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The Efficiency of Mechanization in Weed Control in Artificial Regeneration of Oriental Beech (*Fagus orientalis* Lipsky.)

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Abstract**—**In this study which has been conducted in Akçasu Forest Range District of Devrek Forest Directorate; 3 methods (weed control with labourer power, cover removal with Hitachi F20 Excavator, and weed control with agricultural equipment mounted on a Ferguson 240S agriculture tractor) were utilized in weed control efforts in regeneration of degraded oriental beech forests have been compared. In this respect, 3 methods have been compared by determining certain work hours and standard durations of unit areas (1 hectare). For this purpose, evaluating the tasks made with human and machine force from the aspects of duration, productivity and costs, it has been aimed to determine the most productive method in accordance with the actual ecological conditions of research field. Within the scope of the study, the time studies have been conducted for 3 methods used in weed control efforts. While carrying out those studies, the performed implementations have been evaluated by dividing them into business stages. Also, the actual data have been used while calculating the cost accounts. In those calculations, the latest formulas and equations which are also used in developed countries have been utilized. The variance of analysis (ANOVA) was used in order to determine whether there is any statistically significant difference among obtained results, and the Duncan test was used for grouping if there is significant difference. According to the measurements and findings carried out within the scope of this study, it has been found during living cover removal efforts in regeneration efforts in demolished oriental beech forests that the removal of weed layer in 1 hectare of field has taken 920 hours with labourer force, 15.1 hours with excavator and 60 hours with an equipment mounted on a tractor. On the other hand, it has been determined that the cost of removal of living cover in unit area (1 hectare) was 3220.00 TL for labourer power, 1250 TL for excavator and 1825 TL for equipment mounted on a tractor.

According to the obtained results, it has been found that the utilization of excavator in weed control effort in regeneration of degraded oriental beech regions under actual ecological conditions of research field has been found to be more productive from both of aspects of duration and costs. These determinations carried out should be repeated in weed control efforts in degraded forest fields with different ecological conditions, it is compulsory for finding the most efficient weed control method. These findings will light the way of technical staff of forestry directorate in determination of the most effective and economic weed control method. Thus, the more actual data will be used while preparing the weed control budgets, and there will be significant contributions to national economy. Also the results of this and similar studies are very important for developing the policies for our forestry in short and long term.

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I. Introduction

DUE to new technological developments, people utilize the machinery in every domain of their daily lives. Within this context, the machines are utilized in many of forestry activities depending on improving technology of today. This situation necessitates the mechanization in many of technical forestry activities. Two of the leading short-term and long-term policies of our forestry are the enlargement of forest lands due to their multilateral benefits and the regeneration of unproductive forest lands. Achieving this goal depends on the execution of successful artificial regeneration and foresting activities. For this reason, particularly the enlargement of foresting lands and the incapability of manpower in land preparation activities necessitate the mechanization implementations.

In foresting activities, the primary operation is to prepare the land, where the foresting activity will be executed, for plantation or foresting. The activities to be executed for this purpose are classified under 2 groups as cover removal and soil processing [1]. In foresting activities, selecting the equipment suitable for topographical conditions, soil and existing plant cover gives the most economical solution [2]. First of all, the slope of the land is a limiting factor in foresting and artificial regeneration activities. In general, the lands having slow up to 35% are accepted to be suitable for mechanized work. The type, density, and root and stem thickness of the weed to be removed are effective on machines and equipment to be selected [3]. As a result of the removal of ground vegetation on the area to be planted, the nutrient content of the soil increases, the competitive plant cover is removed, and the humic topsoil is mixed in order for young saplings to grow [4], [5].

The aim of this study is to assess the efficiencies of the excavator, tractor and labourer power methods widely used in artificial beech regeneration activities particularly in Devrek-Akçasu region, and to compare them. Within this context, firstly the lands, where the removal is performed through excavator, were examined, then the artificial regeneration fields, where the rhododendrons were cleaned through the ropes tied to rear end of the tractor and where the removal is

executed through manpower, were examined. During these examinations, the unit-time analyses were done, and it is tried to reveal the efficiencies of these 3 weed cover removal methods by assessing the field data.

