Productivity and Time Studies of MB Trac 900 Tractor at Beech Stands on Mountainous Areas in Turkey

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Abstract

The purpose of this study is to investigate the productivity of the MB Trac 900 tractor during extraction of beech timber from stand of oriental beech in the North of Turkey. By using the methods of time study, the productivity of MB Trac 900 tractor was determined considering two different average skidding distances (i.e. short : 55 m and long: 105 m). The research results implied that some working characteristics of the MB Trac 900 tractor such as skidding distance, load volume, time consumption of handling operations and fuel consumption had an important impact on productivity of the tractor. Hourly productivity was computed as 14.580 m³/hour for the average skidding distance of 55 m while it was 8.850 m³/hour for the average skidding distance of 105 m. The cost of skidding was 3.5 $/m³ and 9.6 $/m³ for the specified average skidding distances, respectively. The average load volume for each cycle was found to be 1,490 m³ and 2,130 m³, respectively.

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

Introduction

Forest harvesting systems chosen must be balanced for the characteristics of the forest, machine types, intensity of the harvesting operation, and other variable factors that affect equipment productivity (Akay et al. 2004). One of the common harvesting systems is ground skidding system, which is the process of moving timber from the felling area to roadside or landing by using mechanized equipment. Mechanized harvesting systems provide higher quality products and safer operation environment than that of conventional systems (Akay and Erdas 2007). In most regions of Turkey, the application of mechanized harvesting equipment is currently low, due to low labor costs and high fuel costs. Therefore, estimating production rates of the equipment is very important for logging managers to develop cost effective mechanized harvesting systems (Akay et.al. 2004).

In Turkey, primary transportation of logs from stands to landings involves the use of human power, animal power and mechanization. Ground skidding by hand (man and gravitation) is applied in small-scale forestry for extraction of small amount of timber and big amount of fuelwood over short distances. Animal skidding, mainly by horses and oxes, is used for preskidding for bunching distance between 20 m and 100 m. Mechanized harvesting is carried out by ground based forestry vehicles (Ozturk and Senturk 2007).

In the mountainous regions of northern Turkey, timber extraction using skidding vehicle is the most common system. The productivity of skidding tractors in forest operation depends on various factors such as forest conditions, equipment type, weather conditions, and operator's experiences. The stand characteristics (tree diameter, log length, number of trees per unit area etc.) and topographic conditions are the main factors that limit the usage of mechanization. Equipment selection is also very critical to perform the forestry operations in an effective way. In primary transportation, rubber-tired tractors are usually used on the gentle slopes and on skid roads for the steep terrain. Crawler tractors can be also preferred on steeper topography to skid logs directly to the landing (Gholami and Majnounian 2008). The rough weather condition may also reduce the productivity and tends to cause the soil erosion problems. Finally, the operator always has an important influence on productivity for the most of the forest operations (Gullberg 1995). The operators should receive sufficient training sessions and their performance, motivations, and abilities should be assessed in real operations.

Due to the combined use of tractors and trucks for primary and secondary (i.e. hauling logs from landing to depots) transportation of logs, the productivity of harvesting operation also relies on the density of forest road network. Forest road networks are expected to decrease the costs of timber extraction by

reducing the amount of strip roads and skid trails, which then leads to reduction in skidding distance, winching distance, and mobility of loaded vehicles on mountainous terrain (Sabo and Porsinsky 2005).

Harvesting and transportation of logs especially on mountainous areas are extremely difficult, expensive, and time consuming operations (Eroglu et.al. 2009). Time studies are very important methods to estimate the productivity of forest operations and to compare productivity of forest harvesting systems of various conditions (McDonald and Fulton, 2005). Many studies have been conducted to perform time studies of various harvesting equipments (Gullberg 1995, Acar 1995, Aykut 1972). Besides, a time study integrated with ergonomic evaluation was conducted by Johansson (1997) to determine the possibility of using a forest machine in forest harvesting operations.

