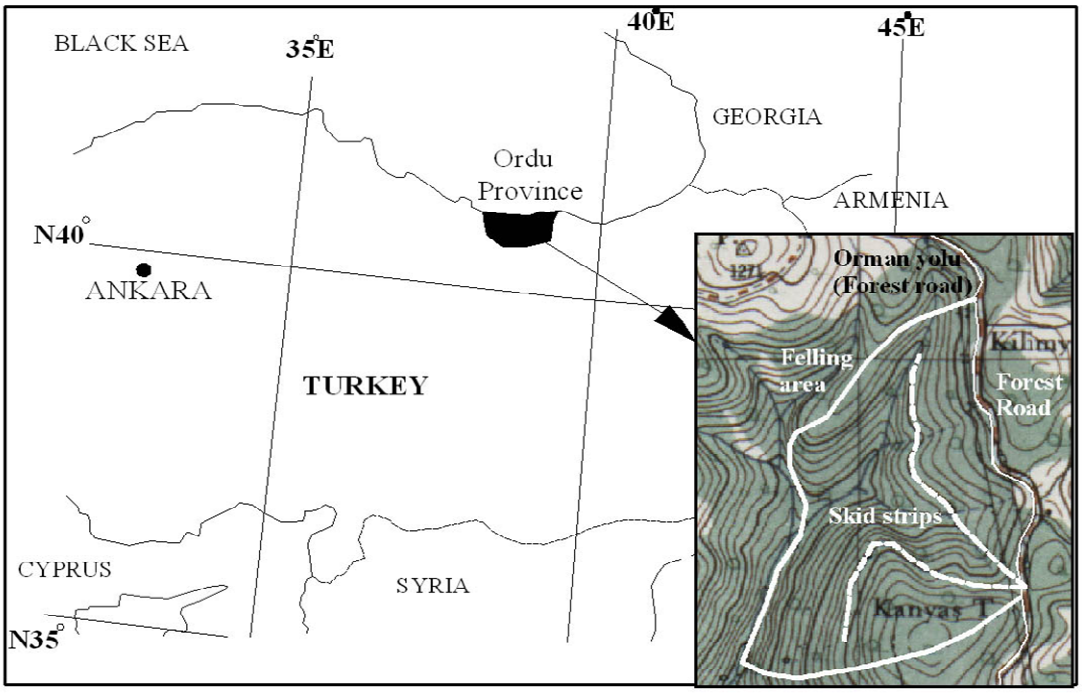

Figure 2. Ordu province and felling area.

tractor arrive the loading area.
b = pulling out of cable: This phase begins at the end of unloaded tractor travel and ends when the choke setter is ready to hook a turn.
c = hookup: It begins at the end of lateral out and ends when the choke setter has completed hooking.
d = winching: Begins at the end of hookup period and it ends when the operator is skidding timber through tractor side.
e = loaded tractor travel: Begins at the end of lateral in and ends when the tractor has reached to the ramp.
f = unhook: Begins at the end of in haul when the tractor passes over to the tripblock and ends when the hook is pulled back to the loading point.
Dt = delay time is the time lost when carrying the log.
Sd = skidding distance is described as the distance between loading point and destination. The distance is measured by meter and marked at regular intervals and recorded.
Lv = load volume is a variable that represents the volume of all transported logs at the destination. This variable is measured as cubic meters.
Ln = load number is a variable that represents the number of all transported logs at the destination. This variable is measured as cubic meters.

All the variables given above are considered as scale variable. Then, theoretically the mathematical equation below is obtained:

$\mathbf{t} = a + b + c + d + e + f + Dt + Sd + Lv + Ln$

In this work, the hypothesis below is set up:

$H_0 = R^2_{y,a,b,c,d,e,f,g,ed,lbd,lv} = 0.0$ (Null hypothesis).

H_0 (null hypothesis) means that the proportion of variance in total cycle time (t) that is explained by unloaded tractor travel, pulling out of cable, hookup, winching, loaded tractor travel, unhook, delay time, skidding distance, load number and load volume included in regression model is equal to zero, in the population from which the sample was selected. Null hypothesis also implies that none of the independent variables has statistically significant effect on total cycle time.

