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A Comparative Study on the Relationship between Tree Form and Volume in Stands of *Pinus koraiensis* and *Larix leptolepis*[1]

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잣나무와 落葉松林에 있어서 樹型과 材積間의 關係 比較[1]

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ABSTRACT

Noticed that large number of the Korean white pine (*Pinus koraiensis* S. et Z.) has lost its typical excurrent tree from by removal of apical shoot in the process of cone harvesting, the investigation and analysis for the species were made on the basis of the relationship among DBH, total height, merchantable height, and merchantable volume, compared with normally grown Japanese larch (*Larix leptolepis* Gordon). One hundred sample trees for each species were selected in the same aged stands for the study. Results have indicated that the pine has shown abnormal height growth pattern mainly by the disturbance of external artificial force. The pine's forked and/or crooked stems by the reason have led the result of less merchantable volume in the same DBH classes. Consequently, the pine would have undesirable tree form in terms of timber production, unless free from apical shoot disturbances. Considered to the merit of the Korean white pine that can produce timber and pine nuts, management alternatives for the pine stand were suggested to achieve maximum rate of return for the silvicultural investment.

Key words: tree form; merchantable volume; pine nut production; Pinus koraiensis; Larix leptolepis.

要 約

거다수의 잣나무가 잣을 收穫하는 과정에서 樹幹 頂端部의 인위적인 손상으로 말미암아 전형적인 잣나무 樹型을 잃게되는 점에 착안하여, 정상적으로 생육한 낙엽송과 비교하여 林木 諸形質들의 관계를 조사 연구하였다. 同齡級의 두 樹種을 비교한 결과, 잣나무는 頂端部의 切斷으로 인하여 정상적인 樹高生長을 못하고 있음을 알 수 있으며, 또한 심하게 分幹되거나 굴곡된 樹幹은 利用材積 값을 낮추는 결과를 초래하여 木材生産의 측면에서는 바람직한 樹型을 갖지 못하고 있었다. 그러나 잣을 收穫할 수 있고 用材를 생산할 수 있는 잣나무의 특성을 감안하여, 造林投資에 대한 回收率을 최대화하기 위한 잣나무 植栽林에 대한 經營的 代案을 제시하였다.

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INTRODUCTION

Form of a tree in a stand is controlled by the combination of inherent genetics and environment, and by the interaction between genetic and environmental factors. It cannot be explained by a single factor. Also it depends upon the characteristics of the species. Most coniferous species develop excurrent tree form, caused by the fact that the terminal leader grows more each year than lateral branches, producing a single undivided central stem and spirelike crown (Zimmerman and Brown, 1971). Although the Korean white pine, one of the major species used for reforestation in Korea, is naturally characterized by excurrent tree form, mechanical disturbance to the terminal leader in the course of cone harvesting process may create divided and/or crooked trunk, shifting from excurrent to deliquescent growth habit. We can practically observe these undersirable tree forms in Korean white pine stands subjected to pine nut production.

Chon and Noh(1983) have recognized that greater number of forked stems of Korean white pine had positive effect on the cone formation. However, as far as timber production concerns, they are not considered to be the ideotype. This is largely a function of translocation of carbohydrates made from photosynthesis, since more food goes toward the live crown where the bulk of the branches occurs, as well as toward cone formation. Furthermore, this type of stems usually reduce absolute merchantable height, producing less merchantable volume than normally grown trees with same DBH class.

The primary purpose of this study is to investigate relationships between DBH, total height, and merchantable height for the Korean white pine (*Pinus koraiensis* S. et Z.) of which apical shoot is often removed in the process of cone harvesting, and for the Japanese Larch (*Larix leptolepis* Gordon) which is normally formed without any external force. And, merchantable volumes of standing crops are to be examined for each species. Management alternatives are also discussed for Korean white pine stands in terms of pine nuts and timber production.

