平成18年12月15日発行

JOURNAL OF THE JAPAN FOREST ENGINEERING SOCIETY

Vol.21 December 2006 No.3

CONTENTS

THE JAPAN FOREST ENGINEERING SOCIETY

J. Jpn. For. Eng. Soc.

森利学誌21 (3) 2006

227～231

Research and Technical Note

Effects of multiple passes of tractor on soil bulk density -A case study in the boreal natural forest of Tokyo University Forest in Hokkaido-*

Juang R. MATANGARAN**, Kazuhiro ARUGA***, Rin SAKURAI****, Hideo SAKAI**** and Hiroshi KOBAYASHI*****

1. Introduction

Increased mechanization in logging operations usually means traffic increased over the ground. The ground, however, is also a substrate for growth. Skidding operation is one of the most important procedures in forest operations and it also represents the environmental aspect of harvesting operations. Skidding machines often damage forest soil and residual stands. There were some effects of skidding operation by tractor on soil. The effects are increase in bulk density, decrease in total pore space, decrease in infiltration rate, and change in soil structure. The degree of soil compaction depends on soil physical properties and forest machines, and the skidding is often recognized as the major cause of soil disturbance (*2, 4*). In order to pay attention to the environmental impact, the effect of skidding operations by tractor on soil compaction must be investigated.

According to some previous researches (*1, 3, 6*), the level of soil compaction is related to the intensity of tractor passes on the soil. Soil becomes more compacted after several times of tractor passes. The most prominent variable related to increase in bulk density is the number of trips or passes with machine and logs. GAYOSO and IROUME (*1*) showed that the bulk density increased significantly after more than 3 passes and the increase in bulk density were still important at the maximum sampling depth of 20 cm. JUSHOFF (*3*) compared the effect of crawler and rubber-tired tractor on soil compaction in Malaysia. He showed that the changes in soil bulk density and total pore space of the rubber-tyred tractor did not exceed those caused by a track type crawler tractor. Most soil physical properties reached a maximum or minimum after the first two passes.

The multiple passes of tractor needed to be examined in order to control or restrict soil compaction impact. The information of extent of soil compaction will be used to minimize environmental impacts of logging operations by planning the location of skidding routes and forest road network. Regarding this problem, looking for the maximum level of bulk density related to the multiple passes of a tractor was investigated in the boreal natural forest of Tokyo University Forest in Hokkaido.

2. Site and Methods

The research forest is consisted of the mixed forest with coniferous and broad-leaved species. Crawler type tractors are used for selection cutting systems. Bulldozer D40A Komatsu used in this experiment was the tractor of crawler type with 66 kW, 114 kN of operating weight and 36 kPa of ground pressure (Table 1). Soil hardness was measured after one until nine passes of the tractor. The tractor passed over the undisturbed area without towing the log. Cone penetrometer was penetrated until 50 cm depth with 3 replications in order to examine the soil hardness at the skid trail, the center between trails,

---

* トラクタ走行回数が土壌密度へ与える影響 －東京大学北海道演習林の北方天然林における事例－

** ジュアン・ラタ・マタンガラン　Bogor Agric. Univ., Indonesia　ボゴール農科大学
*** 有賀一広　Fac. of Agric., Utsunomiya Univ., Tochigi 321-8505　宇都宮大学農学部
**** 櫻井倫・酒井秀夫　Grad. Sch. of Agric. and Life Sci., The Univ. of Tokyo, Tokyo 113-8657　東京大学大学院農学生命科学研究科
***** 小林洋司　Emeritus Professor, The Univ. of Tokyo, Tokyo 113-8657　東京大学名誉教授

Under the 20 cm depth, the bulk density gradually increased by the first to the fifth passes. After fifth tractor passes, the bulk density was slightly affected any further by subsequent passes. The surface bulk density of undisturbed condition was 0.89 g/cm^3 and after the third, fifth and eighth pass, the bulk density increased to 1.08, 1.30, and 1.33 g/cm^3, respectively. The percentage of increasing in bulk density from undisturbed to the third, fifth, and eighth passes was 21.3, 46.1, and 49.4%, respectively.