II. Material and Method

This research has been carried out during weed control activities of Akçasu Forest Range District of Devrek Forest Directorate affiliated with Zonguldak Regional Directorate of Forestry Operation during artificial beech regeneration activities in 2010, which was executed through 3 methods (excavator, tractor, and labourer power) in division of number 36c. the mean annual precipitation value of the study area was 1493 mm, and mean annual temperature was 11.7°C'dir. The soil structure of study area has heavy-structure characteristic, and it has sandy clay loam texture [6].

The study area is 10 ha in size, 935m in altitude, it has northwestern exposure and is located in central shoulder, and it has characteristic of ruined coppice beech forest. After weed control in area, it is planned to prepare the discrete terraces in 3x2m dimensions, and to plant 2+0 naked-rooted saplings originating from Kdz. Ereğli in 3x1.5m distances between each other (Fig. 1).

Fig. 1 Artificial regeneration area, where the weed control will be executed

In this research, firstly the equipment to be used in weed control was examined. Accordingly, the images of HITACHI F20 excavator and FERGUSON 240S tractor involving drum system to be used in weed control are presented in Fig. 2. Besides these tools, the unit-time etudes were executed in area where the weed control was executed through manpower (Figs. 2 and 3).

In this study, after unit-time etudes, 3 methods were also compared to each other from the aspect of costs. For this purpose, the formula below, which is useful in comparing the weed control methods, was utilized [7].

$$Q = (Fe - Fr)/(Ve - Vr) \quad (1)$$

where Q = annual living cover removal area (ha); Fe = fixed costs of Method e (TL); Fr = fixed costs of Method r (TL); Ve = variable costs of Method e (TL); Vr = variable costs of Method r (TL).

On the other hand, statistical methods of variance analysis and Duncan test were utilized both in comparison of unit-time etudes and in comparison of cost analysis.

(a)

(b)

Fig. 2 (a) Excavator, and (b) A view from weed control through drum system mounted on tractor

Fig. 3 Weed control through labourer power, and a view from soil processing

III. Results and Discussion

A. Results Related with Unit-Time Etudes

The first stage of the research consists of unit-time etudes of 3 different weed control methods implemented in 10ha artificial beech regeneration area in Akçasu Forest Range District's division number of 36c. The results obtained from the unit-time etudes in field are presented in Table I.

TABLE I
Results of Unit-Time Etudes

Implemented Living Cover Removal Method	Unit area (Ha)	*F= 145.253****
		Time (Hours)
Excavator	1	15[a]
Agriculture Tractor	1	60[b]
Labourer Power	1	920[c]

***: significance level at *P>0.001*, Ha: hectare
a, b, c: each of letters indicates a different group.

As a result of variance analysis applied to unit-time etudes, it was determined that there was a significant difference between 3 living cover removal methods at the confidence level of *P>0.001*. As a result of Duncan test applied for this reason, it has been determined that 3 groups emerged at the confidence level of *P>0.05*. Accordingly, from unit-time etudes, the fastest weed control method for 1ha surface was determined to be the excavator method. It is followed by weed control by rope tied on rear end of a tractor involving drum-system, and them the weed control through labourer power (Table I). In Turkey, many studies have been carried out on this topic. In a study of [8], it has been determined that the efficiency of machines and equipment used in weed control in Eskişehir, which has semi-arid climate conditions, has been found to be much better than the efficiencies of labourer power and controlled-fire techniques. In another study carried out by [9], it has been determined that the weed control by using mechanization had positive effects on physical conditions of the soil, and that it significantly protected the water balance of the soil in arid and semi-arid climate regions. On the other hand, in another research by [10], the unit-time etudes have been executed in mechanized weed control, and it has been determined that mechanized weed control was very high. The results of similar studies on this topic corroborate the result of this original study carried out in artificial beech regeneration area in Devrek-Akçasu region. In this respect, since its arm length and thread width are enough, it is possible to say that the weed control through excavator is much more sensitive to soil conditions and much more efficient in proportion to other methods.

