論　文

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Distribution and characteristic tree shapes of *Larix kaempferi* seedlings in Okutama Practice Forest of Tokyo University of Agriculture

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Abstract: *Larix kaempferi* is a woody plant of the genus *Larix* Pinaceae. It is only one native deciduous coniferous trees in Japan. *Larix kaempferi* is a strong intolerant tree and grows fast. It is also a pioneer species and invades bare areas such as ground covered by volcanic ash and gravel. The soil demand of *Larix kaempferi* is low, therefore, a colony of them is sometimes formed at sites with poor soil. However, it is rare to see the seedlings in the Okutama Practice Forest of Tokyo University of Agriculture (TUA). The distribution and characteristic tree shapes have yet to be clearly identified. Thus, this study focused on the seedlings of *Larix kaempferi* at 900 m above sea level around a forest road and surveyed the seedlings' distribution and characteristic tree shape. Results showed that 1 to 5-year-old seedlings of *Larix kaempferi* were distributed at bright sites (relative illuminance was 70 %) in the radius of 10 m from the *Larix kaempferi* stand. Seedlings were distributed on the soft ground (soil hardness: 0.5 kg / cm^2) among the gravel soil. The tree shape was mainly dwarf or creeping types, the leaves are 3 to 4 cm long, and T/R ratio was 1.5 on average.
Key-word: seedlings, soil hardness, Yamanaka soil hardness meter, tree shape, T/R ratio

東京農業大学奥多摩演習林におけるカラマツ実生の分布と特性

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要旨：カラマツ（*Larix kaempferi*）は，マツ科カラマツ属の樹木であり，日本に唯一自生する落葉針葉樹である。極陽樹で成長が早く，パイオニア樹木であり，裸地への初期侵入をする樹種の１つである。カラマツは土地の養分に対する要求度も低いため，他の樹木が成立できない立地条件において，群落が成立することがある。しかしながら，東京農業大学・奥多摩演習林内でその実生および群落を見ることは稀であり，その分布や樹形の変化などについてはあまり調べられていない。そこで本研究では，同演習林の標高 900 m 前後の作業道周辺に見られる，カラマツ実生の分布状況と樹形の特徴を調べた。調査の結果，相対照度 70%程度の明るい裸地の，石礫土壌の中でも土壌硬度の低い部分（0.5 kg/cm^2 前後）に多く分布し，矮性または匍匐型に近い樹形で葉長は 3～4 cm，T/R 率が低いことなどが明らかになった。
キーワード：実生，土壌硬度，山中式土壌硬度計，樹形，T/R 率

I Introduction

Larix kaempferi is a woody plant of the genus *Larix,* Pinaceae and it is only one native deciduous coniferous trees in Japan. *Larix kaempferi* is a strong intolerant tree and grows fast and is also one of the pioneer tree species and invades bare areas such as ground covered by volcanic ash and gravel (*1, 3, 4*). The soil demand of *Larix kaempferi* is low, therefore a colony of them can sometimes be formed at poor soil sites (*1, 3, 4*). However, it is rare to see seedlings in the Okutama Practice Forest of Tokyo University of Agriculture (TUA). The distribution and characteristic tree shapes have yet to be clearly identified. Therefore, this study focused on the seedlings of *Larix kaempferi* at 900 m above sea level around a forest road and surveyed the seedlings' distribution and characteristic tree shape.

II Materials and Methods

The survey plots were set at 900 m above sea level around a forest road in the Okutama Practice Forest of Tokyo University of Agriculture. The Okutama Practice Forest is located 650 to 1450 m above sea level in Okutama Town of Tokyo. The forest road was constructed in 2017. Forest tree species are mainly *Larix kaempferi* and the species *Quercus serrata* and *Quercus mongolia.* The average tree height was 17.8 (± 4.8) m, average branch height was 6.0 (± 1.2) m, average tree crown diameters were 4.4 (± 1.4) m, and the average DBH (diameter at breast height) was 26.6 (± 6.1) cm. The stand density of *Larix kaempferi* was 450 / ha. The survey plot was 50 m long and 25

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m wide (1,250 m^2) with 50 meshes (each mesh was 5 m×5m: 25 m^2) in the plot (Fig.1). The slope of the stand was approximately 17 degrees.

