韓國林學會誌 79(4) : 431~434. 1990.
Jour. Korean For. Soc. 79(4) : 431~434. 1990.

Growth Phenology of various Tree Modules in *Pinus koraiensis* S. et Z. Plantation[1]

Joon Hwan Shin[2] and Don Koo Lee[3]

잣나무林에서 林木 生長 모듈들의 季節的 生育反應[1]

辛俊煥[2] · 李敦求[3]

ABSTRACT

The growth pattern of bud-shoot-needle of isolated 15-year-old trees, and seansonal changes in litter-falls and fine root dry weights in the unthinned 28-year-old plantation were investigated to understand the growth phenology of *Pinus koraiensis*. Shoot growth was continued by 7th June when buds appeared, while current needle growth was by 19th July when the bud growth started. Most of the litter-falls occurred in October but many of them were fallen in July and August due to storms. Fine roots were produced mostly in autumn (1,004 kg/ha), and were dead during winter (583 kg/ha) and spring (1,331 kg/ha).

Key words : *Growth phenology*, Pinus koraiensis, *shoot-bud-needle*, *fine root*.

要 約

잣나무의 季節的學 生長過程을 알아보기 위하여, 15年生 잣나무 孤立木의 눈(芽), 新梢, 針葉의 生長 패턴을 調査하였고, 間伐이나 枝打를 실시하지 않은 28年生 잣나무림의 落葉量과 細根量의 季節別 變化를 調査하였다. 新梢는 4月 12日부터 生長을 시작하여 6月 7日에 生長을 停止하였는데 이 때가 눈이 形成되는 時期이다. 新葉은 5月 10日 부터 生長을 始作하여 7月 19日에 生長을 停止하였는데 이 때는 눈이 伸張되는 時期였다. 落葉時期는 대부분 10月中이었으며 7月과 8月에도 폭풍우에 의하여 일부 落葉이 되었다. 細根의 生長은 가을에 大部分 이루어 졌으며(1,004 kg/ha), 細根의 枯死는 겨울(583 kg/ha)과 봄(1,331 kg/ha)에 大部分 發生하였다.

INTRODUCTION

Pinus koraiensis Sieb. et Zucc. grows in Korea, in the Amur and Maritime provinces of Russia (Mirov, 1967). *P. koraiensis* is known as a shade-tolerant tree at young stages, but gradually turns to be intolerant as it grows (Hyun, 1969 ; Kim, 1968). The trees start to bear cones at around 15-year-old, but do not produce the cones much until they are at about 30-year-old (Hyun, 1969). Because of both its nuts and timbers, *P. koraiensis* is one of the major tree species that have been widely planted in Korea.

Architectural approach may be useful in evaluating not only ecological growth process such as competition, differentiation and growth strategies but also silvicultural treatments such as pruning, thinning (Halle *et al.*, 1978). It was found that the architec-

[1] 接受 1990年 10月 10日 Received on October 10, 1990.
본 논문은 제19차 IUFRO 대회 발표 논문임.
[2] 林業硏究院 Forestry Research Institute, Seoul, Korea.
[3] 서울大學校 農科大學 College of Agriculture, Seoul National University, Suwon, Korea.

tural development of *P. koraiensis* conformed Rauh's architectural model(Halle *et al.*, 1978). In order to interpret this architectural process quantitatively, however, it is necessary that the phenology of such growth modules as bud-shoot-needle or fine roots must be expressed quantitatively. The growth phenology of the modules may markedly influence the tree architecture.

The objective of this study was to examine quantitatively the phenology of growth modules in *P. koraiensis* plantations.

MATERIALS AND METHODS

Three of 15-year-old *Pinus koraiensis* trees growing alone were selected, and their diamether and length of shoots at each whorl were measured in Suwon plantations weekly from April 12 to November 10, 1988. Five of 50cm by 50cm nylon screens(0.5mm mesh) were placed in the unthinned plantation of 28-year-old *P. koraiensis* and litter-falls were collected monthly from October 1987 to October 1988.

The amounts of fine roots distributed in a 30cm top soil were estimated from thirty sample cores(2cm in diameter) sampled in the same unthinned plantation as litter-falls were collected. Core samples were collected bimonthly from October 1987 to October 1988. In this study the fine roots were defined as unlignified roots less than 3mm in diameter and their associated root tips. The distinction between living and dead roots was made on the basis of the method that McClaugherty *et al.* (1982) used in a 53-year-old red pine stand.

		LIVE	
		Increase	Decrease
DEAD	Increase	P=ΔL+ΔD M= 0 C= 0	P=ΔL+ΔD M=ΔD or (-ΔL) C=(- L)- D
	Decrease	P=ΔL M= 0 C=(-ΔD)	P= 0 M=(-ΔL) C=(-ΔL)+(-ΔD)

Fig. 1. Decision matrix illustrating one method for estimating the production, mortality, and decomposition of fine roots. The appropriate quadrant was selected according to the direction of change in live (L) and dead (D) standing crop for the successive two samples. Production(P), mortality(M), and decomposition(C) were calculated from the successive biomass using the equations in a chosen quadrant.

