Fundamental Studies on Pruning II*

Effects of pruning on stem growth (1)

By

Takao FUJIMORI[1] and Osamu WASEDA[2]

Summary: The effects of pruning on stem growth and its methodology were examined on several *Cryptomeria japonica* and *Chamaecyparis obtusa* experimental stands, whose ages were around 10-year-old at the beginning of the experiment. The indication of pruning intensity was examined by comparing (1) the ratio of pruning height to the tree height and (2) the ratio of pruning length in a crown to the crown length with (3) the ratio of removed leaves to the whole leaves (fig. 9, 10). From the result of this examination, it was concluded that the ratio (1) cannot be used as the indication for pruning intensity, and the ratio (2) could be used as an approximate indication. But it might be desirable to use the ratio of removed leaves to the whole leaves as the indication for the precise examination.

The degree of pruning intensity and the reduction of the diameter growth had a close relationship both in *Cryptomeria japonica* and *Chamaecyparis obtusa* (fig. 1, 2). The degree of pruning intensity and the reduction of the height growth had also a close relationship in *Cryptomeria japonica*, but in *Chamaecyparis obtusa*, this relationship was not clear (fig. 3, 4).

The relationship between the ratio of removed leaves to the whole leaves, and the reduction rate of the stem growth through all the experimental stands was demonstrated as given in fig. 7. According to this, the efficiency of leaf-bearing branches to the stem growth varies from upper to lower strata in *Cryptomeria japonica*, but it does not vary evidently in *Chamaecyparis obtusa*. On this graph, any relationship between pruning intensity and the reduction rate of the stem growth could be obtained so far as the stands like these experimental stands are concerned. Finally, the criteria of the efficiency of leaf-bearing branches to the stem growth were examined.

Introduction

The authors have been making several examinations on pruning as the basic research to establish a technical system of pruning. As one of them, the examination to clarify the effects of live crown removal on stem growth has continued since 1968 on several stands of *Cryptomeria japonica* (Sugi) and *Chamaecyparis obtusa* (Hinoki) whose ages are around 10-year-old at the time this examination was begun. We report in this paper the results obtained so far.

In general, the purposes of pruning are regarded as follows:

1. Production of good quality timber.
2. Distribution of sunlight to the understoreys.
3. Prevention of disease, fire, and others.

---

* Contributions from JIBP-PT No. 118

Received September 30, 1971

(1)(2) Silviculture Unit, Silviculture Division, Kansai Branch.

4. Control of tree growth.
5. Improvement of forest condition for the efficiency of work.

Among these, this research is primarily focussed on pruning for the production of good quality timber. But at the same time, the results of this experiment will be utilized for the prunings for other purposes. Knotless lumber is supplied by producing large size timber in one way, and knotless squared lumber for poles and pillars can be also supplied from relatively young and small size timber by careful pruning management. In this case, tree size and excution time of pruning must be carefully determined in accordance with the size of salable objective timber.

But at the same time, extreme care must also be taken in regard to botanical law, i. e., the effects of pruning on stem growth in this case. Primary purpose of this examination is based on this viewpoint.

Another important purpose of this paper is to discuss the methodology of this kind of experiment. Although many reports about the effects of pruning on stem growth have been published, the indication of pruning intensity is not always the same, which is a disadvantage when comparing the data from each of them. In this examination, the ratio of removed leaves to whole leaves was adopted as the indication of pruning intensity. And the relationships between the ratio of removed leaves to whole leaves, and the ratio of pruning height to tree height or the ratio of pruning length in a crown to the crown length in different stand densities were compared.

The data of this paper is limited to the definite region and growth stage, but the accumulated data of this kind of study will contribute to more advanced study, and the organization of them will produce the foundation for a technical system of pruning.

The authors wish to acknowledge considerable assistance from the Forestry Section of Kyoto City Administrative Authorities, Forest Owners Association of Ujidawara-Cho, Mr. Yoshio Seto, Mr. Shoichiro Fujii and Mr. Kiyoshi Nishikawa, who offered their own forests for this experiment, and the staff of Forest Division in Kyoto Prefecture Administrative Authorities, who helped us in many ways.

Method and experimental stands

Cryptomeria japonica and *Chamaecyparis obtusa* which are most extensively planted in Japan, excluding Hokkaido Island, were chosen as the experimental species in this experiment. Four *Cryptomeria japonica* and two *Chamaecyparis obtusa* experimental stands were chosen around Kyoto City. Stand statistics at the time this experiment was started are presented in table 1. The site conditions of the experimental stands were equally good and the stand ages were almost the same——around 10-year-old, but the stand densities were considerably different——from 2, 700/ha to 4, 500/ha. Accordingly natural stem clear lengths were different, too; at the beginning of our investigation, the experimental stands of *Cryptomeria japonica* in Betsho and Ogose had not yet begun natural stem clearing, while in other experimental stands natural stem clearing had already advanced.

In each area, experimental stand was laid out, then it was divided into several plots, where the pruning of various intensities were carried out. At that time, extreme care was taken to ensure that the conditions, especially tree size of each plot, was the same as much as possible in each experimental stand. The number of experimental trees in each plot was from 10 to 67 (average 36). Each treatment was replicated a second time. The conditions of the experimental plots just after the treatment are presented in table 2.

