Japanese larch, Larix leptolepis GORD., shows rather restricted areas of natural distribution in Central Japan, despite of its frequent use in forest plantations in northern temperate zone in Japan and in Europe. Artificial planting of this species in Japan started in 1874 using wild seedlings, which were soon replaced with nursery grown seedlings. Plantations of larch became more popular in northern Japan after the later half of 1880s, when nurserymen started active advertisement. It was reported that the first introduction of this species into Hokkaido was in the year 1880, and the first commercial export of seeds was also during the later half of the 1880s (Nakamura, 1925).

Although foresters had well recognized that natural distribution of Japanese larch was broken into several separate groups (Nii, 1929) and that the plants raised from seeds of different origins sometimes showed difference in their traits and plantation achievements (Anon., 1898), trials of provenance studies were seldom carried out in Japan. Only a plantation was established in 1928 at Siono at the foot of Mt. Asamayama, Nagano prefecture, by the efforts of research staffs of the Government Forest Experiment Station, and this plantation was formerly mentioned by Lindquist (1956). However, this plantation produced few reliable pieces of information, since it was designed without any replication. In 1934, managers of the state forests started numerous trial plantations of provenances of principal afforestation trees in Japan, consulting with the staffs of the Government Forest Experiment Station. Japanese larch was also included in this programme, but the share of this species was very limited reflecting the minor importance of it in Japanese man-made forests. In addition, replication in each plantation was not realized again in this time, and the management was soon abandoned during the difficult period of the wartime.

After the World War II, many western foresters and scientists were much interested in Japanese larch, and the following authors among them should be mentioned: Langner (1951, 1958), Schöberl (1953) and Schröter (1954). In 1955, Professor Langner of the Schmalenbeck institute planned a world-wide programme of Japanese larch provenance studies, and he requested the cooperation of the Japanese Government Forest Experiment Station in the procurement of the seeds of known origin. Although Japanese larch gives a lot of seeds every year in northern countries, it is not an easy job to harvest a good

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**The Provenance Trials of Japanese Larch Established in Japan and the Tentative Achievements**

By R. TODA1) and S. MIKAMI2)

(Received December 1976)

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1) The Government Forest Experiment Station, Meguro, Tokyo, Japan.
2) The Toohoku Forest Tree Breeding Station, Takizawa-mura near Morioka, Iwate, Japan.
Fig. 1. — Natural distribution of Japanese larch and the locality of registered provenances. ○ designates the provenance where seeds were not or hardly harvested, and □ designates the provenance where seeds were harvested but not sent to Germany (cf. Table 1).

Table 1. — Designated provenances (cf. Fig. 1)