B. Results Related with Unit-Cost Comparisons of Weed Control Methods

In second stage of the research, the methods used in weed cover control during the artificial beech regeneration were compared in terms of unit-cost, and the obtained results are presented in Table II. The data in Table II were calculated by taking the fixed and variable costs, which are mentioned in Method section, into account. In these calculations, actual tax rates and amortization costs were considered.

TABLE II
Results of Unit-Cost Calculations

Implemented Living Cover Removal Method	Unite Area (Ha)	*F= 38.65****
		Cost (TL)
Excavator	1	1250[a]
Agriculture Tractor	1	1825[b]
Labourer Power	1	3220[c]

***: significance level at *P>0.001*, Ha: hectare
a, b, c: each of letters indicates a different group.

As a result of variance analysis applied to unit-cost etudes, it was determined that there was a significant difference between 3 weed control methods at the confidence level of *P>0.001*. As a result of Duncan test applied for this reason, it has been determined that 3 groups emerged at the confidence level of *P>0.05*. Accordingly, from unit-cost etudes, the fastest weed control method for 1ha surface was determined to be the excavator method. It is followed by weed control by rope tied on rear end of a tractor involving drum-system, and them the weed control through labourer power (Table II). In a research carried out on this topic in black pine forestation activities in Eskişehir region, it has been reported that mechanized weed control with dredging and riper combination was much more efficient and economical in proportion to control through manpower in terms of unit costs [10]. Within the scope of this study, the time- and cost-efficiencies of 3 methods were examined from the aspect of land size, and the obtained results are presented in Fig. 4.

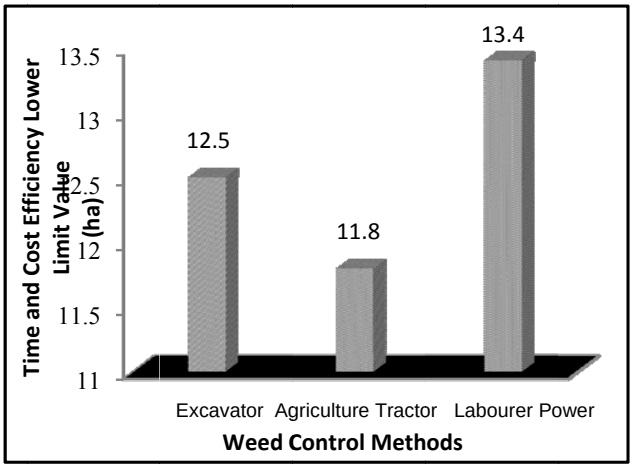

Fig. 4 Lower Threshold Values of Time and Cost Efficiency

When the unit-time analyses related with the living cover removal used in this research and the cost-efficiency values calculated by taking the fixed and variable costs such as purchasing value, salvage value, amortization duration, average investment value, interest rate, insurance costs, operator costs, assistant costs, fuel expenses, repair and maintenance costs, oil and oiling costs into account are evaluated in Fig. 4, it was determined that excavator is more efficient after 12.5 ha, drum-rope system mounted on a tractor is more efficient after 11.8 ha, and the labourer power is more efficient after 13.4 ha. According to these values, it can be

seen that lower efficiency threshold values of excavator and tractor systems were very close to each other. Thus, in a similar study on this topic, the lower threshold value of the combination of dozer, heavy-duty dredger and riper was determined to be 12.3 ha [11]. On the other hand, by [5], it is recommended to determine the lower threshold values of time- and cost-efficiency before starting a forestation activity in any location.

IV. Conclusion

Under the lights of obtained results, it can be said that the utilization of excavator method in weed control in future artificial beech regeneration (plantation) activities in Devrek-Akçasu region will be the best method in terms of both of time and cost. In this method, the fertile topsoil layer is not transferred, it becomes suitable for onsite usage, and consequently an appropriate plantation area comes up. Moreover, removal of rhododendron constituting the weed cover and having high vegetative growth skills through uprooting it improves the efficiency of this method.

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