MATERIALS AND METHODS

The study was based on data from three Korean white pine plantations and two Japanese larch plantations in the Kangweon National University Experimental Forest located at Pukbang-Myun, Hongcheon-Gun, Kangweon-Do. All Plantations are even-aged stands and estimated to be 54 years old in 1985.

One hundred sample trees were randomly selected for each species by the use of random digit table. Diameter at breast height was measured for each tree with a diameter tape. Total and merchantable height measurement were taken to the nearest 0.1m with a Spiegel Relaskop. For the last usable portion of stems, merchantable height was tentatively determined to a minimum top diameter of 10cm for normally grown trees. And, for the considerably crooked and/or divided stems, especially of the Korean white pine, merchantable height was appointed to those abnormal positions.

The volume equation developed by Beers and Miller (1966) was employed to calculate the merchantable volume for each selected sample tree. Since the equation was originated by English unit, conversion has been needed to adjust metric system. However, the precision of the equation could be maintained by extension down the decimal point to reduce mathematical error.

Average values and standard deviation were calculated for DBH, total height, and merchantable height. Correlation was applied to compare and analyze interrelationships among DBH, total height, merchantable height, and merchantable volume.

RESULTS

Because of plantation differences in site conditions and silvicultural treatment, the comparison of growth rate between species has been avoided.

Table 1. Data of DBH, total height, and merchantanle height, by species*.

	DBH (cm)			Total ht.(m)			Merchantable ht. (m)		
	Range	X*	SD#	Range	X*	SD#	Range	X*	SD#
Pinus koraiensis	20.6–54.7	34.1	6.99	12.7–29.6	20.7	3.72	3.4–18.2	9.4	3.46
Larix leptolepis	17.5–46.7	28.3	5.76	14.4–34.3	24.0	4.00	10.0–24.1	17.4	3.19

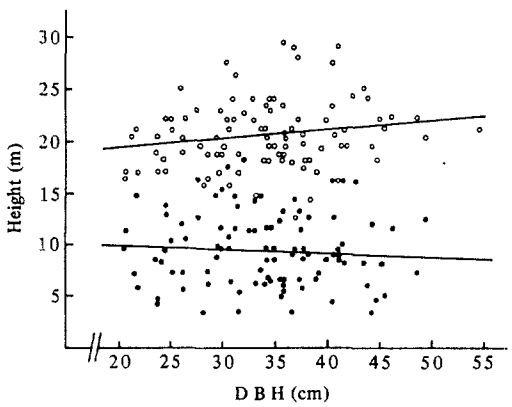
X*; mean
SD#; standard deviation
*; Since the study was not designed for statistical componison, significant differences between growth values could not be determined.

Main points were set on the form of trees based on the investigated growth value.

Table 1 shows data on DBH, total height, and merchantable height for selected trees by species. Even though the stands of Korean white pine have more standing crops per unit area than those of Japanese larch (Kim, 1986), the pine has shown greater diameter value than the larch. On the contrary, average tree height in the larch stands is greater than in the pine stands. The differences are remarkable, presented more than 3m and more than 7m for total height and merchantable height, respectively.

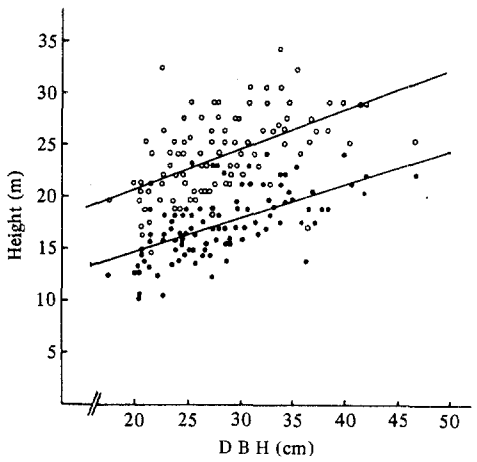
These results have indicated that a limiting factor has possibly existed in height growth of the Korean white pine, that is, trunks of the species are decisively forked and/or crooked by removal of apical shoot in the process of pine unt harvesting. This external artificial force does not conform to the common concept over close relationships between diameter and height. In the Korean white pine, the values of correlation coefficient for DBH vs. total height and DBH vs. merchantable height were calculated by 0.17 and -0.07, repectively, not showing significant correlation at α=5% level between them (Figure 1). This means irregular distribution of heights for corresponding DBH classes. Again, removal of apical shoot in pine nut harvesting have prevented the species from normal height growth.