<table>
<thead>
<tr>
<th>Registration number</th>
<th>Name of provenances</th>
<th>Long. (E)</th>
<th>Lat. (N)</th>
<th>Alt. (m. a. s. l.) (°C)</th>
<th>Mean annual temp.</th>
<th>Mean annual precip. (mm)</th>
<th>Age (yr)</th>
<th>Mean height (m)</th>
<th>Mean DBH (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mt. Manokamidake</td>
<td>140°30'00&quot;</td>
<td>38°05'55&quot;</td>
<td>1500</td>
<td>3.7</td>
<td>1400-1600</td>
<td>350-350</td>
<td>3.5</td>
<td>17.4</td>
</tr>
<tr>
<td>2</td>
<td>Osegahara</td>
<td>139°13'55&quot;</td>
<td>38°55'55&quot;</td>
<td>1410</td>
<td>3.7</td>
<td>1200-1700</td>
<td>16.8</td>
<td>4.2</td>
<td>31.2</td>
</tr>
<tr>
<td>3</td>
<td>Akabana</td>
<td>139°27'56&quot;</td>
<td>36°46'55&quot;</td>
<td>1360</td>
<td>5.5</td>
<td>2250</td>
<td>60</td>
<td>20.4</td>
<td>44.0</td>
</tr>
<tr>
<td>4</td>
<td>Nikko (Nikko)</td>
<td>139°27'56&quot;</td>
<td>36°47'55&quot;</td>
<td>1480-1500</td>
<td>6.8</td>
<td>2470</td>
<td>110</td>
<td>27.2</td>
<td>57.1</td>
</tr>
<tr>
<td>5</td>
<td>Yuyumbara</td>
<td>139°33'56&quot;</td>
<td>36°47'55&quot;</td>
<td>1700</td>
<td>7.3</td>
<td>2000</td>
<td>60-70</td>
<td>14.5</td>
<td>42.3</td>
</tr>
<tr>
<td>6</td>
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<td>36°39'55&quot;</td>
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<td>1800</td>
<td>90</td>
<td>21.2</td>
<td>46.4</td>
</tr>
<tr>
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<td>Oshiwa</td>
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<td>35°23'55&quot;</td>
<td>2350-2500</td>
<td>1.2</td>
<td>2500</td>
<td>80-60</td>
<td>3.6</td>
<td>22.8</td>
</tr>
<tr>
<td>8</td>
<td>Tenjin pass 1 Mt. Huzisan</td>
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<td>35°26'55&quot;</td>
<td>1320</td>
<td>6.2</td>
<td>1820</td>
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<td>16.6</td>
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<td>2866</td>
<td>70</td>
<td>19.2</td>
<td>36.9</td>
</tr>
<tr>
<td>11</td>
<td>upper Misunoto</td>
<td>138°26'35&quot;</td>
<td>36°25'55&quot;</td>
<td>2200</td>
<td>3.7</td>
<td>1300</td>
<td>200</td>
<td>20.0</td>
<td>35.3</td>
</tr>
<tr>
<td>12</td>
<td>lower Misunoto</td>
<td>138°29'36&quot;</td>
<td>36°24'55&quot;</td>
<td>1900</td>
<td>3.2</td>
<td>1890</td>
<td>60-70</td>
<td>14.0</td>
<td>34.7</td>
</tr>
<tr>
<td>13</td>
<td>Kimbake</td>
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<td>35°24'55&quot;</td>
<td>1400-1450</td>
<td>6.2</td>
<td>1400</td>
<td>100-120</td>
<td>22.4</td>
<td>38.6</td>
</tr>
<tr>
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<td>1700</td>
<td>4.3</td>
<td>1300</td>
<td>50-80</td>
<td>13.3</td>
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<td>Tadashima</td>
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<td>1430</td>
<td>140</td>
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<td>35°03'55&quot;</td>
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<td>50-70</td>
<td>20.0</td>
<td>35.3</td>
</tr>
<tr>
<td>17</td>
<td>upper Tatsumawa mountains</td>
<td>138°20'35&quot;</td>
<td>35°57'55&quot;</td>
<td>1750</td>
<td>6.1</td>
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<tr>
<td>18</td>
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<td>19.6</td>
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<tr>
<td>19</td>
<td>Inazao</td>
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<td>6.1</td>
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<td>60</td>
<td>18.7</td>
<td>41.0</td>
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<tr>
<td>20</td>
<td>Uniluito</td>
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<td>36°01'55&quot;</td>
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<td>1480</td>
<td>70</td>
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<td>35°57'55&quot;</td>
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<td>6.5</td>
<td>1360</td>
<td>40-50</td>
<td>16.6</td>
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</tr>
<tr>
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<td>21.8</td>
</tr>
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<td>23</td>
<td>upper Takasegawa valley</td>
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<td>36°24'55&quot;</td>
<td>2680</td>
<td>---</td>
<td>---</td>
<td>190</td>
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<td>1670</td>
<td>50</td>
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<td>5.0</td>
<td>2320</td>
<td>60-150</td>
<td>23.5</td>
<td>38.3</td>
</tr>
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<td>Mt. Hatomoriyama</td>
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<td>36°04'55&quot;</td>
<td>1920</td>
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<td>2300</td>
<td>100-120</td>
<td>18.5</td>
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<td>35°54'55&quot;</td>
<td>1380</td>
<td>6.9</td>
<td>2130</td>
<td>45-67</td>
<td>26.7</td>
<td>79.4</td>
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<td>28</td>
<td>Kiso-komagadake</td>
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<td>35°47'55&quot;</td>
<td>1800</td>
<td>3.2</td>
<td>2380</td>
<td>100-140</td>
<td>22.6</td>
<td>54.3</td>
</tr>
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<td>Kii-komagadake</td>
<td>137°13'35&quot;</td>
<td>35°45'55&quot;</td>
<td>1500</td>
<td>6.5</td>
<td>1720</td>
<td>60-80</td>
<td>17.8</td>
<td>30.8</td>
</tr>
<tr>
<td>30</td>
<td>Akiat-nosewadake</td>
<td>138°06'35&quot;</td>
<td>35°27'55&quot;</td>
<td>1900-2100</td>
<td>4.0</td>
<td>2840</td>
<td>130</td>
<td>20.2</td>
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</tr>
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amount of seeds of known origin in Japan, because heavy crops of larch seeds occur only with intervals of several years. Fortunately, in 1956, the larch seed crops were extremely heavy at almost all localities of natural larch forests. Under the guidance of Mitsuo Iwakawa, the principal forest geneticist by then, the forest geneticists of the Government Forest Experiment Station made efforts in designating noticeable provenances and collecting graft scions and seeds there (Fig. 1 and Table 1). Majority of collected seeds were sent to Germany, and from there they were distributed to all over the world by Langner (1958). The rest of seeds was distributed to several institutions in Japan and trial plantations were established (Fig. 2 and Table 2). Scions were grafted and the clonal materials are kept at three localities, Komoro, Morikota and Nopporo. Some quantities of scions were also sent to Langner and Schober.