A Tokyo Koden illuminometer measured the relative illuminance (ANA-F11), hardness of the soil was measured by a Yamanaka soil hardness meter, and soil pH was measured by a TOA-DKK pH meter (IM-32P). The soil and stones were separated by a 2mm mesh sieve. The distribution condition of the *Larix* seedlings was also surveyed, along with the stand conditions, other present vegetation seedlings, and the characteristics of the seedlings' shape, which includes the length of the needles and the T/R ratio. Analysis of variance was used for relative illuminance of the seedling distribution and hardness of the sites. Correlation analysis and regression were also used to identify the relationship between the number of *Larix* seedlings and the soil hardness.

III Results and Discussion

Within the 5 meshes, 85 *Larix kaempferi* seedlings were found (Fig.1).

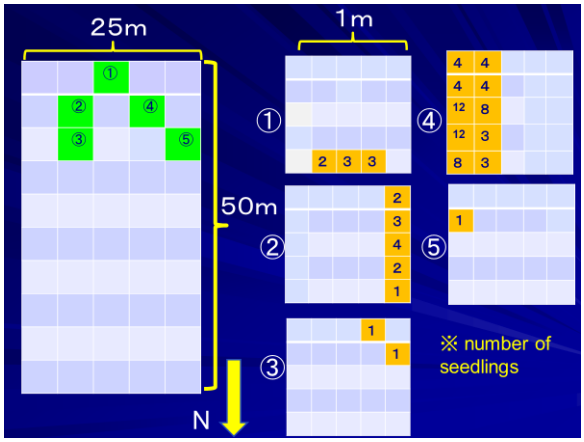

Fig.1 Surveying plots and number of seedlings

The seedlings were 1 to 5-years-old, suggesting these seedlings appeared after the forest road construction. The site conditions are described below.

1. Average relative illuminance Fig. 2 shows the average relative illuminance of the seedlings in the distributed sites. *Larix kaempferi* seedlings were found in bright places with more than 70 % relative illuminance. Tree crowns did not cover the sites. This shows that the relative illuminance was statistically higher than undistributed sites by analysis of variance ($p< 0.05$). However, the the number of seedlings and relative illuminance had no relation.

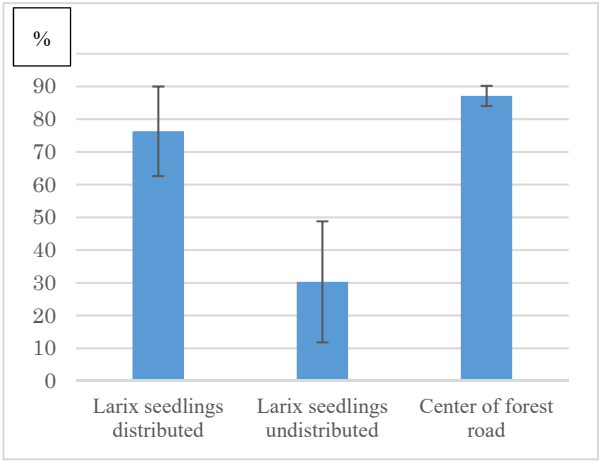

Fig. 2. Relative illuminance of the distributed and undistributed sites (%)

2 Site condition All *Larix kaempferi* seedlings were found on bare sites with gravel. Soil colors were bright (Mansell's pigment table:10 YR 5/6 - 6/6). The hardness of the soil was measured by a Yamanaka soil hardness meter; Fig. 3 shows the hardness of the sites. The average hardness of the sites where seedlings were found was 0.5 (± 0.4), sites with no found seedlings had a hardness of 3.8 (± 1.7), and the middle of the road was reported to be 11.5 (± 6.4). These results showed that the *Larix kaempferi* seedlings were distributed on softer ground, even when the site was composed of gravel. This shows that the soil hardness was statistically lower than the un-distributed sites by analysis of variance ($p< 0.01$). Fig. 4 also shows the number of *Larix kaempferi* seedlings and soil hardness. The relationship found between them was ($r= 0.7023$, $p< 0.01$).