At the same time of pruning operation, several sample trees were chosen in proportion to the frequency distribution of the diameter at breast height (this is hereafter abbreviated as D. B. H.) and the tree height from one of the experimental plots which includes about 50 trees. But from the experimental stands in Betsho and Ohara, owing to the convenience of the forest management, only one sample tree of average size was chosen respectively (table 2). Then sample trees were cut down and divided into vertical strata of 50 cm from base to tip, and tree components such as leaves and branches were measured within each of the stratum. Small samples of respective tree components were taken to the laboratory for stem and branch ring analyses and for oven drying (80°C). The ratio of removed leaves to whole leaves in each experimental stand was estimated from the result of the plot where the leaf amount was directly measured with the method above mentioned. In this paper, tree height, D. B. H. and other length units were expressed with the mean value in each experimental plot, and weight unit was expressed with the dry weight value per ha or per ha. 0.5 m, which was calculated by the following equation:

$$y=y' \ G/G'$$

where y, y', G and G' represents the total weight per ha, of sample trees, the total basal area in ha and of sample trees, respectively.

The establishment of the experimental stands and the first periodical measurement were made in the autumn of 1968 and the pruning operation was carried out in the early spring of 1969. Since then, the measurement of tree height and D. B. H. of all the experimental trees has been taken every year. In this paper, stem volume was roughly approximated with D^2H, where D and H expresses D. B. H. and tree height, respectively. The effects of pruning on stem growth were expressed with the growth of D, H and D^2H during two years after pruning. Exact measurement of stem volume growth shall be made at the final measurement of this experiment in future.

Table 1. Statistics of the experimental stands at the time of beginning the experiment (Autumn of 1968)

Species	Area of experimental stand	Height above sea level (m)	Site quality	Tree age (year)	Stand density (no/ha)	Mean D. B. H. (cm)	Mean tree height (m)	Mean clear length (m)
Cryptomeria japonica (Sugi)	Betsho	650	Good	9	2,700	8.9	5.3	0.3
	Ogose	750	Good	10	2,800	7.7	5.6	0.3
	Obuse	600	Good	10	4,300	8.1	6.1	1.0
	Ujidawara	250	Good	9	4,500	8.0	6.7	1.7
Chamaecyparis obtusa (Hinoki)	Ohara	350	Good	14	3,400	8.4	6.3	1.6
	Ujidawara	250	Good	9	3,900	7.5	6.0	2.0

Table 2. Treatment in the experimental stands

Species	Area of experimental stand	Experimental plot number	Extent of pruning: Height of pruning (m)	Percentage of pruning height, length and weight to whole: Pruning height	Pruning length in crown	Removed leaves
Cryptomeria japonica (Sugi)	Betsho	1 2 3	control 1.5 2.5	0 29 48	0 24 44	0 48 73
	Ogose	1 2 3 4 5	control 1.5 2.0 2.5 3.5	0 27 36 45 63	0 23 32 42 60	0 35 51 64 87
	Obuse	1 2 3	control 2.2 3.5	0 36 57	0 24 49	0 22 53
	Ujidawara	1 2	control 3.5	0 52	0 36	0 38
Chamaecyparis obtusa (Hinoki)	Ohara	1 2 3 4	control 2.0 2.7 3.5	0 32 43 56	0 9 23 40	0 7 17 41
	Ujidawara	1 2	control 3.5	0 58	0 38	0 32

Table 3. Growth following pruning

Species	Area	Plot number	Percentage of removed leaves to whole leaves	Values at the time of: *H* (m)	*D* (cm)
Cryptomeria japonica (Sugi)	Betsho	1 (control) 2 3	0 48 73	5.23 5.26 5.23	8.91 8.92 8.92
	Ogose	1 (control) 2 3 4 5	0 35 51 64 87	5.62 5.48 5.51 5.53 5.40	7.65 7.66 7.63 7.65 7.70
	Obuse	1 (control) 2 3	0 22 53	6.11 6.36 6.24	8.13 8.13 8.13
	Ujidawara	1 (control) 2	0 38	6.73 6.42	8.01 8.01
Chamaecyparis obtusa (Hinoki)	Ohara	1 (control) 2 3 4	0 7 17 41	6.30 6.30 6.11 6.15	8.37 8.38 8.50 8.38
	Ujidawara	1 (control) 2	0 32	6.11 6.05	7.48 7.41

Number of experimental tree in each plot	Number of analyzed trees
44 36 35	1
58 29 47 22 16	8
22 21 24	4
67 67	6
15 13 17 10	1
70 67	6

Result

The progress of stem growth after pruning operation is presented in table 3.

Diameter growth of *Cryptomeria japonica*

As is evident in fig. 1, the degree of pruning intensity and diameter growth reduction have a close relationship. Pruning at Ujidawara was not so intensive as to show any difference in the growth between treated and control plot.

Diameter growth of *Chamaecyparis obtusa*

The result is almost the same as that of *Cryptomeria japonica* (fig. 2).

