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Effects of Light Enviroment on Photosynthetic Rate and Chlorophyll Contents of Three Broad-leaved Species Growing in the Forest[1a]

Gab-Tae Kim[2]

林分의 光環境이 闊葉樹 3 樹種의 光合成率 및 葉綠素 含量에 미치는 影響[1a]

金甲泰[2]

ABSTRACT

To seek for proper regeneration methods with under-planting, Photosynthetic rate and chlorophyll contents of three broad-leaved species seedlings, *Kalopanax pictum*, *Fraxinus rhynchophylla* and *Cornus controversa*, were measured and compared between growing sites, below the canopy of *Larix kaemferi* and open land in the forest. Nursery stocks was planted in open nursery in the forest in late April, 1997, and under-planting below the canopy of *Larix kaemferi* was conducted in late April, 1998. This experiment examined the relationships between shade-tolerance and physiological response to different light environment by tree species. To adapt the shade environment, leaves of *Kalopanax pictum* might be increased the more chlorophyll contents and photosynthetic ability than other species. From these results, shade-tolerance of the tree might be ordered *Kalopanax pictum*, *Fraxinus rhynchophylla,* and *Cornus controversa*.

***KEY WORDS : SHADE-TOLERANCE,* KALOPANAX PICTUM, FRAXINUS RHYNCHOPHYLLA, CORNUS CONTROVERSA**

요 약

이 연구는 큰 나무 아래 어린 나무를 심어(수하식재) 새로운 숲을 가꾸는 방법(임분갱신법)을 찾고자 낙엽송 간벌지에 음나무, 물푸레나무 및 층층나무 묘목을 1998년 봄에 수하식재한 것과 이웃에 위치한 동일한 묘령의 임간포지에서 생육하는 개체들과의 엽록소함량과 광합성율을 2000년 7월에 측정 · 비교하였다. 이는 식물종에 따른 광량에 대한 적응력 차이(내음성)를 생리학적으로 확인하고자 시도하였다. 낮은 광도에 적응하기 위하여 음나무 잎은 다른 수종들에 비하여 보다 많은 엽록소함량과 광합성능을 증가시키는 반응을 보였다고 판단된다. 이러한 결과로 보아 내음성은 음나무, 물푸레나무, 층층나무의 순으로 낮아지는 것이라 판단된다.

주요어 : 내음성, 음나무, 물푸레나무, 층층나무

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2 College of Life Sci. and Nat. Resources, Sangji Univ, Wonju(220-702), Korea(gtkim@sangji.ac.kr)
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Introduction

The forests of Korea had been severely degraded from the time of Japanese occupation to the World War II and during the Korean War. During these periods, average stock volume decreased from about 100m^3/ha in early 1900 to 10.6m^3/ha in 1960(Korea Forest Service:KFS,2000) To rehabiliate deforested area, the Korean Government iniated massive reforestation with fast-growing trees, nut trees and exotic species and hybrids such as *Larix kaemferi, Pinus rigida, Populus species, Alnus* species, Robinia pseudoacacia. Reforestation was implemented from 1959 to improve soil conditions and control erosion, which resulted to the rehabilitation of about 97.4% of deforested area by 1999(KFS,2000).

Large-scale plantation produced certain problems such as simple stand structure and species composition. Much emphasis was placed on the revegetation of deforested land, supply fuelwood and erosin control within a short period: several exotic trees were massively planted(Lee *et al*, 2001). This treatment made forest ecosystems monotonous and simplified and less productivity of the ecosystems. Recently, the restoration approached by native species is becoming on of main issues in forest ecosystem management and may cotribute to the improvement of forest enviromental condition(Urbanska *et al*, 1997) Ashton *et al*(1998) suggested under planting with testing the feasibility of using *Pinus* as a nurse for establishing more shade-tolerant species; and as a technique for forest restoration in south and southeast Asia. On the other hand, Ammer *et al*(2002) report that direct seeding of deciduous trees below the canopy of conifer stands has proven to be a very economical methods for converting pure stands into mixed stands.

In Korea, many investigations dealing with natural regeneration of conifer plantations(Lee and Lee,2002; Lee *et al*, 2001) and natural broad-leaved forests(Lee *et al*, 1999) have been conducted, but sound and practical solutions are not found. Therefore, direct seeding and under planting are suggested as another methods for regeneration of conifer plantations and natural broad-leaved forests.