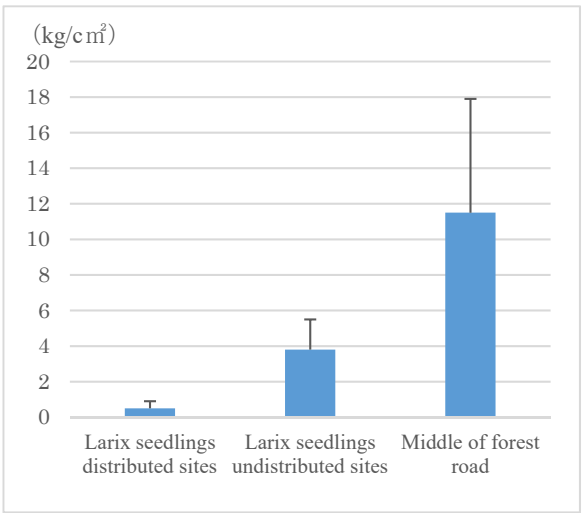

Fig. 3 Hardness of the sites (kg/cm^2)

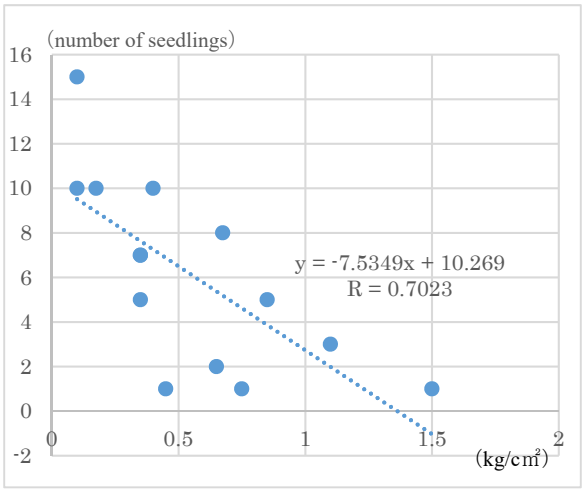

Fig. 4 Relation between the number of *Larix* seedlings and the soil hardness (kg / cm^2,　n= 85)

The average pH condition of the sites was 6.46 (± 0.3). The reason for this weak acidic soil condition might be affected by a B soil layer of clay soil coming to the surface by logging and the construction of the forest road. It has been reported that *Larix kaempferi* can survive on acidic soil, this result confirmed that *Larix* could survive on weak acidic soil. Average soil moisture was approximately 14%. This showed again that *Larix kaempferi* could survive in dry conditions. In addition, the weight ratio of soil and stones was 3 : 7.（Fig. 5）.

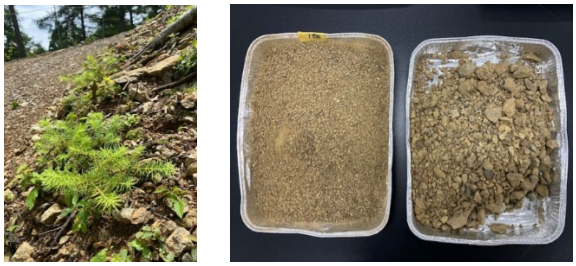

Fig.5 Site(left) and soil (right: soil and stone)

3.Vegetation In total, 20 woody plant species and 761 seedlings were found in the meshes where *Larix kaempferi* was found. Fig. 6 shows the appearance rate of other species. Some species had exogenous root bacteria or necose veins, such as *Acer*, *Carpinus*, and *Alnus*. Especially, *Clethra barvinervis*, *Acer rufinerve*, and *Carpinus laxiflora* were often found with *Larix*'s roots (Fig.7). Fig. 8 shows the rate of symbiosis with *Larix*'s root, and the symbiosis percentage of *Larix* seedling was found to be 27 %.