Height growth of *Cryptomeria japonica*

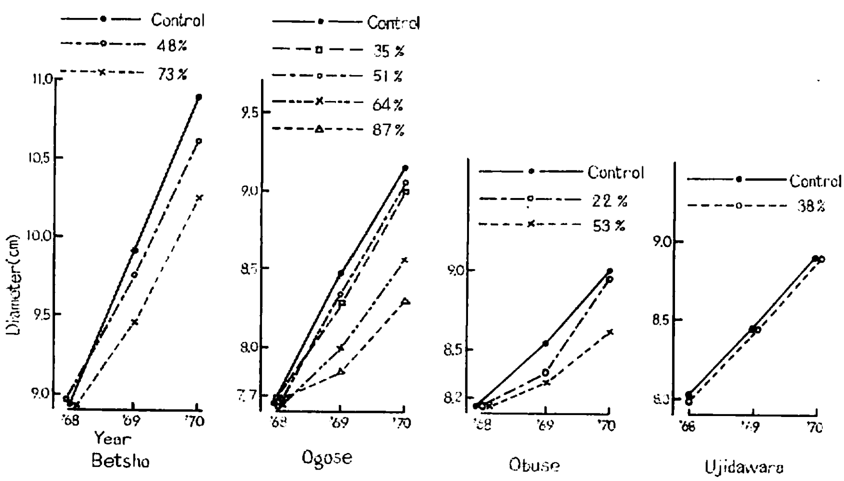
The tendency in the relationship between the degree of pruning intensity and height growth reduction is almost the same as that of diameter growth in *Cryptomeria japonica* (fig. 3).

Height growth of *Chamaecyparis obtusa*

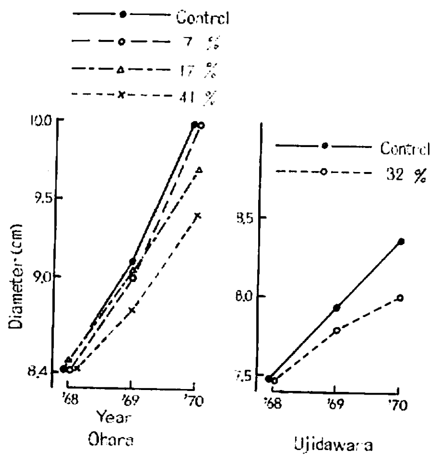
As shown in fig. 4, the effect of pruning on height growth is not so evident, although the diameter growth of *Chamaecyparis obtusa* is obviously affected by the same pruning intensity.

in the experimental stands

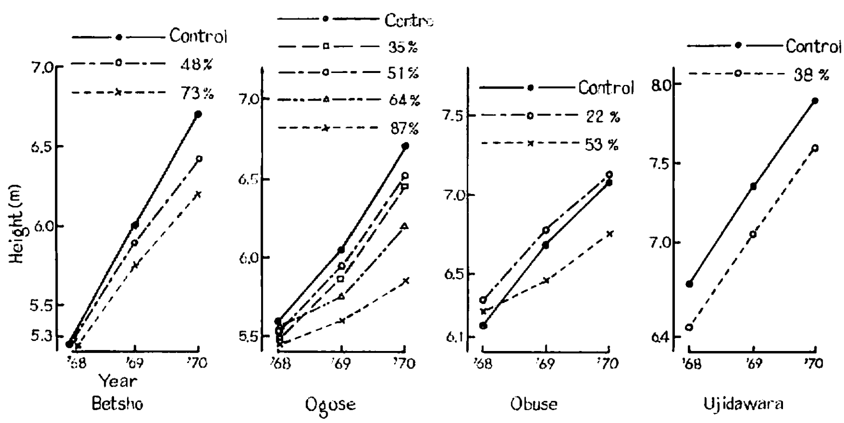
treatment	Annual increment following the treatment					
D^2H	1			2		
($cm^2 \cdot m$)	H (m)	D (cm)	D^2H ($cm^2 \cdot m$)	H (m)	D (cm)	D^2H ($cm^2 \cdot m$)
433 437 428	0.77 0.61 0.54	1.00 0.83 0.53	177 145 104	0.73 0.55 0.46	0.99 0.86 0.80	217 165 140
340 323 337 340 327	0.60 0.38 0.59 0.38 0.32	0.81 0.62 0.71 0.35 0.16	119 78 109 55 36	0.48 0.60 0.44 0.29 0.12	0.69 0.72 0.61 0.58 0.44	119 124 104 85 51
443 438 433	0.56 0.43 0.21	0.42 0.23 0.19	92 42 36	0.42 0.37 0.33	0.43 0.60 0.30	91 114 63
440 427	0.62 0.67	0.41 0.42	90 92	0.55 0.53	0.38 0.39	93 93
450 452 453 439	0.65 0.75 0.57 0.71	0.73 0.66 0.62 0.44	135 136 118 106	0.65 0.41 0.72 0.41	0.88 0.88 0.56 0.58	185 102 140 108
359 340	0.60 0.56	0.46 0.30	86 69	0.64 0.66	0.40 0.41	96 90



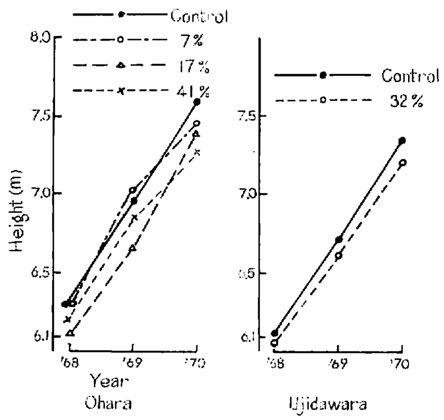
Pruning intensities are expressed by the percentage of removed leaves.
Fig. 1　Diameter growth of *Cryptomeria japonica* experimental stands.



