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Effect of Summer Pruning on the Number of Apical Buds near the Trunk in Slender-Spindle-Trained Apple Trees Grafted on Semi-Dwarfing Rootstocks

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Summary

The effect of summer pruning on shoot regrowth and the number of apical buds was examined by using slender-spindle-trained 'Fuji' apple trees grafted on semi-dwarfing rootstocks (MM106 or M7). Pruning at the portion 10 cm from the shoot base from May to August enhanced shoot regrowth but a slight regeneration of shoot was found in September pruning. The final shoot length of regrowth was shorter than the initial shoot length before pruning. The number of apical buds was increased by pruning. Double pruning to half and one-fourth length of shoot in May and August increased the number of apical buds. Pruning to one-third, half and two-thirds length of shoots (from severe to light) were performed in May, June and July. All treatment in May and June favored the increase in the number of apical buds, but only severest pruning was effective in July. The earlier shoot growth cessation caused the bigger size of apical buds of regenerated terminal shoots but little correlation was in the second and third generated shoots. The larger the apical buds, the greater percentage of flower bud formation. Therefore, summer pruning is effective to maintain fruit bearing portion near the trunk in the slender spindle training systems in apple trees grafted on semi-dwarfing rootstocks.

Introduction

Dwarfing and semi-dwarfing rootstocks have been worldwide used in commercial apple production. Training commonly adopted for such compact trees is slender spindle system, which is one of the modified central leaders. The central leader consists of a main leading trunk and secondary scaffolds from which bearing shoots are formed. On the other hand, slender spindle type has the framework in which bearing shoots are formed directly from the main leading trunk or otherwise near the trunk even from the secondary scaffolds. Apple flowers are likely to bear in the

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apical buds. Especially 'Fuji' cultivar has such characteristics and moreover shows apical dominant traits. Therefore it is difficult to maintain the tree performance slender because the shoots extend outward if apical buds are used to bear fruit.

Effects of summer pruning in apple trees have been investigated for control of tree size[1,2,3,7,9], penetration of photosynthetically active radiation[6], increased net photosynthesis of basal leaves[8], improved fruit color[5] and promotion of flower bud formation[4,7].

In this exepriment, we investigated whether summer pruning is effective to increase apical buds near the trunk for maintaining the fruit bearing portions within the slender spindle frame.

Materials and Methods

Experiment I

Two five-year-old 'Fuji' trees grafted on MM106 were used. Five current shoots were selected from each tree and pruned at the portion 10 cm from the shoot base on May 22, June 22, July 22, August 22 and September 21 (Fig. 1). The shoot growth was monitored after pruning and the size of apical buds was measured in the winter (mid-January). The angle of initial shoots above the horizontal was checked.