A brief description on natural distribution of Japanese larch and the designated provenances

Hayashi (1951), who studied the natural distribution of Japanese conifers, concluded that the northern extreme of Japanese larch occurred at the Mt. Manokamidake, Miyagi prefecture, where longitude, latitude, and altitude were 140° 30' E, 38° 05' N and 1550 to 1580 metres above sea level. This is also the eastern extreme at the same time, and is a very much isolated provenance being remote from any other locality of larch stand. The population is very small and only fifteen wind-suppressed dwarf individuals were counted at the investigation made in May, 1976. All of these individuals were recently propagated vegetatively, for their clonal conservation.

Hayashi also described that the southern and western extremes were Mt. Tenguishima (138° 10' E, 35° 06' N, 1366 m.a.s.l.), Sizuoka prefecture, and Mt. Hakusan (139° 50' E, 36° 10' N, 1600—2200 m.a.s.l.), Ishikawa prefecture, respectively. However, the larch forest at Mt. Hakusan seems to have been lost already, because expeditions sent several times since 1956 have all failed to find it out. Therefore, the western extreme of present natural larch forests seems to be somewhere in the Hida mountains.

The localities of the principal natural forests are illustrated on Figure 1 after Hayashi (1951). Their occurrence is almost always at the altitude of 1400 to 1800 metres; on Mt. Huzisan (Fujj), however, larch trees occur as high as

Table 1. — Trial plantations of Japanese larch provenances established in Japan (cf. Fig. 2)

<table>
<thead>
<tr>
<th>Name and abbreviation</th>
<th>Region</th>
<th>Makeup of the plantation</th>
<th>Time of planting</th>
<th>Organisation responsible for the management</th>
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<tbody>
<tr>
<td>Asama A</td>
<td></td>
<td>25 4 144 lattice</td>
<td>Apr. 1959</td>
<td>Govt. For. Exp. Sta.</td>
</tr>
<tr>
<td>Huzisato H</td>
<td>Nagano</td>
<td>24 3 84 lattice</td>
<td>Apr. 1959</td>
<td>Govt. For. Exp. Sta.</td>
</tr>
<tr>
<td>Sintaka Sn</td>
<td></td>
<td>24 3 84 lattice</td>
<td>Nov. 1958</td>
<td>Govt. For. Exp. Sta., Kiso Branch</td>
</tr>
<tr>
<td>Kano K</td>
<td></td>
<td>16 3 120 lattice</td>
<td>Mar. 1962</td>
<td>Govt. For. Exp. Sta.</td>
</tr>
<tr>
<td>Odaiba Od</td>
<td>Aomori</td>
<td>20 3 60 randomised blocks</td>
<td>Apr. 1959</td>
<td>Oji Inst. For. Tr. Imp.</td>
</tr>
<tr>
<td>Essai E</td>
<td></td>
<td>25 3 126 lattice</td>
<td>Oct. 1959</td>
<td>Govt. For. Exp. Sta., Hokkaido Branch</td>
</tr>
<tr>
<td>Shimizu Sm</td>
<td>Hokkaido</td>
<td>19 3 126 lattice</td>
<td>May 1960</td>
<td>Govt. For. Exp. Sta., Hokkaido Branch</td>
</tr>
<tr>
<td>Minozato M</td>
<td></td>
<td>18 3 100 randomised blocks</td>
<td>May 1961</td>
<td>Hokkaido For. Exp. Sta.</td>
</tr>
<tr>
<td>Yamabe Y</td>
<td></td>
<td>20 1 220 line planting</td>
<td>May 1959</td>
<td>Univ. of Tokyo, Hokkaido Forest</td>
</tr>
</tbody>
</table>

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2500 metres of altitude, where they are completely suppressed by wind.