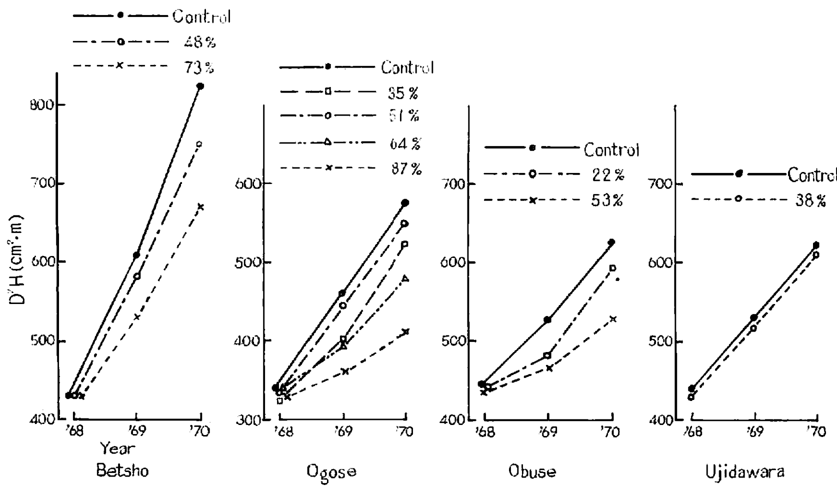
Pruning intensities are expressed by the percentage of removed leaves.
Fig. 2　Diameter growth of *Chamaecyparis obtusa* experimental stands.



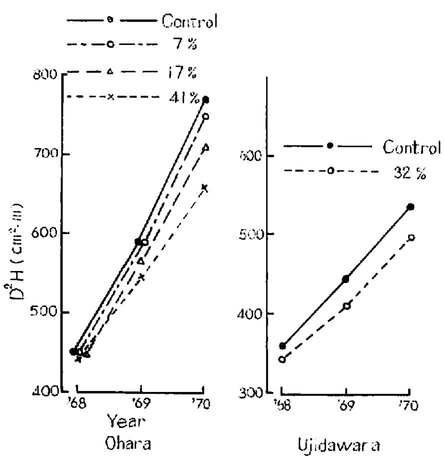
Pruning intensities are expressed by the percentage of removed leaves.
Fig. 3　Height growth of *Cryptomeria japonica* experimental stands.



Pruning intensities are expressed by the percentage of removed leaves.
Fig. 4 Height growth of *Chamaecyparis obtusa* experimental stands.



Pruning intensities are expressed by the percentage of removed leaves.
Fig. 5 D^2H growth of *Cryptomeria japonica* experimental stands.



Pruning intensities are expressed by the percentage of removed leaves
Fig. 6 D^2H growth of *Chamaecyparis obtusa* experimental stands.

D^2H* growth of *Cryptomeria japonica

The tendency is almost the same as that of diameter and height growth of *Cryptomeria japonica* (fig. 5).

D^2H* growth of *Chamaecyparis obtusa

Intermediate tendency between diameter and height growth of *Chamaecyparis obtusa* is seen in fig. 6.

Discussion

Effect of pruning on height growth

Since HONDA[3] said that a certain extent of pruning promoted the growth of tree height, TANAKA[7][8], WATANABE[9] and others have insisted that the promotion of height growth is one of the merits of pruning. But as the experimental data of HONDA[3] and TANAKA[7][8] have not been expressed, we cannot check the condition of their experimental stands and their methods and the report of WATANABE[9] was not based on precise examinations.

As far as the result of this experiment is concerned, the promotion of height growth by pruning was not recognized in any treatment during two years after pruning. TAKAHARA[6] did not recognize it either in *Cryptomeria japonica* and *Chamaecyparis obtusa* stands during five years after pruning. KURITA and INUMA[4] recognized the remarkable reduction of height growth during two years after pruning in their experiments using a young *Cryptomeria japonica* stand. And in other needle trees, YOUNG and KRAMER[10], SLABAUGH[5], BARRET[1], etc. did not recognize the reduction of height growth in their pruning examinations.

On the other hand, the authors have not seen any report based on precise examination which recognized the promotion of height growth by pruning. So it might be said that, in general, pruning does not promote the height growth, or at least it cannot be said that one of the purposes of pruning is for the promotion of height growth, even if the promotion of height growth was recognized to a certain extent in a definite pruning intensity.