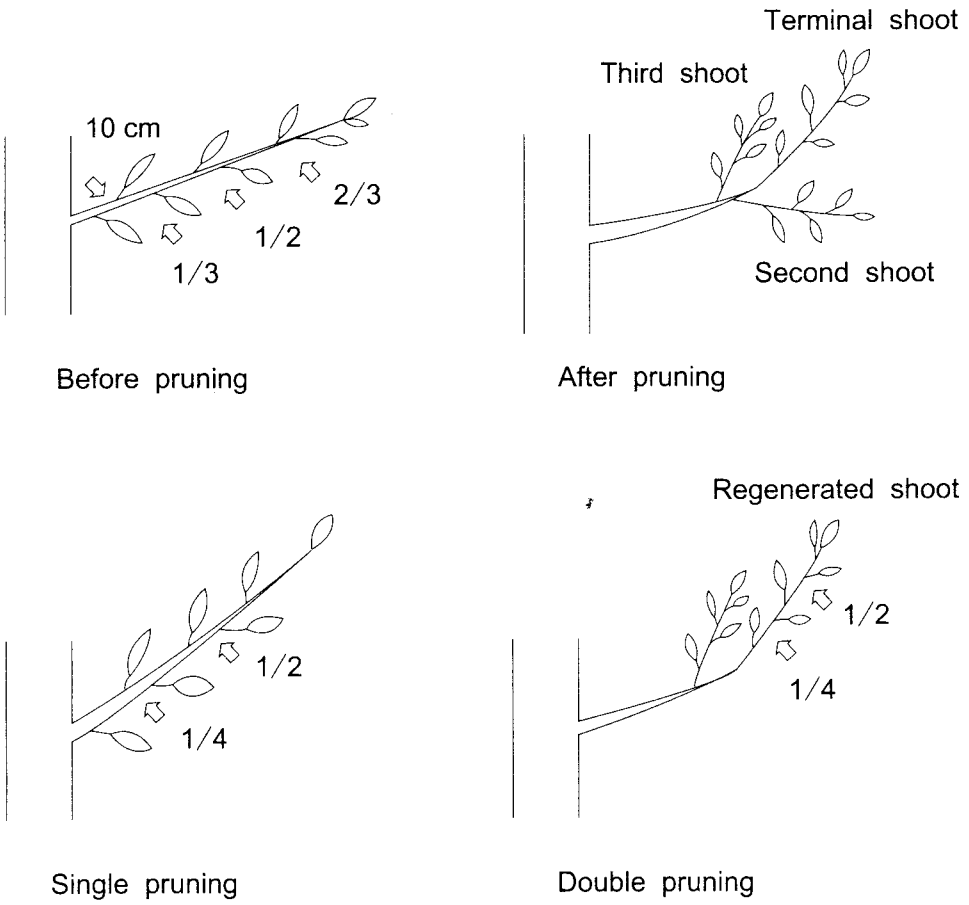

Fig. 1 Schematic diagrams for various summer pruning treatments.

Experiment II

Two five-year-old 'Fuji' trees grafted on MM106 were used. Current shoots were single-pruned or double-pruned to one-fourth and half length of the shoots (Fig. 1). The first pruning was performed on May 22, and the regenerated terminal shoots were again pruned similarly on July 10. However, the regenerated second and third shoots remained unpruned. Ten shoots were allocated to each treatment and control shoots were five. Shoot growth was monitored after pruning and the size of apical buds was measured in the winter (mid-January). The angle of initial shoots above the horizontal was checked.

Experiment III

A ten-year-old 'Fuji' trees grafted on M7 was used. Current shoots were single-pruned to one-third, half and two-thirds length of the shoots on May 18, June 14 and July 19 (Fig. 1). Five shoots were allocated to each treatment and control shoots were five. Shoot growth was monitored after pruning and the size of apical buds was measured in the winter (mid-January). The angle of initial shoots above the horizontal was checked.

Experiment IV

Fifty-eight apical buds were randomly selected from several six-year-old 'Fuji' trees grafted on MM106 in January and their size was measured and tagged. They were checked whether they bear flowers or not at anthesis.

Results and Discussion

Fig. 1 depicts the schematic diagrams of various summer pruning methods adopted in this experiment. Usually most current shoots do not branch, because 'Fuji' cultivar exhibits strong apical dominant traits. The regrowth of shoots after summer pruning at the portion 10 cm from the shoot base at different growth stages is shown in Fig. 2. Pruning severity was the reduction of shoot length to approximately to one-fourth to one-eighth of initial shoot length (Fig. 2). Pruning from May to August enhanced regeneration of shoot growth but only slight regrowth was found in September pruning. The final shoot length after pruning in all cases was shorter than the initial shoot length (Fig. 2). The angle of the initial shoots above the horizontal ranging from 30° to 60° had no clear effect on the shoot regrowth (Fig. 3). Most

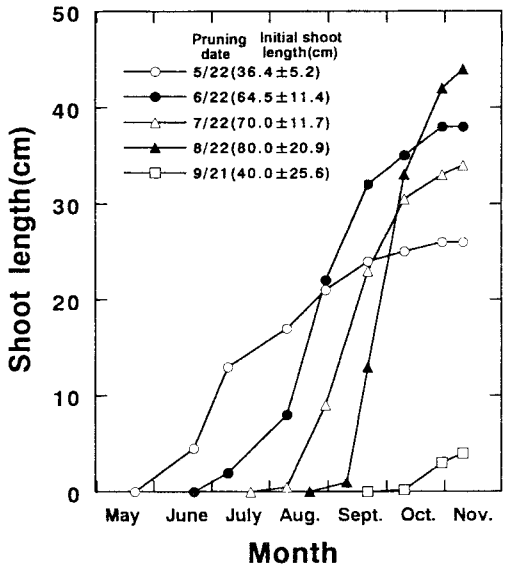

Fig. 2 Regrowth of shoot after summer pruning at different growth stages. Current shoots were pruned to the portion 10cm from the shoot base. The numbers in parentheses were the mean initial shoot length ± SD before pruning.