Thirty localities were designated as the representative provenances as shown in Figure 1 and in Table 1, covering almost whole range of larch distribution. Four provenances among them, however, supplied no or very few seeds because of poor crops in these stands. In each of other provenances, twenty to twenty-two individuals served as mother trees. Seed from one provenance, Huzisan-Sizuoka (No. 10), was not included in those sent to Germany but the reason is unknown). Thus the number of provenances distributed from Schmalenbeck was twenty-five in all, and each of them carried Schmalenbeck number, which is also shown in Table 1. However, in this article, we will refer to them by original Japanese numbers.

Graft scions were collected in all the thirty provenances, from ten ortets in each. The ortets were selected independently from the selection of seed trees. Only at the No. 1 provenance, Mt. Manokamidake, selected ortets were as few as three by then, but, later, all the individuals in this provenance were conserved as clones, as stated previously.

**Observations in the nurseries**

Phenological observations were chiefly made in the nurseries, and the variation in winter hardness was also recognized.

**Variation in the dates of bud opening**

Variation in bud opening dates was studied at Nopporo, Hokkaido, by Yanagisawa (1961). The number of open buds in comparison with the total number of buds was investigated several times during April 19 to May 23, and average percentages of open buds were calculated separately for apical buds and lateral buds. Apical buds opened slightly later but in close correlation with the opening dates of the lateral buds. There was a wide variation in the dates of bud opening among the provenances, but no correlation was found between this trait and the latitude or altitude of the localities of provenance. However, there was a slight correlation between this trait and the date of autumn colouring, which was, as stated later, significantly correlated with the latitude of provenances. Plants of the early opening provenances tended to change the needle colour into yellow in autumn later.

Provenances of early bud opening were No. 21 Mt. Kobusidake, No. 15 Yatugatake mountains-Tadesina, and No. 29 Mt. Kai-komagadake, while those of extremely late opening were No. 22 Mt. Rengedake, No. 19 Yatugatake mountains-Inago, and No. 3 Nikkoo-Akanuma.

**Autumn colouring of the foliage**

Yanagihara et al. (1961) reported their observations on the variation among provenances in dates of autumn colouring at the nurseries in Nagano prefecture. The dates of the initiation of colour change were investigated in 1957 and 1958, and the results were very parallel in the two succeeding years. However the difference between the earliest and latest provenances was six days in the first year, while it was thirteen days in the second year. The earliest colouring provenances were No. 3, No. 4 and No. 5 of the Nikkoo area, No. 6 Manza, No. 12 Mt. Assayama-lower Mizumoto, and No. 22 Mt. Rengedake, while the latest colouring provenances were No. 8, No. 9 and No. 10 of Mt. Huzisan, and No. 15 to No. 20 around Yatugatake mountains except No. 17 lower Tatsuawa. No. 21 Mt. Kobusidake was also included in the latest group. It is noticeable that the northern provenances are generally earlier in the initiation of autumn colouring.

The dates of the finish of colour change were studied only in 1957, and it was revealed that the early colouring plants tended to finish their colour change in a shorter period.

Izuka and Arai (1966) made the follow-up studies on this trait and confirmed that the tendency was not changed up to the seventh year in the plantations.

In Hokkaido, Yanagisawa (1961) studied the variation in the time of autumn colouring by the method of ranking at the standard days. The results fairly coincided with those reported by Yanagihara et al. (1961).

In 1968, Chiba and Nagata (1972) sowed stored seeds, which were retained from the original lots of provenance seeds, in Hokkaido, and studied the time of autumn colour change with the similar method to that of Yanagisawa (1961). The results well coincided with the two previous papers. Kurahashi et al. (1972) also confirmed that the tendency was not changed in the Yamabe plantation, at the tenth year after planting.

**Cessing of annual height growth**

Yanagisawa (1961), as well as Chiba and Nagata (1972), investigated the dates of ceasing of height growth, while Izuka and Arai (1966) studied the rates of seedlings carrying visible winter buds every four days during a certain period. They were all successful in revealing the differences among the provenances in the ceasing time of height growth and the close correlation of this trait with the dates of autumn colouring and further with the latitude of the provenances.