Relationship between ratio of removed leaves and reduction rate of stem growth

The reduction rate of stem growth was defined as follows in this paper.

$$\frac{D^2H(t_2) \text{ of control plot} - D^2H(t_2) \text{ of any plot}}{D^2H(t_0) \text{ of control plot}}$$

where t_0 and t_2 expresses the time at the pruning operation and of two years later respectively.

The relationship between the ratio of removed leaves and reduction rate of stem growth through all the experimental stands is presented in fig. 7. In *Cryptomeria japonica*, as this relationship seems to be free from stand density effect, it was approximated by one line. In *Chamaecyparis obtusa*, although the number of plots is not enough to obtain a definite tendency, an approximate line was roughly drawn. According to this graph, the effect of leaf removal on stem growth in upper strata of *Cryptomeria japonica* is more severe than that in under strata. In *Chamaecyparis obtusa*, on the other hand, that relationship is proportional from under to middle strata.

The relationship between the accumulated leaf amount and accumulated branch increment in each stratum is expressed in fig. 8, which demonstraties that the leaf efficiency of *Cryptomeria japonica* decreases from upper to lower strata, while that of *Chamaecyparis obtusa* does not vary so much from upper to lower strata. This is based on the following assumption: the amount of the organic matter which transfers from the leaves in each stratum to branches and stem is proportional to the amount of organic matter which accumulates in the branches of the respective stratum. Fig. 8 accounts for the difference of tendency between *Cryptomeria japonica* and *Chamaecyparis obtusa* in fig. 7. These characteristics of leaf efficiency in both species agree with the result of a previous report[2].

TAKAHARA[6] reported that the growth condition of most of pruned stands began to recover from two or three years after pruning operation and almost recovered within five years after pruning in *Cryptomeria japonica* and *Chamaecyparis obtusa*. Judging from this, 5 percent reduction rate at second year after pruning in this examination will be negligible at the present

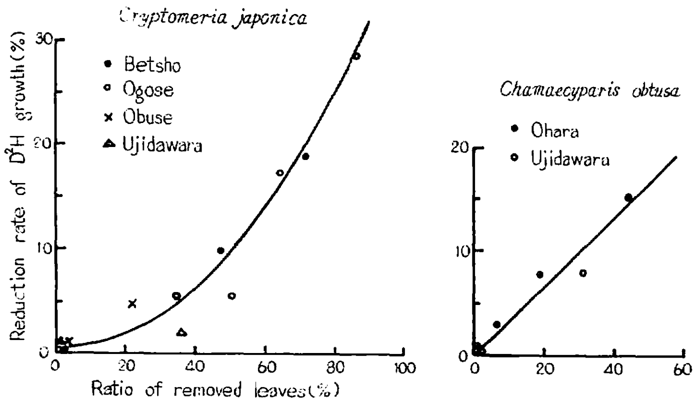


Fig. 7 Relationship between the ratio of removed leaves and the reduction rate of D^2H growth in the experimental stands.

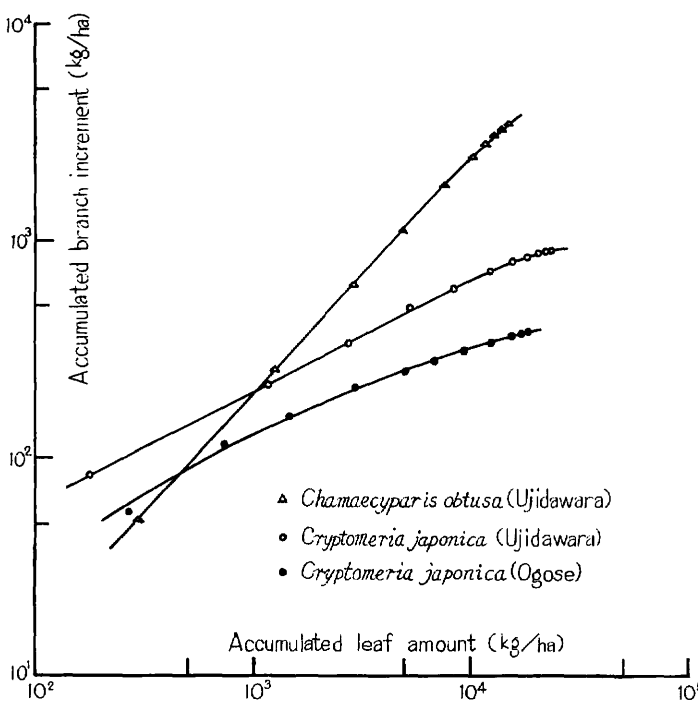
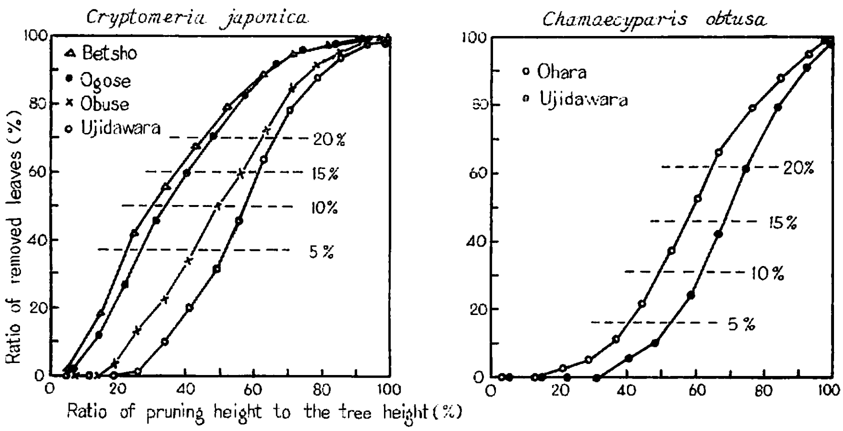