The aim of this study is to perform a time study to determine the productivity of articulated MB Trac 900 tractor in skidding of logs from a beech stand. The structure of total consumed time, time standards of work phases, and daily output standards for two different skidding distances (i.e. short: 55 m and long: 105 m) were established.

Material and methods

MB Trac 900 tractor

Forestry tractors are designed for skidding timber on skid roads and skid trails as well as off road. MB Trac 900 is a four-wheel drive vehicle with articulated structure. The main technical characteristics of the tractor were shown in Table 1. Figure 1 indicates the MB Trac 900 skidding logs in a forest.

Study area

The extraction of beech timber was carried out by MB Trac 900 in Golkoy Local Forest Enterprise within the Ordu Forest Administration. Study area is located in the mountainous area of Black Sea Region in Turkey.

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

Features	Values	Features	Values
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/hour	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/hour	Depot Capacity	120 lt
- back	20 km/hour	Machine Type	OM 314

Figure 1. MB Trac 900 tractor

Golkoy Local Forest Enterprise manages a forested area of 47,847 ha. The compartment number of study area is 67 with the average stand age of 40. The beech is the dominating tree in the section of an 25 ha. The road density of the area was computed as 9.60 m/ha. Figure 2 shows the maps of the Ordu province and the topographic map of the investigated subcompartment. The average slope of the study area was 30% and the altitude of the region was between 1,200 and 1,500 meters.

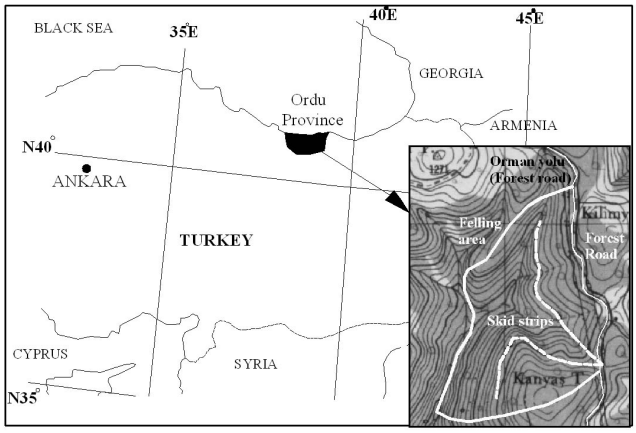

Figure 2. Ordu province and felling area

Two skid roads were scheduled for skidding logs from the felling site to the landing area. Along skid roads, soil was loam and skidding was uphill. The forest road was used as the landing area as wood assortments were stocked along both sides of the road.

Data collection

The performance of MB Trac 900 was investigated by using 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 skidding distance was measured by using a steel measuring tape. The slope gradient of the terrain and strip roads was measured by using a clinometer. The load for each cycle was computed based on the length and diameter information of the logs. The log diameter under bark was measured by using a caliper.

The field data were recorded into the data tables, and then entered into computer 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 using Microsoft Excel 2003 and SPSS.11.

In this study, the time measurement phases within a skidding cycle of tractor are composed seven stages. The definitions of these time measurement phases and how to measure them are summarized below:

a = unloaded tractor travel is started when the tractor is ready to move the loading area. This phase ends when tractor arrives the loading area.

b = pulling out of cable, begins when tractor stops moving and ends when the choker setter is ready to hook a turn.

c = hookup, begins at the end of lateral out and ends when the choker setter has completed hooking.

d = winching, begins at the end of hookup period and 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 landing area.

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 that is lost when skidding operation is stopped, due to some obstacles on the ground or machine timeout.

In this study, the impact of the specified independent variables onto "total cycle time" (total time) was investigated. Thus, the total time was chosen as a dependent variable whereas; "skidding distance", "load volume" and "load number" were selected as independent variables.

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

Dependent variable:

t = total time is the time in which a tractor completes one skidding cycle. The measurement unit is minute.

Independent variables:

Sd = skidding distance is described as distance between loading point and destination at landing. The distance is measured in meter and marked at regular intervals and recorded.