**Winter hardness**

Yanagisawa (1961) reported that there was a variation in the rate of shoot damages in winter among the provenances when the plants were out-planted in early autumn. This variation correlated with the earliness or retarding of growth ceasing, and the northern provenances were more healthy.

Unpublished data from the Kiso Branch of the Government Forest Experiment Station clearly show the variation in the susceptibility to early frost. On September 29, 1960, an early frost of four degrees C below zero attacked the seedlings of the twenty provenances in the sowing beds. The results are shown in Figure 3, and we can recognize the close correlation with the time of growth ceasing and with the latitude of provenances.

**Juvenile performance in the plantations**

Growth in the young stage, stem crookedness, branching habit, juvenile flowering, spiral grain of the wood, and the resistance against some diseases have been studied.

**Height growth**

Performances in some trial plantations in Nagano prefecture during the first few years were briefly reported by Yanagihara et al. (1961) and Izuka and Arai (1966). Later, Mikami (1971) summarized the results in the same plantations, Asama, Huzisato and Sintaka, being based on the tree height measurements of twenty-five provenances,
nine years after planting. In each plantation, he classified provenances into five categories, namely: "very good", "good", "normal", "poor" and "very poor", separated by the values m ± 2σ and m ± 3σ, where m and σ stand for the mean value and the standard deviation. Some provenances were recognized as "very poor" but no provenance was "very good" in these trials. He noticed that the following provenances were "superior" because they were "good" in two or more plantations and above average in the rest: No. 4 and No. 5 of Nikko area, No. 8, No. 9 and No. 10 of Mt. Huzisan, No. 19 and No. 20 around Yatugatake mountains, No. 21 Mt. Kobusidake, and No. 27 Mt. Ontake. Similarly, the provenances were assessed to be "inferior" when they were "poor" or "very poor" in two or more plantations and below average in the remaining ones. " Inferior" provenances were No. 6 Manza, No. 12, No. 13 and No. 14 of Mt. Asamayama, No. 26 Mt. Hatimoriyama, No. 28 Mt. Kiso-komagadake and No. 30 Mt. Akaisi-ossawadake.

In Hokkaido, Kishida et al. (1972) analyzed the data from three plantations, Nopporo, Simizu and Easai, up to ninth year since planting. Only the data of nineteen provenances were utilized because the other provenances were absent in some of the plantations. Analysis of variance showed the large variation among the trial plantations and replications, but less significant variation among provenances. The results of partition into categories "superior", "intermediate" and "inferior", by the similar method to that by Mikami (1971), were very variable year after year; generally speaking, provenances of Mt. Huzisan and around Yatugatake mountains were "superior" and those of Mt. Asamayama and from southern alpine regions were "inferior".

Chiba and Nagata (1972) reported the growth in the Otaru plantation at the tenth year after planting, where significant variation of growth due to provenance was observed. Briefly speaking, provenances of Mt. Huzisan and Nikko area were good in juvenile growth, and those of Mt. Asamayama and southern alpine areas were poor. Provenances of Yatugatake mountains and Kiso area were variable in their performance.

The Oodaira plantation in Aomori prefecture was seriously damaged by the needle cast and shoot blight diseases and had to be excluded from the materials of discussing growth (Chiba and Nagata, 1972).

Considering the seven trial plantations cited above, three in Nagano prefecture and four in Hokkaido, provenances being always better than average were No. 4 and No. 5 from Nikko area, No. 9 and No. 10 of Mt. Huzisan, No. 19 around Yatugatake mountains, and No. 21 Mt. Kobusidake. On the other hand, provenances always showing inferior results below average were No. 24 Takasegawa, No. 28 Mt. Kiso-komagadake, and No. 30 Mt. Akaisi-ossawadake.

Stem crookedness

Crookedness of a stem is a very important trait to be strictly avoided. Because there seemed to be a variation among provenances in this trait, an investigation was planned (Mikami, 1971). Plants were classified into three categories: straight, slightly crooked, and heavily crooked. Crookedness index was calculated for each provenance in each plantation, and the results are shown in Figure 4.