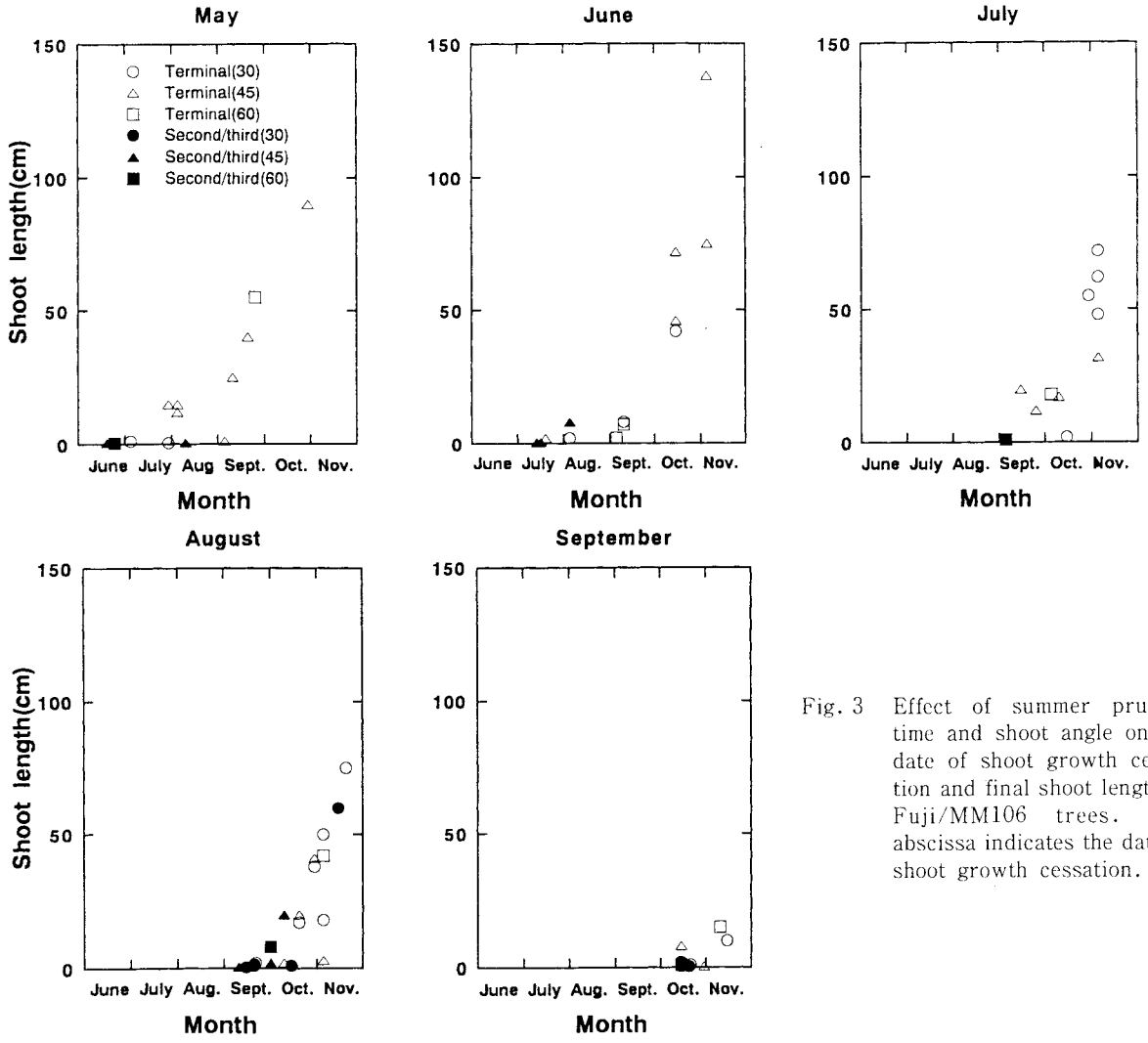

Fig. 3 Effect of summer pruning time and shoot angle on the date of shoot growth cessation and final shoot length in Fuji/MM106 trees. The abscissa indicates the date of shoot growth cessation.

Table 1 Effect of summer pruning time on the number and size of apical buds in Fuji/MM106 trees.