Fig. 8 Relationship between accumulated leaf amount and accumulated branch increment in each stratum in the experimental stands.

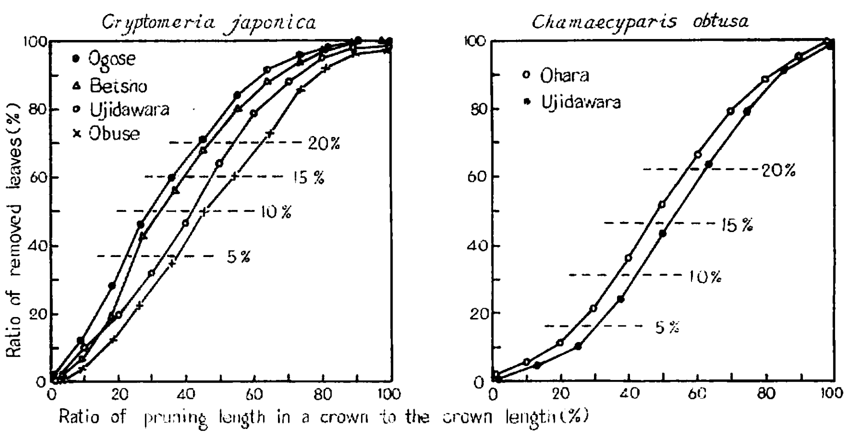
time and in future. In fig. 7, when 5 percent reduction of stem growth is allowed, from 35 to 40 percent of leaves can be removed in *Cryptomeria japonica* and around 15 percent in *Chamaecyparis obtusa.* In the same way, any relationships between the ratio of removed leaves and reduction rate of stem growth can be looked up on this graph, and this could be expanded to the stand whose condition is similar to these experimental stands.

Indication of pruning intensity

The relationship between the ratio of pruning height to the tree height and the ratio of removed leaves in the different stand densities of the experimental stands is presented in fig. 9. In this graph, when reduction rate of stem growth is allowed within 5 percent in *Cryptomeria japonica,* pruning can be made up to 52 percent of the tree height in the high density stand (Ujidawara) and 23 percent in relatively low density stand (Betsho), although the same ratio (37%) of leaves was removed respectively. And also in fig. 9, if pruning is made up to 40 percent of tree height, 64 percent of leaves is removed in the low density



Parallel lines on the graphs express the reduction rate of D^2H growth.
Fig. 9 Relationship between the ratio of pruning height to the tree height and the ratio of removed leaves in the different stand densities of the experimental stands.



Parallel lines on the graphs express the reduction rate of D^2H growth.
Fig. 10 Relationship between the ratio of pruning length in a crown to the crown length and the ratio of removed leaves in the different stand densities of the experimental stands.

stand (Betsho), while only 19 percent of leaves is removed in the high density stand (Ujidawara), a difference of more than three times. Thus the conclusion is that the ratio of pruning height to the tree height cannot be used for the general indication of pruning intensity.

The relationship between the ratio of pruning length in a crown to the crown length and the ratio of removed leaves in different stand densities of the experimental stands is presented in fig. 10. This relationship differs to a certain extent in accordance with the difference of the stand densities. But as the difference of this relationship is not much, when rough estimation is permitted, the ratio of pruning length in a crown to the crown length could be used for the general indication of pruning intensity. Strictly speaking, it must be desirable that the ratio of removed leaves be used for the indication of pruning intensity, at least in the case of the pruning examination.

Criteria of the efficiency of leaf-bearing branch

In the practice of pruning, if the efficiency of leaf-bearing branches in each stratum to the stem growth is judged from some criteria in a tree crown, it must be convenient for the practice. FUJIMORI[2] discussed the criteria of the efficiency of leaf-bearing branches to the stem growth, that is, the relationship between the efficiency of leaf-bearing branches and clear length ratio of branches in each stratum, or the stratum with the largest branch amount and with the largest leaf amount. And the authors would like to discuss it again in this paper.

The relationship between the pruning height and the percentage of clear length in branches just at the pruning height or others in this experimental stands are presented in table 4. According to this table, the clearing of leaves from the base of branches had not yet started at the height of pruning in most of the *Cryptomeria japonica* stands. In a 19-year-old *Cryptomeria japonica* stand[2], even in the leaf-bearing branches which is still contributing to the growth, clearing of leaves was advancing to a certain extent. But in this experimental stand, although the pruned branches had not yet started the clearing of leaves, effect of pruning on stem growth was not recognized much without intensive pruning. This difference seems to be primarily owing to the difference of stand age, and it will be necessary to clarify this relationship in association with the growth stage of *Cryptomeria japonica* stands.