Analysis

MB Trac 900 tractor was investigated in terms of work performance by using time and work study methods. Initially a 95% significance level was set to test the null and alternative hypothesis presented above. F-test (variance analysis) was used for testing whether the data verify statistical model or not. F-test = 185.567 and was statistically based on a 0.05 significance level. Since F-test (185.567) is higher than $F_{0,005}$, the null hypothesis that none of these independent variables has a statistically significant effect on total cycle time was rejected. Consequently, the data were consistent with the alternative hypothesis that the proportion of variance in total cycle time (t), explained by the set of independent variables included in the regression model was greater than 0.01 in the population from which this sample was selected. It also implied that at least one of these independent variables had a statistically significant effect on total cycle time and that this relationship was linear.

The regression model for study area was calculated as follows:

$t = 1.238 + 1.128e + 1.607a + 0.976c + 0.833Dt + 1.405b$

In preparing the model for the study area cut-block, when the other variables were hold constant above the dependent variables, the coefficient of Durbin-Watson was 2.143. Since the coefficient was approximately 2 or below, this means that there was no correlation between the independent variables that form the model and that they were completely separated from each other.

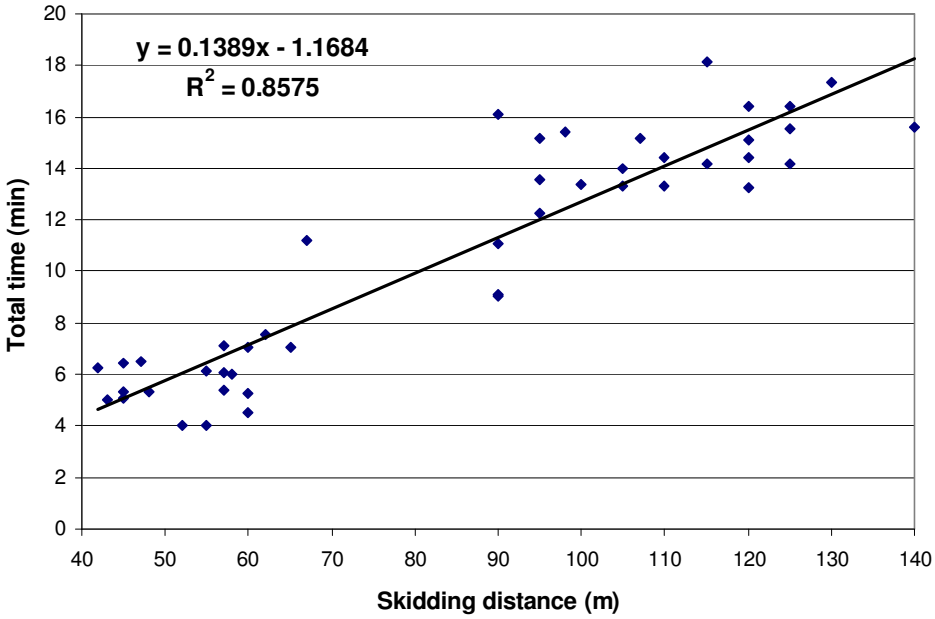

Figure 3. Relationship of skidding distance vs. total time

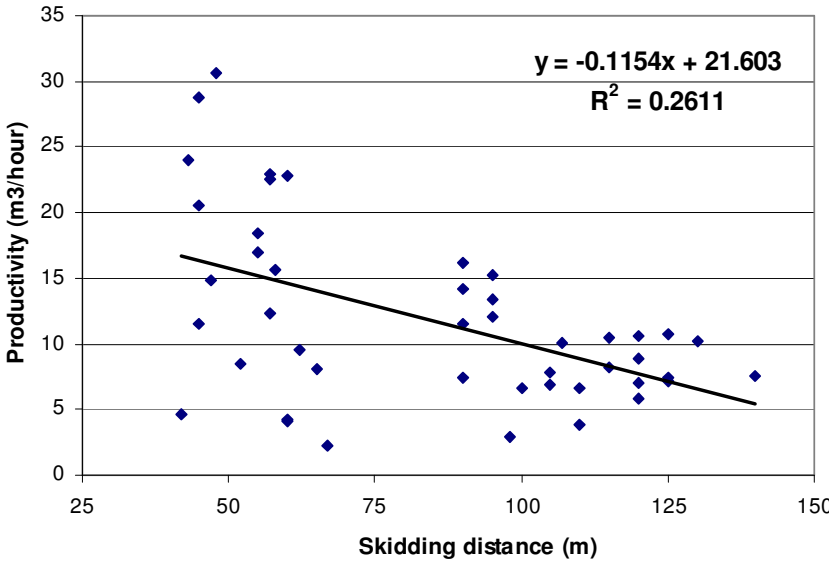