Trees in the forest have effected various environments such as light intensity, temperature, soil nutrients and water relations(Kimmins,1999). Growth of trees has been represented by interaction of these environmental and genetic characteristics. Many studies have reported that different light intensities in the forest change chlorophyll contents and photosynthesis in many coniferous and broad-leaf tree species, and the changes of these physiological parameters have attributed to changes in growth such as height, diameter and leaf production (Bjorkman and Holmgren,1963; 1966; Lee and Woo,2000). Chlorophyll contents in the leaf is a sensitive indicator of photosynthtic energy conversion. It is one of the important tree features and functions in any effort to understand shading effects on tree growth because it is positively related to photosynthtic ability in trees (Kramer and Kozlowski,1979; Gutschick,1988).

Therefore, the objective of this study was to seek for proper regeneration methods with under planting, photosynthetic rate and chlorophyll contents of three species, *Kalopanax pictum*, *Fraxinus rhynchophylla* and *Cornus controversa*, were measured and compared between growing sites, below the canopy of *Larix kaemferi* and open land in the forest in July 2000.

Materials and Methods

1. Study sites and plant materials

To seek for proper regeneration methods with under-planting, study sites of under planting and open lands are selected in thinned *Larix kaemferi* forest and nursery in the forest at Mt. Joongwang in Pyeungchang-gun, Kangwon-do. Major environmental factors of study sites are shown(Table 1). Environmental conditions of

Table 1. Major enviromental factors of the study sites

Growing site	Altitude (m)	Slope direction/gradient(°)	Relative light intensity(%)	Soil moisture	Soil depth (cm)	Amout of weeds
Nursery in the forest	900	S/ 4～5	100	moderate-wet	30	a few
Thinned *L. kaemferi* forest	900	S/ 4～5	20～40	moderate-wet	25	less dense

two sites located near by are similar to each other.

Study sites 'thinned *L. kaemferi* forest' located at Mt. Joongwang, 900m altitude is artificial forest conducted 2nd thinning in 1997. In this forest, soil has deep profile and wet condition, and ground covers are less developed. Study sites 'Nursery in the forest' was established in the same 'thinned *L. kaemferi* forest' in 1997. Soil texture and moisture contents might be similar between two study sites located near by. Soil texture of two is sandy loam with relatively wet and high fertility.

One-year-old nursery stocks of three species - *Kalopanax pictum*, *Fraxinus rhynchophylla* and *Cornus controversa*- were transplanted on the nursery in the forest for under-planting in the late April, 1997. After hardening during one year, a lot of two-years-old nursery stocks of three species were under-planted on thinned *Larix kaemferi* forest in the late April, 1998, and some of the nursery stocks remained on the nursery in the forest. Two-years later, 5-years-old nursery stocks for each sites were tested in this study. Studied sites were managed to only several weed-controls and brush-cuttings.

2. Measurement of photosynthetic rate and chlorophyll contents

Photosynthetic rate of *L. fischeri* leaves for each growing sites are measured by Portable Photosynthesis System(LI-6400; LI-COR) on July 14-16th, 2000. Light is supplied by LED light source(LI-COR)with light intensity 1,000(PAR μmol $m^{-2}sec^{-1}$), and CO_2 concentration is not adjusted artificially. Measurement of photosynthetic rate was conducted 4 times per trees , 4 trees for each species.

Chlorophyll contents of three hardwood species for each study sites are measured by Chlorophyll meter(SPAD-502, Minolta). Measurement of Chlorophyll contents was conducted 5 times per trees , 4 trees for each species. This methods measured total chlorophyll contents indirectly.

3. Satatistical analysis

The significance of differences in means of photosynthetic rates and chlorophyll contents among the study sites were evaluated with one-way ANOVA. All statistical analyses were conducted using the SPSS(version 10.0).

Results and Discussion

1. Comparison of chlorophyll contents be tween growing sites for each species

Total chlorophyll contents were significantly different between the growing sites(Table 2). For all species, leaf chlorophyll contents of the under-planted seedlings growing in the thinned *L. kaemferi* forest were higher than those growing in open nursery in the forest. These results might be similar to the report(Logan and Krotkov,1969). These trends might be caused by adaptation to low light intensity.