Pruning[Z] date	No. of apical buds[Y]	Total shoots		Terminal shoot		Second shoot		Third shoot		Initial shoot length (cm)
		Width (cm)	Length (cm)	Width (cm)	Length (cm)	Width (cm)	Length (cm)	Width (cm)	Length (cm)	
Control	1.00±0.00[V]	0.46±0.04	0.70±0.10							30.7±13.5
5/22	1.30±0.48	0.41±0.10	0.67±0.19	0.44±0.09	0.74±0.15	0.31±0.05	0.44±0.13			36.4± 5.2
6/22	1.40±0.52	0.36±0.09	0.58±0.18	0.36±0.09	0.62±0.19	0.36±0.08	0.48±0.13			64.5±11.4
7/23	1.10±0.32	0.31±0.08	0.51±0.18	0.31±0.08	0.51±0.19	0.26	0.48			70.0±11.7
8/22	2.00±0.67	0.26±0.05	0.45±0.09	0.26±0.03	0.46±0.08	0.27±0.06	0.44±0.10	0.25±0.03	0.40±0.03	80.0±20.9
9/21[X]	1.33±0.30	0.25±0.06	0.41±0.11	0.25±0.07	0.38±0.07	0.27±0.05	0.52±0.17			40.0±25.6

Z : Ten current shoots were pruned to the portion at 10 cm from the shoot base.
Y : No. of apical buds per initial shoot.
X : One of the shoots pruned on September 21 flowered in late November.
V : Mean ± SD

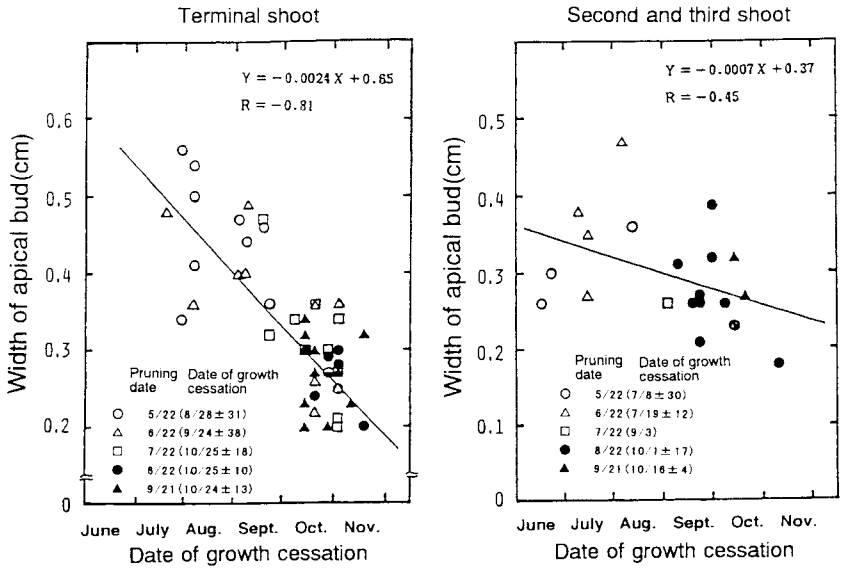

Fig. 4 Effect of summer pruning on date of shoot growth cessation and size of apical buds in Fuji/MM106 trees. Current shoots were pruned to the portion 10cm from the shoot base. The numbers in parentheses are the mean date of growth cessation ± SD.

regenerated second and third shoots were very short in length compared with the regenerated terminal shoots (Fig. 3). The size of apical buds in the regenerated terminal shoots was negatively correlated with the tardiness of cessation of shoot growth (R=-0.81). The earlier the date of cessation of shoot growth, the greater the bud size (Fig. 4 left). However, the correlation coefficient was reduced in the second and third shoots (R=-0.45) (Fig. 4 right). The number of apical buds per treatment increased by pruning although the control shoot had only one apical bud (Table 1). The average bud size became smaller as the pruning date was delayed.

Fig. 5 shows the single and double pruning on shoot regrowth. Double pruning tended to extend the date of growth cessation. Again there was no clear relationship between the initial shoot angle above the horizontal and shoot regrowth (Fig. 6). The correlation coefficient between apical bud size of generated terminal shoots and the date of growth cessation was reduced when the data of single and double pruning were combined (Fig. 7). The size of apical buds of regenerated terminal shoots was greater in single pruning than double pruning (Fig. 7 and Table 2).