Figure 4. Relationship of skidding distance vs. Productivity

RESULTS AND DISCUSSION

The Golkoy forest district operating under the management of Ordu Forest Administration was chosen as the study area for timber haulage operations. All workers employed at tractor operations were housed in the barracks located within the forest area.

The first result revealed by this research is that there is a linear and positive correlation between the set of ten independent variables (unloaded tractor travel, pulling out of cable, hookup, winching, loaded tractor travel, unhook, delay time, skidding distance, load volume and load number) and dependent variable (total cycle time). This implies that when an independent variable increases, total cycle time increases as well. The relationship between total time and skidding distance are shown in Figure 3 and the relationship between total time and productivity are shown in Figure 4.

The MB Trac 900 tractor performance was being observed at the felling area for 15 working days. During that time 950 m³ of beech timber was extracted in 55 recorded cycles. Timber skidding was carried out at

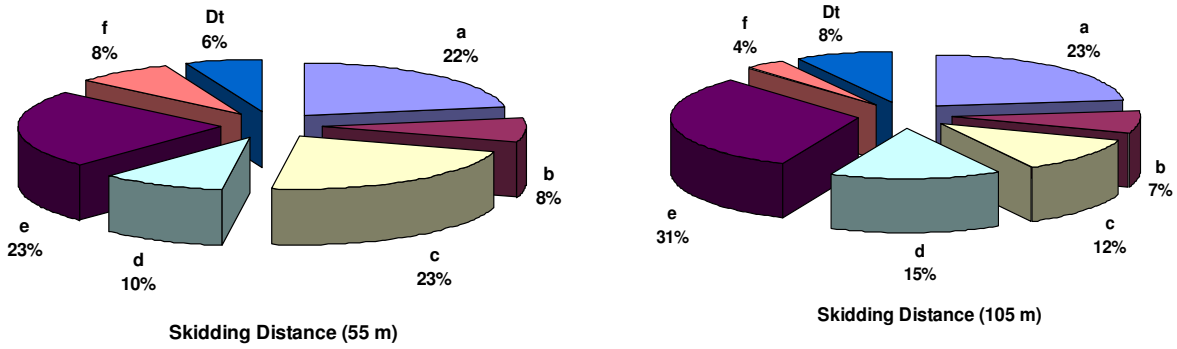

Figure 5. Percent of work phases.

Table 2. Results of measurements.

Skidding distance (m)	Time measurement phases (min)						Delay time (min)	Total time (min)	Load volume (m³)	Load number	Productivity (m³/h)
	a	b	c	d	e	f					
55	1.10	0.37	1.11	0.49	1.18	0.38	0.30	6.13	1.490	2	14.410
105	3.15	1.00	1.57	2.00	4.30	0.48	1.13	14.43	2.130	2	8.700

a: Unloaded tractor travel, d: Winching, b: Pulling out of cable, e: Loaded tractor travel, c: Hookup, f: Unhook