![Figure 4](image-url) - Crookedness index calculated in each provenance in plantations. The formula being

\[ \text{Index} = \frac{60 \times n_1 + 40 \times n_2 + 20 \times n_3}{n_1 + n_2 + n_3} \]

where \( n_1 \), \( n_2 \) and \( n_3 \) represent the number of straight, slightly crooked and heavily crooked trees, respectively.
Provenances of more straight stems, showing indices smaller than average in all of the three plantations were No. 3 from Nikkoo area, No. 6 Manza, No. 9, No. 9 and No. 10 of Mt. Huzisan, No. 13 and No. 14 of Mt. Asamayama, No. 23 Kamikooti, No. 27 Mt. Ontake and No. 30 Mt. Akasi-ooasawadake. On the other hand, those with more crooked stems were No. 17 from Yatugatake mountains, No. 26 Mt. Hati-moriyama, No. 28 Mt. Kiso-komagadake and No. 29 Mt. Kai-komagadake.

Kurahashi et al. (1972) studied the stem crookedness in the Yamabe plantation, in which they assessed the trait into four grades instead of three. The results showed that provenances of more straight stems were No. 3 and No. 5 from Nikkoo area, No. 6 Manza, No. 9 of Mt. Huzisan, No. 13 of Mt. Asamayama, and No. 16 and No. 19 around Yatugatake mountains, while those of more crooked stems were No. 17 from Yatugatake mountains, No. 28 Mt. Kiso-komagadake, and No. 29 Mt. Kai-komagadake.

It can be concluded that the crookedness and straightness of the stems are more dependent on heredity than on the specific environmental conditions at certain sites.

Branching habit and crown types

Izuka and Asai (1966) noticed that there were variations of the following items among the provenances or the groups of provenances: crown diameter; relative thickness of limbs; and the coarse or slender types of crown. Although they did not show the details of the study, they summarized that, in the Huzisato plantation, provenances from Mt. Huzisan and Mt. Kobusidake were generally provided with thinner branches and those on Mt. Asamayama with thicker ones. Percentage of coarse crown type was high in provenances of southern alpine areas and those of Mt. Huzisan, while it was extremely low in provenances from Nikkoo area. The last statement was also confirmed by Kurahashi et al. (1972) in the Yamabe plantation, Hokkaido.

Juvenile flowering

In the trial plantations in Nagano prefecture, only plants of Mt. Huzisan provenances (Nos. 8, 9, 10) bore flowers in some special cases that they were strangled by vines or suffered from root-rot caused by Armillaria mellea (F.) Quel. (Izuka and Asai, 1966; Mirami, 1971). Kurahashi et al. (1972) also noticed in the Yamabe plantation, that plants of Mt. Huzisan provenances (Nos. 8, 9, 10) significantly bore both male and female strobili and those from Mt. Asamayama provenances (Nos. 13, 14) did less abundantly.

Spiral grain of the wood

Japanese larch logs of smaller diameter show a serious defect that they significantly warp and twist when they are sawn and dried. This defect is due to the spiral arrangement of tracheids which is most significant in the annual sheaths near the trunk axis and gradually decrease in the outer sheaths. It is known that the intensity of warping is well correlated with the angle of spiral grain.

Mikami and Nagatsa (1974) studied the variation of spiral angles using thinned logs of twenty-five provenances from the Asama plantation and of ten provenances from the Kanoo plantation. There were significant variations among the provenances and the correlation between the two plantations was very high. Smallest angles were observed in the provenance No. 5 Nikkoo-Yasyuubara, and the largest were in No. 28 Mt. Kiso-komagadake, which showed extraordinarily large angles.

Susceptibility to some diseases and other damages

Needle cast disease, caused by Mycosphaerella larici-leptolepis Iro et Satto, and shoot blight disease, caused by Guignardia laricina (Sawada) Yamamoto et Iro, are the most serious ones among the biological infestations in larch plantations in Japan. Mirami (1971) summarized the observations in the plantations in Nagano prefecture, that the plants from the provenances No. 8, No. 9 and No. 10 of Mt. Huzisan, No. 13 and No. 14 of Mt. Asamayama, and No. 22 Mt. Rengedake were more resistant to needle cast disease, while the provenances No. 15, No. 16 and No. 17 of Yatugatake mountains, No. 29 Mt. Kai-komagadake and No. 30 Mt. Akasi-ooasawadake were more susceptible.