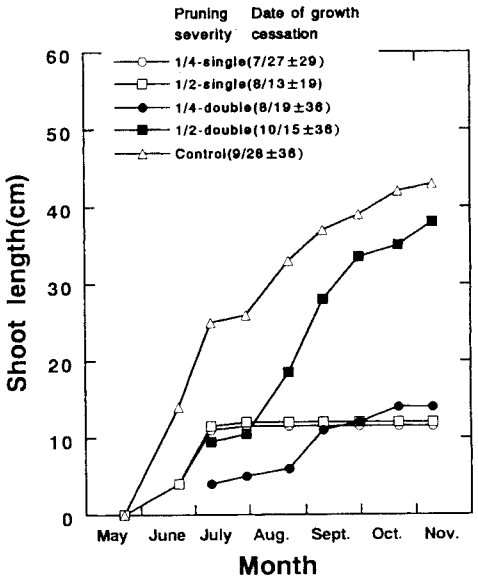

Fig. 5 Regrowth of shoots after single and double summer pruning in Fuji/MM106 trees. Current shoots were pruned to their half and one-fourth length on May 22 (first) and July 10 (second). The numbers in parentheses are the mean date of growth cessation ± SD.

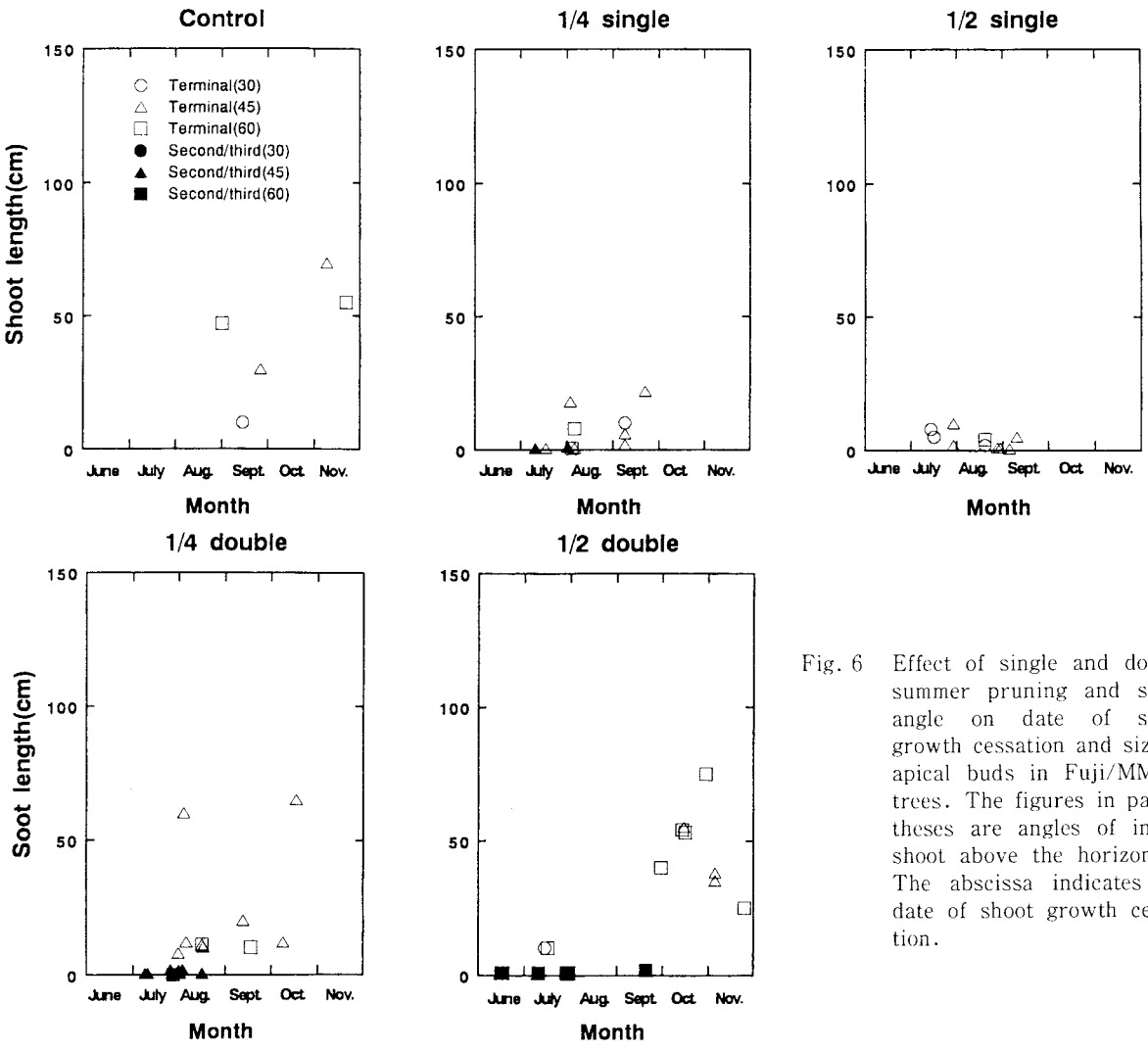

Fig. 6 Effect of single and double summer pruning and shoot angle on date of shoot growth cessation and size of apical buds in Fuji/MM106 trees. The figures in parentheses are angles of initial shoot above the horizontal. The abscissa indicates the date of shoot growth cessation.

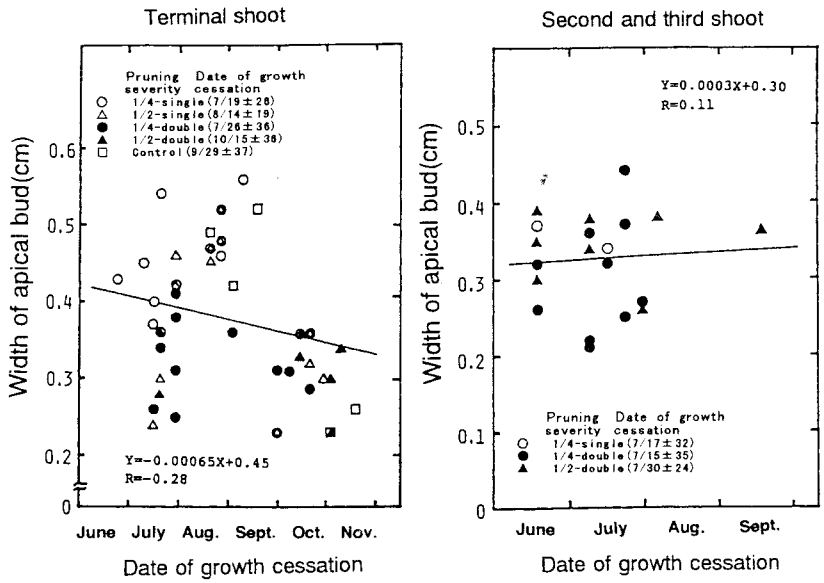

Fig. 7 Effect of severity and times of summer pruning on date of shoot growth cessation and size of apical buds in Fuji/MM106 trees. The first pruning was performed on May 22 and the second on July 10. The numbers in parentheses are the mean date of growth cessation ± SD.

Table 2 Effect of severity and times of summer pruning on the number and size of apical buds in Fuji/MM106 trees.

Pruning severity[z]	No. of apical buds[y]	Bud size	
		Width (cm)	Length (cm)
Control	1.00±0.00[x]	0.38±0.13	0.69±0.17
1/4 single	1.40±0.70	0.40±0.11	0.66±0.25
1/2 single	1.00±0.00	0.44±0.10	0.83±0.19
1/4 double	1.80±0.63	0.34±0.06	0.59±0.13
1/2 double	1.80±0.92	0.30±0.09	0.50±0.18

z : The first pruning was performed on May 22 and the second on July 10, 1985. Current shoots were pruned to their half and one-fourth length from the shoot base and the regenerated terminal shoots were similarly pruned in double pruning.
y : No. of apical buds per initial shoot.
x : Mean ± SD

The effect of pruning severity at different growth stages on shoot regrowth is shown in Fig. 8. The pruning severity was classified into three categories (Fig. 1). At any growth stage, severe pruning tended to enhance the shoot regrowth. The shoot regeneration capacity decreased as the growth stage proceeded. A negative correlation was noted between the size of apical buds of regenerated terminal shoots and the tardiness of cessation of shoot growth (Fig. 9 left). However, no such correlation was found in the apical buds of second and third shoots (Fig. 9 right). The effect of shoot angle from 30° to 60° on shoot regrowth was not clear again (Fig. 10). A 1.2- to 1.8-fold increase in the number of apical buds per initial shoot was found in May and June pruning, whereas only severest pruning was effective in July pruning (Tabl 3).