Lv = load volume represents the volume of the transported logs in each cycle. This variable is measured as cubic meters.

Ln = load number represents the number of the transported logs in each cycle. This variable is measured as numbers.

All the variables given above are considered as scale variable. Then, following hypothesis were set up:

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

H_0 (null hypothesis) means that the proportion of variance in total cycle time (t) that is explained by skidding distance, load number, load volume. Null hypothesis also implies that none of the independent variables has statistically significant effect on total cycle time.

Finally, production per hour (m^3/hr) can be determined by using the equation below:

Production = (Lv / t) x 60

Lv = load volume per cycle (m^3)

t = cycle time (min)

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 = 85.306 and statistically based on a 0.05 significance level. Since F-test (85.306) was higher than $F_{0,005.}$, the null hypothesis was rejected that none of these independent variables has a statistically significant effect on total cycle time. 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 0,0 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:

$t = -1.693 + 0.138 \times Sd - 0.285 \times Lv + 0.536 \times Ln$ ($R^2 = 0.86$)

In preparing the model for he study area cutblock, when the other variables were hold constant above the dependent variables, the coefficient of Durbin-Watson was 2.027. 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.

Results

The Golkoy forest district operating under the management of Ordu Forest Administration was cho-

sen as the study area for timber skidding operations. All workers employed at tractor operations were housed in the barracks located within the forest area.

When we look at the relationship between each of these independent variables and total cycle time, we can find out some sound and clear conclusions:

Total cycle time (t) vs. skidding distance (sd): The unstandardized coefficient is 0.138, which means that the relationship between skidding distance and total cycle time is positive. When skidding distance increases one minute, total cycle time increases 0.138 minutes, if we control all other variables constant. Since beta (β) is 0.919, the relationship between skidding distance and total cycle time is moderate, but statistically significant. Beta coefficient means that for each standard deviation increases in the skidding distance, total cycle time increases 0.919 units, when we control all other independent variables constant in the model. Since the coefficient is statistically significant, the relationship between total cycle time and skidding distance is linear.

Total cycle time (t) vs. load volume (lv): The unstandardized coefficient is -0.285, which means that the relationship between load volume and total cycle time is negative. When load volume increases one minute, total cycle time decreases -0.285 minutes, if we control all other variables constant. Since beta (β) is -0.050, the relationship between load volume and total cycle time is weak, but statistically significant. Beta coefficient means that for each standard deviation increases in the load volume, total cycle time increases -0.050 units, when we control all other independent variables constant in the model. Since the coefficient is statistically significant, the relationship between total cycle time and load volume is linear.

Total cycle time (t) vs. load number (ln): The unstandardized coefficient is 0.536, which means that the relationship between load number and total cycle time is positive. When load number increases one minute, total cycle time increases 0.536 minutes, if we control all other variables constant. Since beta (β) is 0.106 the relationship between load number and total cycle time is weak, but statistically significant. Beta coefficient means that for each standard deviation increases in the load number, total cycle time increases 0.106 units, when we control all other independent variables constant in the model. Since the coefficient is statistically significant, the relationship between total cycle time and load number is linear.

The relationship between total time and skidding distance is shown in Figure 3 and the relationship between total time and productivity is shown in Figure 4. As shown in Figure 3 and 4, when the skidding distance increases, the total time of a cycle is increasing. In addition, when the skidding distance increases, the productivity of tractor is decreasing.