In the Oodaira plantation in Aomori prefecture, plants were badly damaged by both of the mentioned diseases, and the relative susceptibility of the plants from different provenances was investigated by Satto and his colleagues. Results of their studies were partly published in their own article (1971), while the unpublished data were cited by Chiba and Nagata (1972) from the informally circulated materials. The results can be summarized that provenances of No. 8, No. 9 and No. 10 Mt. Huzisan were the best resistant against needle cast disease, followed by No. 3 and No. 5 Nikkoo area, as well as No. 29 Mt. Kai-komagadake. On the other hand, provenances of Mt. Huzisan (Nos. 8, 9, 10) were extremely susceptible to the shoot blight, while the more resistant provenances were No. 3 and No. 5 Nikkoo area, No. 6 Manza, No. 14 Mt. Asamayama-Oiwake, No. 26 Mt. Hatimoriyama, and No. 27 Mt. Ontake.

Mizuno, (1973) studied the relative resistance against shoot blight in the Nopporo plantation, and the results generally coincided with Satto and others (Chiba and Nagata, 1972). Disagreement between them was considered as the influences of different environmental conditions.

In addition, Mirami (1971) made mention of relative susceptibility to Armillaria root-rot and to snow damages. He also noticed that No. 13 and No. 14 Mt. Asamayama, No. 20 Yatugatake mountains-Uminokuti, and No. 25 Kamikooti were more resistant to the root-rot, while No. 21 Mt. Kobusidake, No. 27 Mt. Ontake, No. 28 Mt. Kiso-komagadake and No. 30 Mt. Akasi-ooasawadake were more susceptible.

Snow damages were more frequently seen in the provenances No. 15, No. 16, No. 19 and No. 20 around Yatugatake mountains and in No. 26 Mt. Hatimoriyama, and they were less frequent in provenances of No. 3, No. 4 and No. 5 Nikkoo area, No. 6 Manza, No. 24 Takasegawa and No. 30 Mt. Akasi-ooasawadake.

General assessment

Considering these information items altogether, provenances from the Nikkoo area appear to be the best in the juvenile stage of the life cycle. Provenances of Mt. Huzisan are good in growth and resistant against needle cast disease, but they are very susceptible to shoot blight and also less hardy in winter. Provenances occurring at the southwestern alpine part of the distribution area appear to be less favourable ones for establishing plantations.

Genetic differentiation between provenances

Mikami (1973) studied the electrophoretic pattern of peroxidase isozymes in foliage of ten provenances at the Asama plantation, at the age of twelve years. Thirty individuals were sampled in each provenance. Fifteen isozyme bands were recognized in total, and individual trees were provided with four to ten bands. Differences were found among provenances in the average number of bands.
Table 3. — Indices of genetic differentiation between provenances based on peroxidase isozymes

<table>
<thead>
<tr>
<th>Provenances</th>
<th>Mt. Huzisan</th>
<th>Nikkoo</th>
<th>Manza</th>
<th>Mt. Asamayama</th>
<th>Mt. Rengegake</th>
<th>Takasegawa valley</th>
<th>Mt. Hatimoriyama</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sangoo-</td>
<td>Sizoo</td>
<td>Kootoku</td>
<td>Mianu-</td>
<td>Nage-</td>
<td>Takase-</td>
<td>Hatimori-</td>
</tr>
<tr>
<td>Mt. Huzisan</td>
<td>---</td>
<td>5.15</td>
<td>25.72</td>
<td>34.90</td>
<td>32.84</td>
<td>32.35</td>
<td>32.08</td>
</tr>
<tr>
<td>Sizoo</td>
<td>---</td>
<td></td>
<td>27.05</td>
<td>36.86</td>
<td>35.65</td>
<td>34.26</td>
<td>36.11</td>
</tr>
<tr>
<td>Kootoku</td>
<td>---</td>
<td></td>
<td></td>
<td>18.81</td>
<td>21.60</td>
<td>18.43</td>
<td>19.35</td>
</tr>
<tr>
<td>Manza</td>
<td>---</td>
<td></td>
<td></td>
<td>12.67</td>
<td>13.40</td>
<td>14.59</td>
<td>17.61</td>
</tr>
<tr>
<td>Mt. Asamayama</td>
<td>Mianu-</td>
<td></td>
<td></td>
<td>15.15</td>
<td>14.45</td>
<td>16.45</td>
<td>22.84</td>
</tr>
<tr>
<td>Kutekake</td>
<td>---</td>
<td></td>
<td></td>
<td>11.59</td>
<td>17.52</td>
<td>22.27</td>
<td>12.18</td>
</tr>
<tr>
<td>Oiwahe</td>
<td>---</td>
<td></td>
<td></td>
<td>13.76</td>
<td>27.19</td>
<td>10.88</td>
<td></td>
</tr>
<tr>
<td>Mt. Rengegake</td>
<td>---</td>
<td></td>
<td></td>
<td>27.50</td>
<td>18.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takasegawa valley</td>
<td>---</td>
<td></td>
<td></td>
<td>21.72</td>
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</tr>
</tbody>
</table>

per individual and the frequency of occurrence of each specific isozyme band.