On the other hand, in *Chamaecyparis obtusa*, clearing of leaves in branches is considerably advancing at the height of each pruning. So far as this experiment is concerned, the pruning whose height is less than the height where clearing of leaves in branches is 55 or 62 percent did not cause any remarkable reduction of stem growth. And in a 19-year-old *Chamaecyparis obtusa* stand[2], the pruning until the height where clearing of leaves in branches is around 40 percent was judged not to cause considerable reduction of stem growth, either. Judging from these experiments, it might be said that the height where clearing is advancing around 50 percent in branches is adopted as the criterion until whose height pruning can be made without considerable reduction of stem growth in *Chamaecyparis obtusa*.

Furthermore, the stratum with the largest branch amount or with the largest leaf amount could be adopted as the criteria of the efficiency of leaf-bearing branches to the stem growth. The height of these in each experimental stand are presented in table 4. As is evident from this table, the stratum with the largest leaf amount is higher than that with the largest branch amount both in *Cryptomeria japonica* and *Chamaecyparis obtusa*. The stratum with the

Table 4. Crown structure and the indications of pruning intensities in this experiment

Species	Area of experimental stand	The stratum with the largest branch weight (m)	The stratum with the largest leaf weight (m)	The stratum with the largest branch increment (m)	Height of pruning (m)	Percentage of removed leaves	Percentage of clean length in the branches of the stratum at the pruning height
Cryptomeria japonica (Sugi)	Betsho	0.3〜0.8	1.3〜1.8	3.3〜3.8	 1.5 2.5	0 46 73	 0 0
	Ogose	0.8〜1.3	1.3〜1.8	3.3〜3.8	 1.5 2.0 2.5 3.5	0 35 51 64 87	 0 0 0 0
	Obuse	1.3〜1.8	2.8〜3.3	4.3〜4.8	 2.2 3.5	0 22 53	 15 0*
	Ujidawara	3.8〜4.3	3.8〜4.3	4.8〜5.3	 3.5	0 38	 0*
Chamaecyparis obtusa (Hinoki)	Ohara	2.8〜3.3	3.3〜3.8	3.3〜3.8	 2.0 2.7 3.5	0 7 17 41	 88 62 25
	Ujidawara	3.3〜3.8	3.8〜4.3	3.8〜4.3	 3.5	0 32	 55

* The stratum where the clearing in branches is beginning.

largest branch increment is above the stratum with the largest leaf amount in *Cryptomeria japonica*, and just the same in the stratum with the largest leaf amount in *Chamaecyparis obtusa*. These tendencies agree with the result of the previous report[2].

Judging from table 4 and the result of stem growth after pruning as above mentioned, in the case of *Cryptomeria japonica*, the pruning up to the stratum with the largest branch amount will be allowed, and even the pruning nearly up to the stratum with the largest leaf amount could also be allowed without considerable reduction of stem growth. In *Chamaecyparis obtusa*, on the other hand, only the pruning up to the stratum with the largest branch amount will be allowed.

As far as this experiment is concerned, the following items could be adopted as the criteria for the upper limit of the pruning intensity which does not so much affect the reduction of stem growth. In the case of *Cryptomeria japonica*, the amount of removed leaves is about 40 percent, pruning length in a crown to the crown length is about 30 percent or nearly the stratum with the largest leaf amount. In the case of *Chamaecyparis obtusa*, the amount of removed leaves is about 15 percent of the total leaves, pruning length in a crown to the crown length is about 25 percent, the stratum with the largest branch amount or the stratum with the branches whose clear length is about 40 percent.

Literature cited

1) Barret, J. W. : Pruning of Ponderosa Pine——Effect on growth. Pacific Northwest Forest and Range Exp. Sta., USDA Forest Serv. Res. Pap. PNW-68 (1968)

2) Fujimori, T. : Fundamental studies on pruning I. Discussion about pruning on the basis of an ecological research. Bull. Jap. Gov't. Forest. Exp. Sta. **228**, 1〜38, (1970)*

3) Honda, S. : Essential theory of silviculture. Miura Shoten, 958〜962, (1911)**

4) Kurita, N. and M. Inuma : Pruning of young Sugi trees for the prevention of snow damage. Rec. **19** Meet. Tohoku Sect Jap. Forest. Soc., 92〜95, (1967)**

5) Slabaugh, P. E. : Effect of live crown removal on the growth of Red Pine. J. For., **55**, 904〜906, (1957)

6) Takahara, S. : Influence of pruning on the growth of Sugi and Hinoki. Bull. Tokyo Univ. For., 46, 1〜24, (1954)*

7) Tanaka, H. : Present silvicultural techniques. Nippon Ringyo Gijutsu Kyokai, 331〜334 (1954)**

8) Tanaka, H. : Practice of silvicultural techniques and its fruites. Nippon Ringyo Kairyo Fukyu Kyokai, 119〜121, (1967)**

9) Watanabe, S. : Pruning promotes stem growth. The Ringyo Shinchishiki, **214**, 12〜17 (1971)**

10) Young, H. E. and P. J. Kramer : The effect of pruning on the height and diameter growth of Loblolly Pine. J. For., **50**, 474〜479, (1952)

Remarks : * denotes that the literature is written in Japanese with English summary.
** denotes that the literature is written only in Japanese.