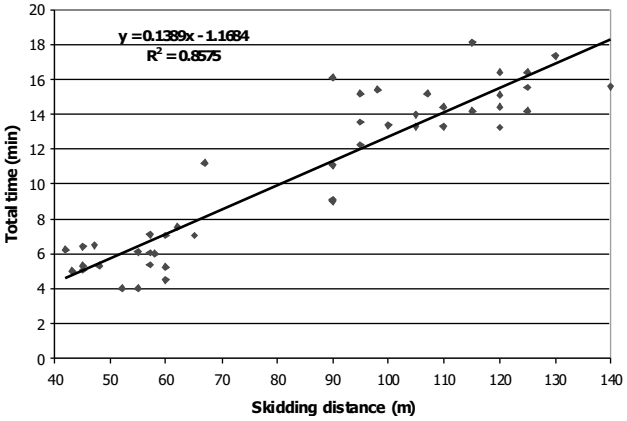

Figure 3. Relationship of skidding distance vs. total time

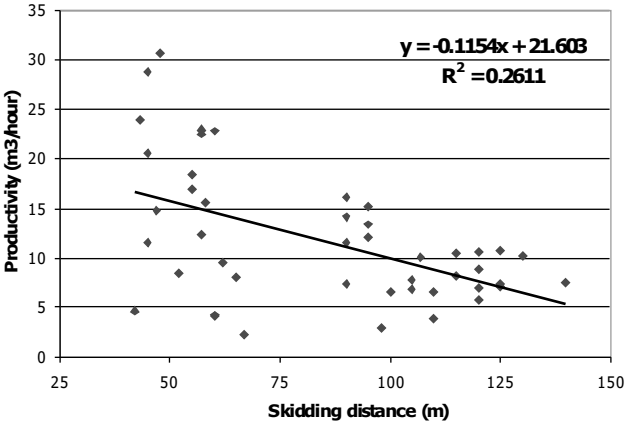

Figure 4. Relationship of skidding distance vs. productivity

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 different distance, but two different average skidding distances (i.e. short : 55 m and long: 105 m) are observed for this study. The average total cycle times of MB Trac 900 tractor at the distance of 55 and 105 meters are 6.13 and 14.43 minutes, respectively. The average total cycle time is 10.25 minute for this study. The average delay time was found to be 0.52 min/cycle. Delay times occurred during hookup and loaded tractor travel. The distribution of time consumption is shown in Figure 5.

The results indicated that the average load volume is 1.80 m³/cycle. The volume of an average piece of timber was 0.90 m³ and it was 2.5 to 6 meters long. The results of time measurements are shown in Table 2.

Hourly productivity is 14.580 m³/hour for skidding distance of 55 m, 8.850 m³/hour for skidding distance

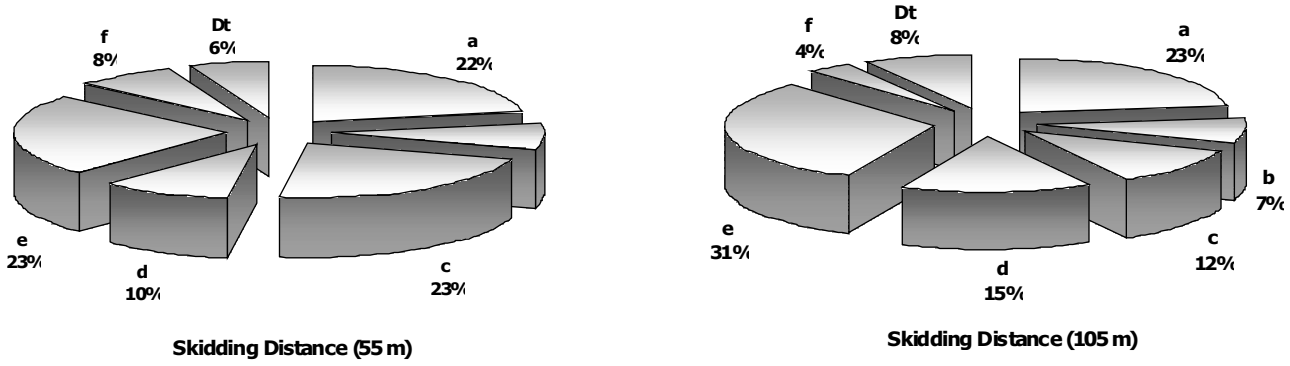

Figure 5. Percent of work phases

Table 2. Results of measurements

Skidding Distance	Time measurement phases (min)						Average delay time	Average total time	Average load volume	Average load number	Average Productivity
(m)	*a*	*b*	*c*	*d*	*e*	*f*	(min)	(min)	(m³)		m³/hour
55	1.10	0.37	1.11	0.49	1.18	0.38	0.30	6.13	1.490	2	14.580
105	3.15	1.00	1.57	2.00	4.30	0.48	1.13	14.43	2.130	2	8.850