By contrast, in the Japanese larch, the values of correlation coefficient for DBH vs. total height and DBH vs. merchantable height were calculated by



○ Total height; Y=17.89072 + 0.08193X (r=0.17)$^{N.S.}$
● Merchantable height; Y=10.62993 –0.03489X(r=-0.07)$^{N.S.}$
N. S.; not significant

Fig.1. The relationship between DBH and height in *Pinus koraiensis*.



○ Total height; Y=13.09092 + 0.38457X (r=0.55)**
● Merchantable height; Y=8.11099 + 0.32746X (r=0.60)**
**; significant, α=1%

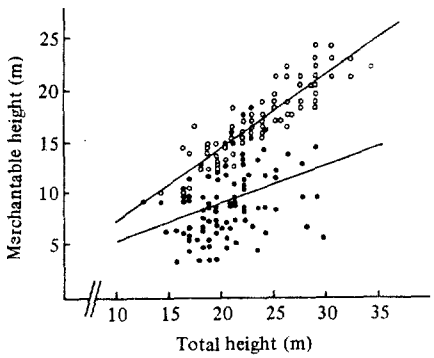
Fig.2. The relationship between DBH and height in *Larix leptolepis*.

0.55 and 0.60, respectively, showing significant correlation at α=1% level between them (Figure 2). The larger diameter the tree has, the greater total and merchantable height shows the tree proportionally. The species has typical coniferous characteristics, representing forms of straight bole and excurrent crown.

In the same total height class, average merchantable height of Japanese larch was taken much higher than that of Korean white pine. Table 2 shows applied ratio of merchantable height to total height and number of trees for each species. The range of the rario in the pine was 17.3–79.6%, and 78 trees out of 100 sample trees were fallen within 31-70% of application ratio. But, the range of the ratio in the larch was 59.9-93.2%. and 87 trees out of 100 sample trees were fallen within 61-80% of application ratio. Another point to be indicated is that the range of application ratio of the pine is more dispersed and has smaller number of trees, being comparative with the larch. We can obviously notice these correlationships through Figure 3. In the pine, quite low value of correlation coefficient (r=0.35) between total and merchantable height agrees with the aforementioned particular.

Table 2. Number of trees by application ratio of merchantable height to tatal height.

Application ratio	Number of trees	
	Pinus koraiensis	*Larix leptolepis*
11–20	5	–
21–30	11	–
31–40	24	–
41–50	24	–
51–60	15	1
61–70	15	36
71–80	6	51
81–90	–	11
91–100	–	1
T Total	100	100

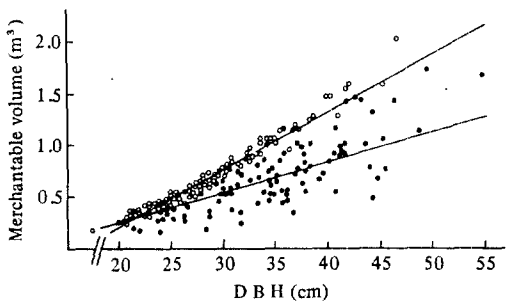


● *Pinus koraiensis*; Y=1.80845 + 0.36880X (r=0.35)**
○ *Larix leptolepis*; Y=0.47687 + 0.70402X (r=0.88)**
**; significant, α=1%

Fig.3. The relationship between total height and merchantable height, by species.