The relationship between sizes of apical buds and flower bud formation is presented in Table 4. The greater buds are likely to bear flowers. Although the buds investigated were randomly selected from non-summer pruned shoots, this tendency can be applied to the regenerated shoots. Lord et al. (1979) reported that summer pinching and heading cuts can induce flower bud formation on shoots when done in early to mid summer[4]. Fig. 11 shows the fruitlets from the apical

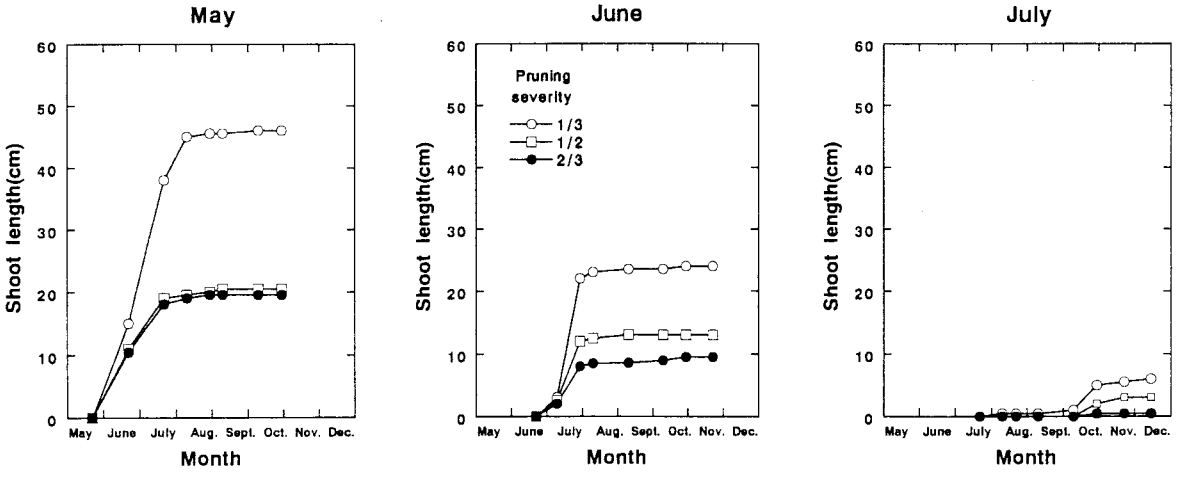

Fig. 8 Effect of severity and time of summer pruning on the regrowth of shoots in Fuji/M7 trees.

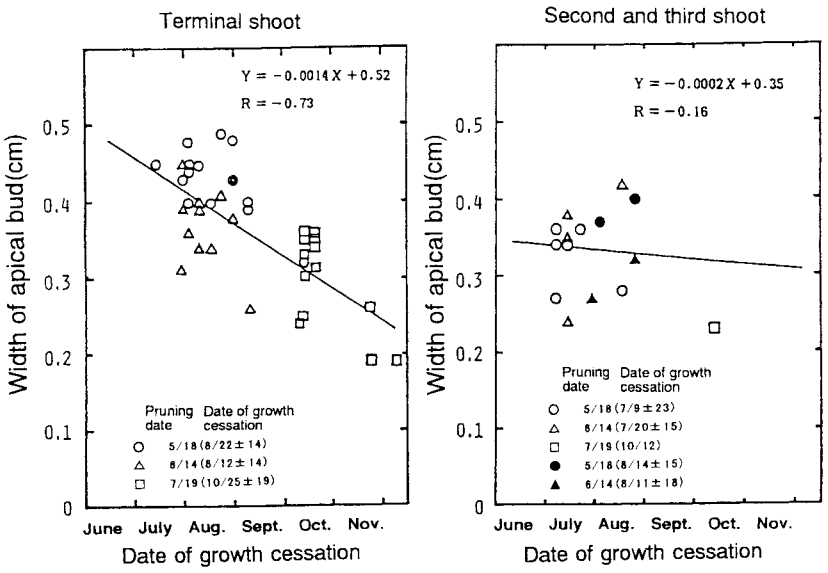

Fig. 9 Effect of summer pruning on date of shoot growth cessation and size of apical buds in Fuji/M7 trees. (●, ▲ : apical buds of third shoots) The numbers in parentheses are the mean date of growth cessation ± SD.