An index of differentiation D was calculated for the paired combinations among the investigated provenances by means of the following formula:

\[ D_{jk} = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (X_{ij} - X_{jk})^2} \]

where N was total number of separate bands, and X_{ij} and X_{jk} were the frequency of i-th band in the j-th and k-th provenances, respectively.

The results are shown in Table 3, where we can see that two provenances of Mt. Huzisan are almost similar in their genetic nature, and the three provenances of Mt. Asamayama are not much different but not so similar to each other as the Huzisan provenances are. On the other hand, the largest differences are seen between the provenances Mt. Huzisan (Nos. 9, 10) and Mt. Rengegake (No. 22).

Conclusions

Japanese larch has only a minor importance in Japanese and European forestry, however, still it has a steady position in the man-made forests of northern temperate zone being not replaceable with other trees. Although its natural distribution is very restricted, regional variation in morphological traits and plantation performance has often been noticed in Japan. However, there have been various obstacles in Japan for establishing well-planned provenance trial plantations, so we are very much grateful to Professor Dr. W. LANGNER for his efforts taking the initiative of the provenance studies of this species. Without his efforts, we have probably had no opportunity to establish a network of trial plantations as such including so good a collection of provenances. At the same time, we ourselves are satisfied with and proud of the works done by us which were of the great assistance to the programme of LANGNER.

The trial plantations have already become over ten years of age, and various observations have been published. They are briefly reviewed in this article, and the following conclusions can be stated.

1. There are differences in phenological traits of seedlings and young plants among the selected provenances, and the variation is fairly related to the latitude of the provenances. This is important in relation to the cold and frost damages of the planting materials.

2. There are significant variations in responses to the diseases. Among the provenances studied, Mt. Huzisan provenances are the most remarkable ones in these traits, because they are the best resistant against needle cast disease while they are, at the same time, the worst susceptible to shoot blight. Provenances of the Nikkoo area are moderately or remarkably resistant against both of the two diseases.

3. Significant variation was also observed in the vigour of plant growth, but the juvenile growth cannot be relied on in relation to the final achievement at the rotation age. Therefore, too much attention should not be paid on this trait.

4. Miscellaneous traits, such as crown types, branching habit, straightness or crookedness of the stem, and the spiral grain of the wood, are also significantly varied among provenances. They cannot be dismissed in the practice of selecting provenances for commercial plantations.

5. As far as judged from the juvenile achievements in various traits stated above, the provenances from the Nikkoo area appear to be the best for plantations in Japan. However, this statement is only tentative, and may be revised by the future observations. The circumstances are the same for the statement that the provenances of southwestern alpine region are generally inferior to other provenances.

Summary

Natural distribution of Japanese larch and the selection of provenances for the study project planned by LANGNER are explained. Using the residual seeds of those sent to Germany, eleven trial plantations were established in Japan, and several authors reported their observations in them. Variation in phenological traits such as the dates of autumn colouring or cease of elongation is well correlated with the latitude of provenances except in the bud opening dates. This is very important in relation to the hardness of plants. Relative resistance and susceptibility to the two serious diseases also vary among provenances, and it is noticeable that the provenances of Mt. Huzisan (Fuji) are the most resistant to needle cast disease but, at the same time, the worst susceptible to shoot blight. On the other hand, those from the Nikkoo (Nikko) area are highly or moderately resistant to both of the two diseases. There are also variations among provenances in crown types, branching habit, stem straightness, and spiral grain of wood, which must be taken into consideration for the selection of planting materials. Of course, variation is also found in juvenile growth of the plants, but it cannot be relied on in relation to the final performance of them at the end of the rotation.

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Unterlagenwahl als Mittel zur Beeinflussung der Blüte und des Samenertrages bei Fichte

Von D. Krusche1) und G. H. Melchior2)

(Eingegangen November 1976)

Einführung