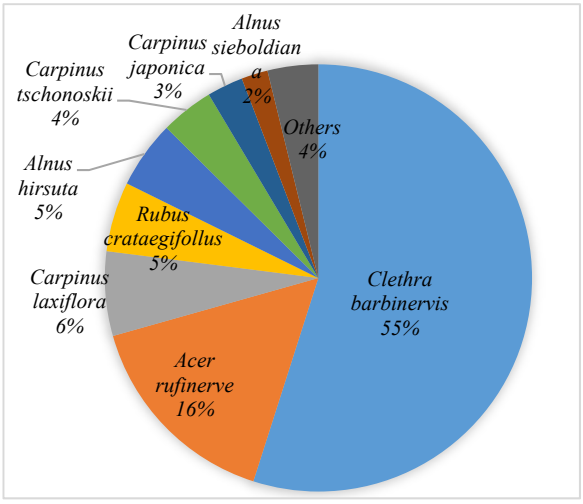

Fig. 6. The appearance rate of woody plants except for *Larix kaempferi* (n= 761)

Fig.7 Symbiosis of *Clethra barvinervis*, with *Larix*'s root

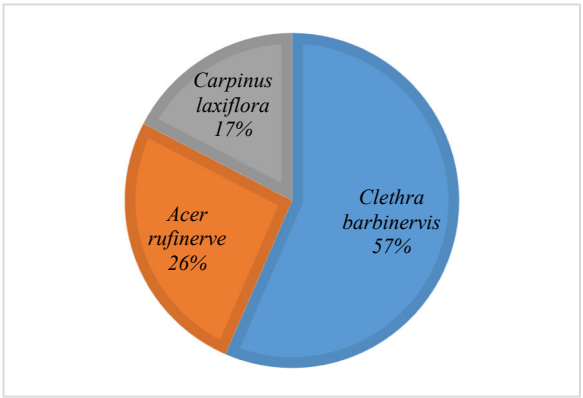

Fig. 8 The rate of species symbiosis with *Larix*'s root　(n= 23)

4. Tree shape Most of the seedlings' shape was dwarf or creeping types The average tree height was 12.8 (± 5.4) cm, and the average root diameter was 2.5 (± 0.7) cm. The average needle length was 3.1(± 0.8) cm (Fig. 9), with the needles growing in multiple directions.

Fig. 9 The leaves of *Larix* seedlings

There were two types of seedlings, one with long needles (4 to 5 cm-long) and one with short needles (2 to 3 cm-long). It is reported that the growth of pines varies significantly by the affection of mycorrhizal fungi (*2*). These differences in needle leaf length between individuals might be affected by mycorrhizal fungi (Fig.10)**.**

Fig. 10. 2 to 3cm-long leaves type (left) and 4 to 5 cm-long leaves type (right) of the *Larix* seedlings

Larix kaempferi has been regarded to have a shallow root system (*1*). However, the seedlings' root system was observed to be advanced with the average T/R ratio at 1.6 (± 0.5), and even the ordinary *Larix kaempferi* stocks' was 3 to 4 (Fig.11). More than 60 % of the seedlings were inflective in a right angle position, showing the ability to adapt to specific geographical features, like the slope of the terrain (Fig.12).

Fig.11 Advanced root system of the seedlings

Fig. 12 Seedling inflective in a right angle

IV Conclusion

This research showed the distribution of *Larix kaempferi* seedlings in the Okutama Practice Forest. They grow on the soft sites among gravel stands, and the root system was able to progress on the weak acid stand. The next step for this research is how to promote the growth and cultivation of *Larix kaempferi* by thinning.

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