The chlorophyll contents of *Fraxinus rhynchophylla* in the open nursery was the highest 35.79 units(SPAD), followed by *Cornus controversa*, and that of *Kalopanax pictum* in the open nursery was the lowest 27.77 units(SPAD). The chlorophyll contents of *Kalopanax pictum* below the canopy of *Larix kaemferi* was the high-

Table 2. Mean values of chlorophyll contents of three species Broad-leaved Seedlings by the growing sites

Growing site (relative light intensity)	Chlorophyll contents (SPAD)		
	Kalopanax pictum	*Fraxinus rhynchophylla*	*Cornus controversa*
Nursery in the forest(100%;A)	27.77	35.79	33.09
Thinned *L. kaemferi* forest(20-40%; B)	42.05	42.01	34.95
Total Mean	34.91	38.90	34.02
F-values	71.47**	11.90**	1.88*
The gap between growing sites (B-A)	+14.28	+6.22	+1.86

** and * indidcate significances at 1% and 5% significant, respectively

Table 3. Mean values of photosynthetic rates of three species Broad-leaved Seedlings by the growing sites

Growing site (relative light intensity)	Photosynthetic rate (μmol CO_2 $m^{-2}sec^{-1}$)		
	Kalopanax pictum	*Fraxinus rhynchophylla*	*Cornus controversa*
Nursery in the forest(100%;A)	11.14	12.46	12.34
Thinned *L. kaemferi* forest(20-40%; B)	9.29	9.41	7.52
Total Mean	10.22	10.94	9.93
F-values	2.91NS	6.59*	24.07**
The gap between growing sites(B-A)	-1.85	-3.05	-4.82

** and * indidcate significances at 1% and 5% significant, respectively

est 42.05 units(SPAD), followed by *Fraxinus rhynchophylla*, and that of *Cornus controversa* below the canopy of *Larix kaemferi* was the lowest 34.95 units(SPAD). This results are same trends to the the report(Kim, P.G. and E.J. Lee, 2001); shade leaves have more chlorophylls than sunny leaves. The gap of total chlorophyll contents between the growing sites was the largest value +14.28 SPAD in *Kalopanax pictum*, and the smallest value +1.86 in *Cornus controversa*. In *Kalopanax pictum*, to adapt the shade environment, leaves of *Kalopanax pictum* might be increased the more chlorophyll contents than other species.

This results mean that *Kalopanax pictum*, have more shade-tolerant than other species. From these results, shade-tolerance of the tree might be ordered *Kalopanax pictum*, *Fraxinus rhynchophylla*, and *Cornus controversa*.

2. Comparison of photosynthetic rates between growing sites for each species

Photosynthetic rates of *Fraxinus rhynchophylla*, and *Cornus controversa* were significantly different between the growing sites, and that of *Kalopanax pictum* was not significantly different between the growing sites(Table 3). In general, photosynthetic rates of the leaves growing in the thinned *L. kaemferi* forest were lower than those growing in open nursery in the forest. Photosynthetic rate of *Fraxinus rhynchophylla* in the open nursery was the highest 12.46 (μmol CO_2 $m^{-2}s^{-1}$), followed by *Cornus controversa*, and that of *Kalopanax pictum* in the open nursery was the lowest 11.14 (μmol CO_2 m-$^2s^{-1}$). Photosynthetic rate of *Fraxinus rhynchophylla* below the canopy of *Larix kaemferi* was the highest 9.41 (μmol CO_2 m-$^2s^{-1}$), followed by *Kalopanax pictum*, and that of *Cornus controversa* below the canopy of *Larix kaemferi* was the lowest 7.52 (μmol CO_2 m-$^2s^{-1}$). This results are same trends to the the report(Kim, P.G. and E.J. Lee, 2001 ; Choi *et. al.*, 2000 ; Kim *et. al.*, 2000); sunny leaves have more photosynthetic ability than shade leaves. Photosymthetic rates of this study 7.5 - 12.46(μmol CO_2 m-$^2s^{-1}$) are similar to the values 4.7 - 17.5 reprted by Choi *et. al.*(2000). The gap of photosynthetic rates between the growing sites was the largest value -4.82 (μmol CO_2 m-$^2sec^{-1}$) in *Cornus controversa*, and the smallest value -1.85 (μmol CO_2 $m^{-2}sec^{-1}$) in *Kalopanax pictum*. In *Kalopanax pictum*, to adapt the shade environment, leaves of *Kalopanax pictum* might be increased the more chlorophyll contents and photosynthetic ability than other species. These results might be similar to the report(Logan and Krotkov,1969); Intraspecific differences in the ability of photosynthetic apparatus to adapt to low light intensity is related to the differences in shade-tolerance.

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