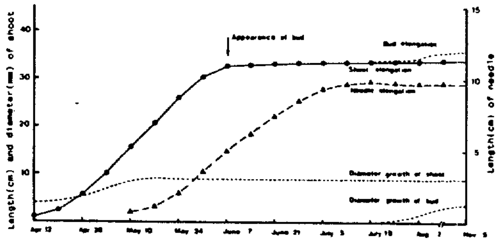

Fig. 2. Growth pattern of module(bud-shoot-needle) of 15-year-old *Pinus koraiensis* trees growing alone.

A decision matrix(Fig. 1) modified from the method described by McClaugherty *et al.* (1982) was used to estimate the total amount of fine root products.

RESULTS AND DISCUSSION

The overall seasonal pattern of module growth in the *Pinus koraiensis* tree was shown in Fig 2. Bud appeared on the top of shoot near 7th June in this study. It appeared at the end of shoot elongation and its expansion began with the cessation of needle elongation. Such phenomena may be controlled by innate developmental program of the tree(Kozlowski, 1971), and such pattern may be efficient to allocation in

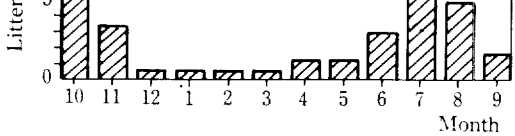

Fig. 3. Seasonal changes of litter-fall in the 28-year-old *Pinus koraiensis* stand.

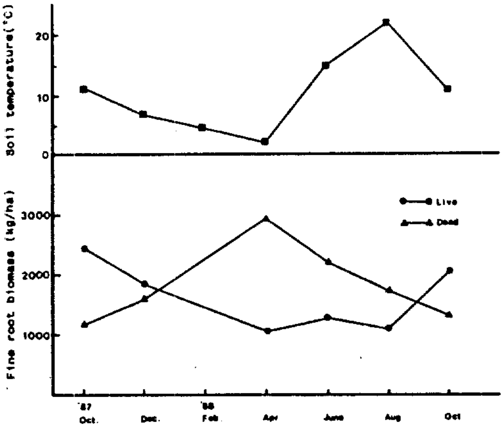

Fig. 4. Seasonal changes of fine root dry weights (kg/ha) and soil temperature at 15cm depth in the 28-year-old *Pinus koraiensis* stand.

limited nutrients for tree growth.

Most of the litters were shed during October(Fig. 3). Many litters fallen in July and August in this study were caused by storms and this abnormal litter-fall was also reported by Gwak(1986) in *Quercus mongolica* stand.

More living fine roots were found in autumn and early winter than dead ones, but in late winter, spring and summer, more dead fine roots were found than living ones(Fig. 4).

The results estimated from the decision matrix (Fig. 1) indicated that fine root biomss in the stand was produced mostly in autumn(1,004kg/ha), most of them were dead during winter and spring(1,914kg/ha) and decomposed mostly during summer(1,398kg/ha) (Table 1). The decomposition rate might be dependent upon soil temperature (Fig. 4) as Swift *et al*. (1978) reported.

Various phenological events of growth modules of *P. koraiensis* are shown in Figure 5. Most of the module growth started in spring and early summer. Kramer and Kozlowski(1979) reported that much energy was demanded during those seasons. However, the amounts of current needles which are energy sources, were the smallest during those seasons since they have not fully expanded and most of the needles also have fallen in previous autumn. Therefore energy for tree growth was insufficient in spring and early summer. In late summer and autumn when litters had not fallen yet(Fig. 3) after current needles had grown up to old needles(Fig. 2), energy for growth was not lacking in module growth. Surplus energy in this season may be supplied for cambial growth of stem(Brand and Janas, 1988) and for growth of fine roots (Table 1 and Fig. 5), and may be reserved for winter and next spring (Kramer and Kozlowski, 1979).

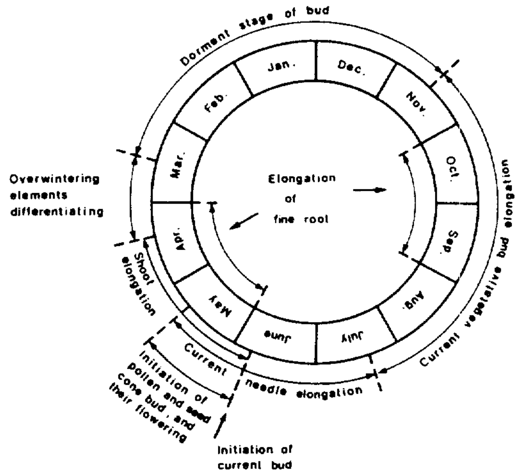

Fig. 5. Phenology of vegetative growth module, reproductive growth module, root growth module of *Pinus koraiensis* in Suwon, Korea.

CONCLUSION

Shoot growth was continued by 7th June while current needle was by 19th July. Bud appeared on the

Table 1. Amounts(kg/ha) of seasonal production, mortality and decomposition of fine roots in the 28-year-old *Pinus koraiensis* stand.

	Winter	Spring	Early summer	Late summer	Autumn	Total
Production	0	540	222	0	1004	1766
Mortality	583	1331	0	211	0	2125
Decomposition	155	0	721	677	421	1974

top of the shoot near 7th June when shoot elongation was ended, and its expansion began wih the cessation of needle elongation.

Most of the litter-falls occurred in October but many of them were fallen in July and August due to storms.

Fine roots were produed mostly in autumn(1,004 kg/ha), most of them were dead during winter and spring(1,914 kg/ha), and decomposed mostly during summer(1,398 kg/ha).

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