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Thinning Intensity for Large Diameter Trees in Korean White Pine Plantation of South Korea

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Abstract

The purpose of this study is to analyze the effect of thinning intensity on the growth of large diameter trees in Korean white pine (*Pinus koraiensis* S. et Z.) plantation. Eight thinning plots were analyzed by categorizing into heavy thinning, light thinning, no thinning (control) according to thinning intensity. As a result, average DBH increased more in heavy thinning plots than in light thinning or unthinned plots. The number of large trees (DBH>25 cm) were obviously shown the most in heavy thinning plots. It is considered that heavy thinning is needed for the production of the large diameter trees.

Key Words: heavy thinning, light thinning, no thinning, DBH, Korean white pine

Introduction

In Korea, Korean white pine (*Pinus koraiensis* S. et Z.) has been planted in 440,000 ha as a representative commercial tree species since 1960s (Korea Forest Research Institute 2012). At present, *P. koraiensis* plantation accounts for 18.7% of the coniferous plantation area in Korea (Korea Forest Service 2016). *P. koraiensis* plantation should be sustainably managed for wood production, and thinning is required because *P. koraiensis* plantation is mostly distributed in age class IV (Bae et al. 2010).

In general, thinning improves site productivity, diameter growth of residual trees, and production at stand level (Nyland 1996). Also, thinning increases production of large diameter trees and improves wood values through qualitative improvement of wood (Smith 1986). For these reasons, thinning researches to produce large diameter trees have been proceeded through permanent monitoring plots in developed countries (Burkhart and Bredenkamp 1989; Amateis and Burkhart 2005).

In Korea, thinning studies of *P. koraiensis* had conducted through permanent monitoring plots, but were not continued for major tree species. In the past, several researchers have studied about growth by thinning method (Kim et al. 2004; Lee 2003). Also, studies on growth monitoring through repeated measure were conducted (Choi and Choi 1998; Choi and Choi 1999; Choi et al. 2003; Kang et al. 2004). Some researchers were studied about the initial diameter growth and environmental factors according to thinning (Hwang et al. 2008; Bae et al. 2010).

However, studies on the production of large diameter trees by thinning intensity are not sufficient for *P. koraiensis*. Therefore, the objective of this study is to analyze how the number of large diameter trees by thinning intensity changes

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over time.

Materials and Methods

Study areas and plot design

The study area is located in *P. koraiensis* plantation in the Research Forest of Kangwon National University, Gangwon province, South Korea (Choi et al. 2014a). Trees in this stand was planted in 1977 with 3,000 seedling per hectare and stand age is 40 year in 2017. In order to study thinning effect, the eight permanent plots were established in 1996, and each plot size is 0.04 ha with 20 m×20 m, respectively (Choi 1996).

First thinning was operated at the time of establishing the plots with the consideration of qualitative and quantitative thinning (Choi 1996). Thinning intensity ranged from 20-59% based on basal area, and the control plots were maintained with no thinning (Table 1). Overall status of the stand condition was reported by Choi et al. (2014a) in detail. For this study, 8 plots were grouped by categorizing 3 treatment groups based on the thinning intensity of basal area: heavy thinning treatment group (53-59%), light thinning treatment group (20-32%), unthinned treatment group (0%).

Tree inventory and analysis

Thinning plots were investigated four times: 1996, 2001, 2008, and 2014 (Choi 1996; Choi and Ji 1998; Choi et al. 2001; Choi et al. 2010; Choi et al. 2014b). All the trees were labelled and tree location were collected in XY coordinate system with measuring tape. DBH (Diameter at breast height) was measured at 1.2 m above ground and marked for re-measuring every time (Choi et al. 2014b). Tree height was investigated using Vertex-IV. For growth analysis, buffer zone was computed and outliers were excluded to prevent external effect other than thinning.

Table 1. Thinning intensity and residual trees in 1996

Treatment	Plot	Thinning percentage (%)		Residual trees (N/plot)
		Basal area	No. of trees	
Heavy	A	59	69	26
	B	53	59	48
Light	C	32	46	38
	D	28	44	41
	E	25	31	58
	F	20	29	52
Control	G	0	0	77
	H	0	0	98

Results and Discussion

Average growth by thinning intensity over time

Stand growth was summarized by thinning intensity treatment over time (Table 2). Average DBH was not different among thinning intensities right after thinning at age 19. However, average DBH of heavy thinning treatment was 2.6 cm larger than unthinned treatment at age 37. Average height was not clearly different between thinning intensity at both age 19 and 37. Dead trees were occurred the most in unthinned treatment over time. Thus, the number of residual trees was similarly maintained over time in heavy thinning treatment, but evidently decreased in unthinned treatment.