枝打ちに関する基礎的研究 II*

枝打ちの樹幹成長におよぼす影響 (1)

藤森隆郎[1]・早稲田　収[2]

摘　要

筆者らは枝打ち技術体系の確立のためにいくつかの基礎的研究をすすめているが，その一つとして枝打ちの強さの度合が幹の成長にどのように影響するかの試験を行なっている。この試験の方法論の検討と，枝打ち処理後2年間に得られた結果，およびそれに基づく考察を報告する。

試験方法と試験地

スギとヒノキを対象樹種とし，京都市周辺に10年生前後のスギ4林分，ヒノキ2林分の試験地を設定した。それぞれの試験地を，構成木の平均サイズができる限り等しくなるようにいくつかの区に分け，強さの異なる枝打区と対照区を設けた。同時に設けた伐採区から得た葉量，その他の直接測定値から枝打ちにともなう各区の葉の除去率などを推定した。枝打ち処理後の生育経過は毎年生育休止期に測定し，各試験区の生育状況の比較は下記の数値を用いて行なった。

$$\frac{\{\text{対照区の}\ D^2H(t_2)\}-\{\text{各区の}\ D^2H(t_2)\}}{\text{対照区の}\ D^2H(t_0)}$$

ここで，D と H は胸高直径と樹高を，t_0 と t_2 は枝打ち処理時と処理後2年目を示す。

結果と考察

枝打ちの強さを表わす指標として樹高に対する枝打ち高率と，樹冠長に対する樹冠内の枝打ち長率がよく用いられているが，それらと葉の除去率との関係を示したものが Fig. 9, 10 である。樹高に対する枝打ち高率は同じであっても，密度の違いによって葉の除去率は2倍も3倍も違う（Fig. 9）ため，樹高に対する枝打ち高率は枝打ちの強さの指標として用いることは不適であるといえる。樹冠長に対する樹冠内の枝打ち長率と葉の除去率との関係も，立木密度の違いによってある程度異なるが，枝打ちの強さの指標として樹冠長に対する樹冠内の枝打ち長の割合は一応用いられてもよさそうである（Fig. 10）。しかし，試験における枝打ちの強さの指標は，事情が許せば葉の除去率によることが望ましいといえよう。

各種の枝打ち程度と幹の直径成長との関係は，スギ，ヒノキともにほぼ枝打ちの強さに応じて直径成長減少率も大きくなることがわかる（Fig. 1）。枝打ちの樹高成長におよぼす影響は，スギでは直径成長における傾向とほぼ同じであるが，ヒノキではその直径成長に比べて目だった影響はみられなかった（Fig. 3, 4）。しかしながら，枝打ちによって樹高成長が促進される[3)6)7)9)]ということは，この試験に関する限りスギ，ヒノキともに一例も認められなかった（Fig. 3, 4）。

全試験地を通しての葉の除去率と幹の成長減少率との関係は Fig. 7 のとおりである。いまこの試験地で5% までの幹の成長減少率は現在，将来ともに問題ないものとすると，Fig. 7 からスギでは 35～40%，ヒノキでは約 15% の葉は下層から除いてもよいということがわかる。同じようにして，いろいろな関係

---

* Contributions from JIBP—PT No. 118

1971年9月30日受理

(1)(2)　関西支場

がこの図から読み取れるが，このことはこの試験地と同じ条件の林分にも応用することができよう。

中層から下層にかけてスギの葉の幹生産能率は減少するが，ヒノキのそれはほとんど変わらない（Fig. 7）。また各階層における葉の枝生産能率（Fig. 8）においても，スギでは下層にいくほど著しく減少するが，ヒノキでは上層から下層までの変化は少なく，このことは Fig. 7 の傾向をより確実に裏付けるものである。このことから，スギではある程度までの強さの生枝打ちを行なっても，幹の成長犠牲は少ないが，ヒノキでは下層の枝打ちにおいても幹の成長はかなりの影響を受けるものということができる。

いま幹の成長減少率が5％におさまる枝打ちを，仮に幹の成長犠牲に対して安全な枝打ちとしてその強さの限界の指標を示すと次のようである。スギでは葉の除去率約 40％，樹冠内における枝打ち長率約 30％，葉量最大層の近くまでなどである。一方ヒノキでは葉の除去率約 15％，樹冠内の枝打ち長率約 25％，葉量最大層，枝の基部からの枯れ上り長率約 40％ の枝の存在する層までなどである。同じようにして，いろいろな幹の成長減少率に対応する枝打ちの外観的指標を求めることができよう。

以上のような資料の積み重ねは，枝打ち技術体系の確立に役だつであろう。なおこの試験は引きつづき行なう。