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

of 105 m. The cost of skidding are 3.5 $/m³ and 9.6 $/m³ for two different skidding distances, respectively. Daily fuel consumption was measured by the volume method. The average fuel consumption per operating hour was 4.5 l/hr. Time consumptions by working component are shown in Figure 6.

Discussion and conclusions

This paper shows the results from skidding beech timber by the MB Trac 900 tractor. Four forestry workers with an experienced tractor operator engaged in the skidding operation. The timber skidding was car-

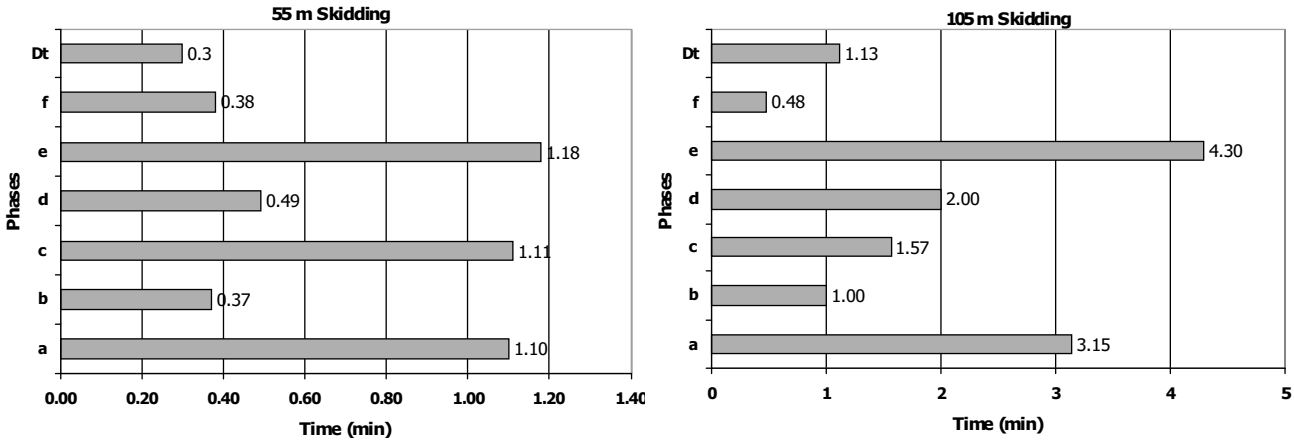

Figure 6. Distribution of time consumption phases

ried out uphill for two skid roads with the slopes of 2% to 12%.

In this study, productivity of MB Trac 900 was found to be 14.580 m³/hour and 8.850 m³/hour for the average skidding distance of 55 m and 105 m, respectively. In a similar study conducted by Acar (1997) in Artvin Taslıca region, productivity of MB Trac 900 was found to be 6.300 m³/hr for the average skidding distance of 50 metres. In another study by Acar (1995), productivity of MB Trac 900 was found as 5.73 m³/hr for skidding distance of 76 metres. By Ozturk (2001), productivity of MB Trac 900 was found as 6.36 m³/hr for skidding distance of 600 metres. The results indicated that the productivity of MB Trac 900 in this study area was more than the productivity values from other studies.

In this study, the average cost of MB Trac 900 was calculated as 3.5 $/m³and 9.6 $/m³ for 55 and 105 metres skidding distances, respectively. A similar study conducted in the same region (Acar 1997) reported that cost of MB Trac 900 was 16.8 $/m³ for average skidding distance of 50 metres.

Increasing the average skidding distance during the forest operations decreases the efficiency of machines. At the same time, the cost of skidding increases in felling area. Therefore, in the felling areas forest engineers should use shorter skidding distances. Besides, the skid roads should be coated in the form of a network in production areas.