Compared with average merchantable volume between species based on the same DBH class, the Korean white pine has 0.35m^3 less volume per tree than the Japanese larch. The interpretation for the result can be mainly put on the relationship between DBH and merchantable height. In spite of greater average DBH, the pine has considerably smaller merchantable height than the larch (Table1), negatively influencing volume estimation. As DBH class increases, the difference of average merchantable volume per tree between species increases (Figure 4). It is also presumed that the disturbance to height growth of the pine has been continued by indiscreet cone harvesting from the time of seed production after juvernile period.

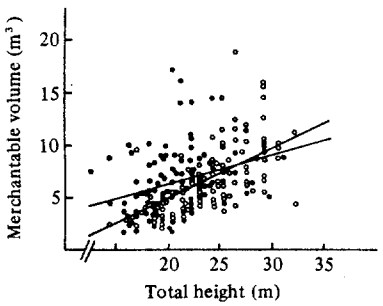
On the contrary, compared with average merchantable volume between two species based on the same total height class, the pine has 0.10m^3 more volume per tree than the larch. It is because



● *Pinus koraiensis*; Y=-0.32606 + 0.02890X (r=0.70)**
○ *Liarx leptolepis*; Y=-0.90192 + 0.05560X (r=0.95)**
**significant, α=1%

Fig.4. The relationship between DBH and merchantable volume, by species.

the pine has greater average DBH than the larch (Table 1), and the DBH is counted for major function to estimate the volume of a tree (Beers and Miller, 1966). As shown in correlations of Figure 5, until total height of two species reaches around 27m, despite of smaller merchantable height, the pine of which DBH is larger shows greater value of merchantable volume than the larch. However, it is noted that, after passing the diverging point, as trees get tall and DBH difference between two species becomes small,the larch of which merchantable height is superior produces more volume than the pine. Consequently, as stands get old, the pine with forked and/or crooked stem would continuously fall behind the larch in volume production.



• *Pinus koraiensis;* Y=0.04699 + 0.02918X (r=0.30)**
○ *Larix leptolepis;* Y=-0.52414 + 0.04984X (r=0.59)**
**; significant, α=1%

Fig.5. The relationship between total height and merchantable volume, by species.

DISCUSSION

Through comprehensive results of the study, we have noticed that the Korean white pine has been characterized by abnormal tree form and has produced less merchantable volume due to external artificial force. These circumstances could be considered in the management of Korean white pine stands for timber production. It is possible to make forest management alternatives for the confliction between timber production and pine nut harvesting.

Lee (1977) have found that the Korean white pine generally has straight trunk and excurrent crown in plantations or natural stands unless disturbed by external environmental forces. And, Yim et al. (1976) have reported that, when the pine stands reaches 15 years old, no matter which factor of DBH, height, or volume would be, we could have estimate hereafter growth rate from present growth. The actuality has made us to suggest practical ideas in the management of Korean white pine stands.

In these points of view, for the around 15-year-old Korean white pine plantation, we could have designate the whole stand or specific trees forehand in accordance with the management purpose of timber production or pine nut harvesting. We would restrain the height growth and induce forked branches as extremely as possible for the stand or trees primarily decided to harvest pine nuts, so as to maximize cone formation and minimize timber production. This is supported by the result of the research done by Chon and Noh (1983), which have noted that cone formation of the Korean white pine is mainly associated not with the height but with the number of branches. As another alternatives, we would prevent trees from damage of apical shoot and bring up straight bole as extremely as possible for the stand or trees primarily decided to produce timber, so as to maximize high quality timber production and minimize pine nut harvesting. Likewise, the pine stands would have been placed upon obvious management goal either pine nut or timber.

Furthermore, in order to make effective management planning for Korean white pine stands, more research will be needed to achieve maximum rate of return for the silvicultural investment. Economic evaluation for three alternatives 1) conventional method, 2) management mainly for timber, and 3) management mainly for pine nuts– can be suggested to make rational decision in forest management planning.

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