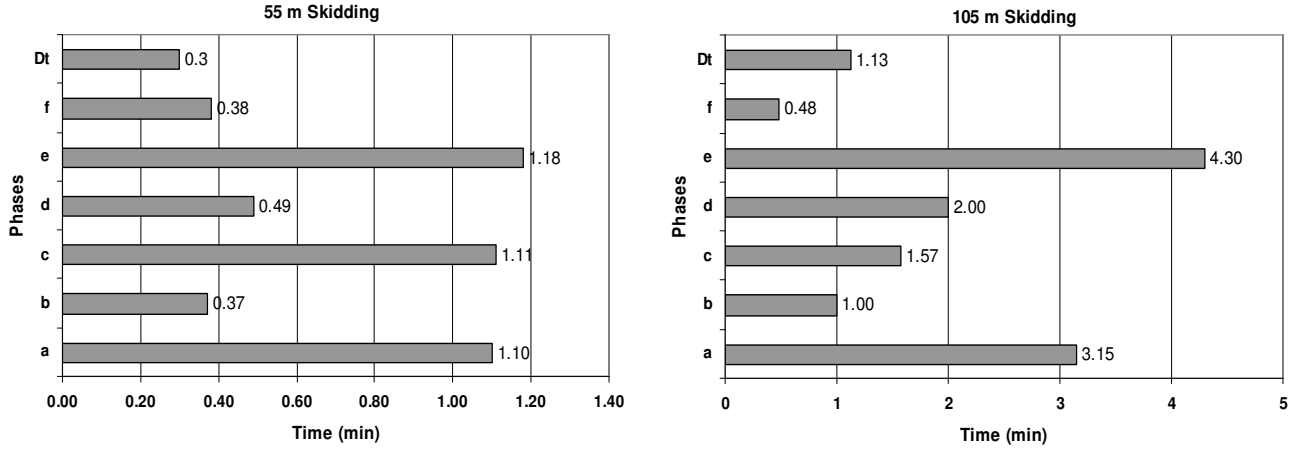

Figure 6. Distribution of time consumption phases.

different distance.But, average two different distances are observed for this study. The average total cycle times of MB Trac 900 tractor at the distance of 55 and 105 m are 6.10 and 14.40 min, respectively. The average total cycle time is 10.25 min for this study. The average lost time was found to be 0.52 min/cycle. Lost times were occurred during hookup and loading tractor travel. The distribution of time consumption are shown in Figure 5.

The average load volume is 1.800 m³/cycle. The volume of an average piece of timber was 0.90 m³ and it was 2.5 and 6 m long. The results of time measurements are shown in Table 2.

Hourly productivity are 14.400 m³/h for skidding distance of 55 m, 8.700 m³/h for skidding distance of 105 m. The cost of skidding are 3.5 m³/$ and 9.6 m³/$ at different distance. Daily fuel consumption was measured by the volume method. The average fuel consumption per operating hour was 4.5. Time consumptions by working component are shown in Figure 6.

Conclusion

This paper shows the results of research of skidding beech timber by the MB Trac 900 tractor. The tractor with two different skid roads was skidding and four workers were engaged. The timber skidding was carried out uphill for two skid roads. Length of skid roads were 2 m and

slopes of skid roads were between 2 and 12%.

In this study, productivity of MB Trac 900 tractor was found as 14.400 m³/h for skidding distance of 55 m, 8.700 m³/hour for skidding distance of 105 m. In a similar study conducted by Acar (1997) in Artvin Taslıca region, skidding distance for 50 m, productivity of MB Trac 900 tractor was found as 6.300 m³/h. In another study by Acar (1995), skidding distance for 76 m, productivity of MB Trac 900 tractor was found as 5.73 m³/h, Ozturk (2001), skidding distance for 600 m, and productivity of MB Trac 900 tractor was found as 6.36 m³/h. The productivity value of MB Trac 900 in this study area was above productivity values of other studies.

In this study, the average cost of MB Trac 900 tractor was calculated as 3.5 $/m³ and 9.6 $/m³ for 55 and 105 m skidding distance, respectively. A study conducted in Artvin region (Acar, 1997) reported that cost of MB Trac 900 tractor was found to be 16.8 $/m³ (for average 50 m). Average fuel consumption of these tractors were similar to other studies. When the skidding distance during forest production works is increased, the efficiency of machines decreased. At the same time, the cost of skidding increases with respect to felling areas. Therefore, in the felling areas, skidding distance should be kept short. The skid roads should be coated in the form of a network in production areas.

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