References

Acar, H.H. 1995. Investigation on the transport from compartment of forest trees by MB Trac 900 special forest tractor on Artvin region. *Turkish Journal of Agriculture and Forestry* 19: 45-50.

Acar, H.H. 1997. Investigation of extraction with forest tractors on mountainous areas. *Turkish Journal of Agriculture and Forestry* 21: 299-306.

Akay, E.A., Erdas, O. and Sessions, J. 2004. Determining productivity of mechanized harvesting machines. *Journal of Applied Sciences* 4(1): 100-105.

Akay, E.A. and Erdas, O. 2007. Estimating rut depth during skidding with a rubber-tyred skidder. SDU, *Journal of Faculty of Forestry* A(1): 49-57.

Aykut, T. 1972. Equipments and methods using for time measurement. Istanbul University, Review of the Faculty of Forestry B22(1):17-33

Eroglu, H., Ozkaya, M.S., Acar, H.H., Karaman, A. and Yolasıgmaz, H.A. 2009. An investigation on roundwood extraction of *Fagus orientalis* lipsky, *Abies nordmanniana* (Stew.) Spach. and *Picea orientalis* (L.) Link. by Urus MIII forest skyline on snow. *African Journal of Biotechnology* 8(6):1082-1089.

Gholami, M.J. and Majnounian, B. 2008. Productivity and cost of wheeled skidder in Hyrcanian forest. *International Journal of Natural and Engineering Science* 2(3): 99-103.

Gullberg, T. 1995. Evaluating operator-machine interations in comparative time studies. *Journal of Forest Engineering* 7(1): 51-61.

Johansson, J. 1997. Small tree harvesting with a farm tractor and crane attached to the front. *Journal of Forest Engineering* 8(1): 21-33.

McDonald, T.P. and Fulton, J.P. 2005. Automated time study of skidders using global positioning system data. *Computers and Electronics in Agriculture* 48: 19-37.

Ozturk, T. 2001. A research on special forest tractors used to extraction works. Istanbul University, Review of the Faculty of Forestry B51(2):101-110.

Ozturk, T. and Senturk, N. 2007. Extraction of spruce timber by Gantner cable crane from selective forests of Artvin region. *Croatian Journal of Forest Engineering* 27(1): 59-66.

Sabo, A. and Porsinsky, T. 2005. Skidding of fir roundwood by Timberjack 240C from selective forests of Gorski Katar. *Croatian Journal of Forest Engineering* 26(1): 13-27.

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ПРОИЗВОДИТЕЛЬНОСТЬ И ВРЕМЯ ИССЛЕДОВАНИЯ MB TRAC 900 ТРАКТОРНЫЕ В БУКОВЫХ ЛЕСОВ НА ГОРНЫХ РАЙОНАХ ТУРЦИИ

Т. Озтурк и Н. Сентурк

Резюме

Целью настоящего исследования является изучение производительности MB Trac 900 трактора при добыче букового леса из восточных насаждений бука в Северной Турции. С помощью метода время исследование производительности MB Trac 900 трактора определяется с учетом двух различных скольжений среднего расстояния (например, краткое: 55 м и долго: 105 м). Результаты исследований следует, что некоторые рабочие характеристики MB Trac 900 трактора такие как занос расстояния, объем нагрузки, время потребление погрузочно-разгрузочных работ и расход топлива оказали важное влияние на производительность трактора. Часовая производительность рассчитывалась как 14,580 м^3 / час для заноса среднем расстоянии 55 м, а это было 8,850 м^3 / час на среднем расстоянии от заноса 105 м. Стоимость заноса составил 3,5 $ / м^3 и 9,6 $ / м^3 для указанного среднего расстояния заноса, соответственно. Средний объем нагрузки для каждого цикла оказался 1490 м^3 и 2130 м^3, соответственно.

Ключевые слова: MB Trac 900, трелевка, производительность, стоимость, хронометраж