The growth in heavy thinning treatment of this study was compared with the Standard Manual of Forest Resource Management by KFRI (Korea Forest Research Institute 2005). When compared with silvicultural method of the large diameter log goal, DBH of this study in 24 yr was 1.8 cm higher than DBH of KFRI in 25 yr. Also, the DBH in 37 yr was 2.1 cm higher than DBH of KFRI in 35 yr

Table 2. Growth change of DBH and height by thinning intensity

Year (Age)	Treatment	Average DBH (cm)	Average height (m)	Stand density (N/ha)
1996 (19)	Heavy	13.5	9.5	1,056
	Light	13.4	9.3	1,605
	Control	13.5	9.2	3,009
2001 (24)	Heavy	17.8	11.1	1,043
	Light	16.8	11.1	1,605
	Control	16.5	10.8	2,378
2008 (31)	Heavy	21.6	13.3	1,043
	Light	19.7	13.1	1,556
	Control	19.2	12.7	1,916
2014 (37)	Heavy	23.1	16.1	1,013
	Light	21.1	15.4	1,465
	Control	20.5	15.1	1,731

Table 3. Growth comparison of Korean white pine plantation between our study and Korea Forest Research Institute (KFRI 2005)

Our study[a)]				KFRI[b)]			
Age (yr)	DBH (cn)	Height (m)	Trees (N/ha)	Age (yr)	DBH (cn)	Height (m)	Trees (N/ha)
19*	13.5	9.5	1,056	25*	16	10	800
24	17.8	11.1	1,043	35*	21	16	400
31	21.6	13.3	1,043	60*	30	21	250
37	23.1	16.1	1,013	90	45		250

[a)]Growth of heavy thinning plot, [b)]Growth by standard manual for large diameter tree (DBH > 45 cm).
*Thinning treatment age.

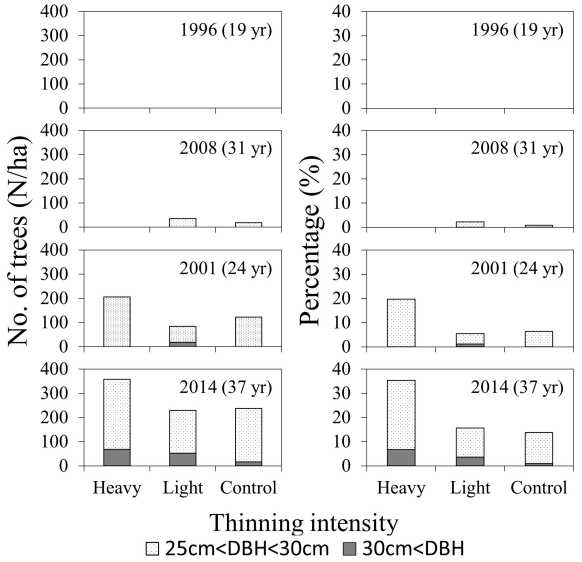

Fig. 1. Appearance of large diameter trees by thinning intensity over time.

(Table 3). The DBH growth is higher in this study, considering the number of residual trees.

Large timber by thinning intensity over time

The large diameter trees (DBH > 30 cm) and candidates (25 cm < DBH < 30 cm) were compared calculating the number of trees per hectare by thinning intensity (Fig. 1). No large diameter tree candidates were appeared in all plots at age 19. A few large diameter tree candidates were shown at age 24:36 trees/ha in light thinning treatment and 18 trees/ha in unthinned treatment.

The trees with DBH > 25 cm in heavy thinning plot was more than in light thinning and unthinned treatment at age 31. The number of the trees in heavy, light, and no thinning treatment were 205, 85, and 123 trees/ha, respectively, with 19.7%, 5.4%, and 6.4%.

The number of the trees with DBH > 25 cm of heavy thinning treatment were differentiated from light and no thinning treatment at age 37, while it was not different between the light and no thinning treatment. The number of the trees were 358, 230, and 238 trees/ha, respectively, with 35.4%, 15.7%, and 13.8% at age 37. Also, the number of large diameter trees (DBH > 30 cm) was the most in heavy thinning treatment at age 37. It is considered that heavy thinning treatment is appropriate to produce large diameter trees.

Conclusion

This study was performed to figure out the thinning intensity to produce large diameter trees in Korean white pine plantation. For this study, DBH growth change was compared and the number of large diameter trees were analyzed by thinning intensity treatment through 4 time measurements. As a result, the DBH growth was higher in heavy thinning treatment than in light thinning or unthinned treatment. When compared with Standard Manual by KFRI, DBH of heavy thinning treatment in our study was similar to large diameter trees in Standard Manual of KFRI.

The number of large diameter trees (DBH > 30 cm) and candidates (25 cm < DBH < 30 cm) was analyzed by thinning intensity over time. Large diameter trees and candidates were clearly observed at age 31. The number of large diameter trees was the most in heavy thinning treatment. However, the number is not clearly different between light thinning treatment and unthinned treatment. Therefore, it is judged that heavy thinning is needed for large timber production. Overall, this study is expected to be used as a

reference for thinning intensity and time of *P. koraiensis* plantation in South Korea.

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