In the Fig. 5, the soil hardness at the skid trail compared with those at the center and 50 cm from the side of trails. The result showed that the soil under the trail was more compacted than those under the center and 50 cm from the side of trails. The degree of soil hardness at the center was nearly the same with the 50 cm from the side of the trail and both of them increased slightly with the increase of the tractor passes. The bulk density at the center and 50 cm from the side of trails after tractor passes was higher than that at the undisturbed area. The percentage of increasing bulk density of the center and 50 cm from the side of trails from undisturbed to the eighth passes was 13.5% and 14.9 %, respectively.

The rut is the visual impact which directly can be seen after logging operation. In Fig. 6, it was recognized that the number of tractor passes influenced the rut formation. After the second passes, the average rut was 7.3 cm, and increased to 12.95 cm after eight passes. According to another research about the rut, the wider tires caused smaller ruts (5). The number of skidder passes was also the significant factor influencing the increasing of rut formation. Changes in rut profile could be a function of number of passes, soil type and tire size.

4. Conclusions

In the natural forest of Tokyo University Forest in Hokkaido, the bulk density increased with the increase of tractor passes. The bulk density increased until eight passes at least. It increased by 49 % from the undisturbed condition. The bulk density at the center and 50 cm from the side of trails also increased slightly with the increase of tractor passes. However, the bulk density under the trails was higher than the center and 50 cm from the side of trails. The cone index showed that the soil was compacted from the surface down to 50 cm depth. The trend of increase in soil hardness affected by the multiple pass could be explained by cone index even though some data were deviated. The crawler tractor D40A Komatsu with ground pressure 36 kPa created about 13 cm-depth ruts after eight passes on the sandy loam soil. The soil compaction needs attention in relation to the stand growth, especially for the natural regeneration. The next study should be conducted to find out the natural regeneration and seedling growth response in this site.

The rut is the visual impact which is easy to measure. If we find out the relationship between the rut and the physical condition of soil, we can easily identify the magnitude of soil compaction. This information will be used to restrict soil compaction impact on the site. In the future discussion, the rut formation will be examined with the physical condition of soil such as bulk density and cone index.

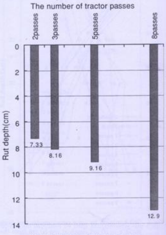

Fig. 6 Rut depth after tractor passes

Literature cited

(1) GAYOSO, J., and IROUME, A. (1991) Compaction and Soil Disturbance from Logging in Southern Chile. Annales des Sciences Forestieres (Paris) **48**(1) : 63-72.

(2) GJEDTJERNET, A.M.F. (1994) Forest Operation and Environmental Protection. Proc. of the International Seminar on Forest Operations Under Mountainous Conditions, Harbin, R. P. of China : 205-214.

(3) JUSHOFF, K. (1991) Effect of Tracked and Rubber-Tyred Logging Machines on Soil Physical Properties of the Berkelah Forest Reserve, Malaysia. Pertanika **14**(3) : 265-276.

(4) LIHAI, W. (1994) Effects of Skidding Traffic on Soil Properties and Growth Reduction of Seedlings. Proc. of the International Seminar on Forest Operations Under Mountainous Conditions, Harbin, R. P. of China : 205-214.

(5) MCDONALD, T.P., STOKES, B.J. and AUST, W.M. (1995) Soil physical property changes after skidder traffic with varying tire widths. Journal of Forest Engineering, **6**(2) : 41-50.

(6) SHISHIUCHI, M. and ADACHI, K. (1982) Influence of tractor logging on soil surface condition (I) Effect of soil compaction from tractors on the growth of planted Japanese larch seedlings. J. Jpn. For. Soc. **64** :136-142.

(2006年7月31日受付，2006年10月21日受理)