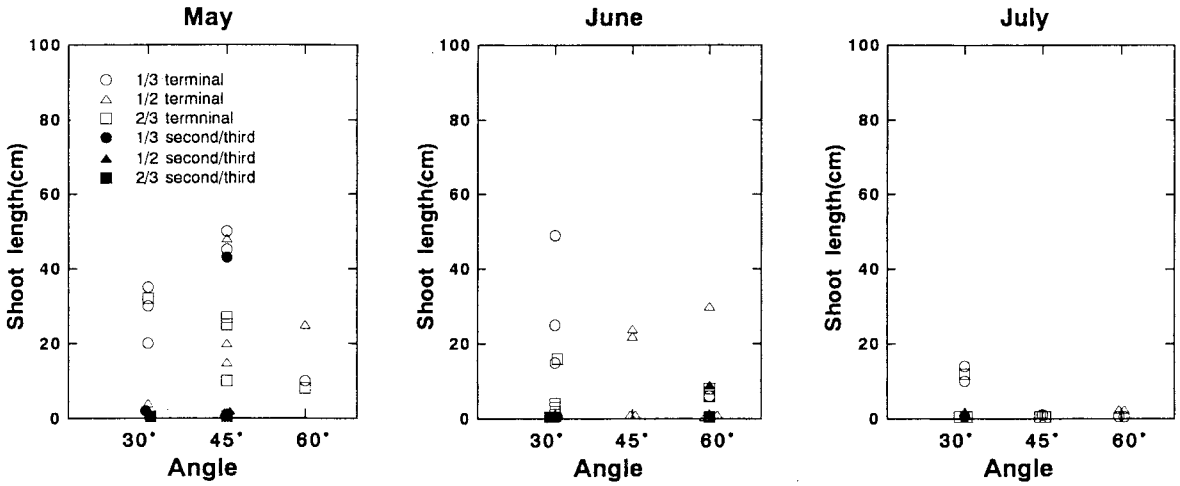

Fig.10 Effect of time and severity of summer pruning and shoot angle on final shoot length in Fuji/M7 trees.

buds on the regenerated second and third shoots in Fuji/M26 trees by double summer pruning in another experiment.

'Fuji' cultivar shows strong apical dominant traits and bear flowers only in the apical buds. No or little flowers are formed in the axillary buds. Therefore, it is difficult to maintain the tree shape as slender spindle because the fruit bearing portion extends outward from the trunk as the tree ages. As a result, the inner part of the tree becomes ineffective space for fruit bearing. Furthermore if the branches extend outward from the trunk, orchard practices like thinning, bagging and picking fruit especially inside the tree become hard.

As shown in our present results, summer pruning is effective to keep the fruit bearing portion to near the trunk and mantain the tree shape as slender spindle in Fuji/semi-dwarfing rootstocks.

Summer pruning to half or one-third length of current shoots in May and June should be recommended depending on the shoot vigor.

Table 3 Effect of severity and time of summer pruning on the number and size of apical bud in Fuji/M7 trees.

Pruning date	Pruning severity[Z]	No. of apical buds[Y]	Terminal shoot		Second shoot		Third shoot	
			Width(cm)	Length(cm)	Width(cm)	Length(cm)	Width(cm)	Length(cm)
Control		1.00±0.00[X]	0.45±0.05	0.78±0.11				
5/18	1/3	1.60±0.89	0.42±0.03	0.64±0.05	0.32±0.06	0.64±0.11	0.40	0.48
5/18	1/2	1.40±0.89	0.41±0.06	0.74±0.13	0.36	0.78	0.37	0.42
5/18	2/3	1.40±0.55	0.45±0.04	0.83±0.09	0.31±0.05	0.64±0.18		
6/14	1/3	1.20±0.45	0.36±0.07	0.71±0.12	0.24	0.48		
6/14	1/2	1.80±1.30	0.37±0.02	0.66±0.08	0.39±0.05	0.61±0.10	0.32	0.61
6/14	2/3	1.40±0.55	0.36±0.03	0.65±0.08	0.37±0.02	0.61±0.02		
7/19	1/3	1.20±0.45	0.29±0.07	0.62±0.20	0.23	0.34		
7/19	1/2	1.00±0.00	0.31±0.03	0.56±0.10				
7/19	2/3	1.00±0.00	0.29±0.07	0.55±0.08				

Z : Five current shoots were pruned at one-third, half and two-thirds portion of shoot length from the shoot base. The number of control shoots were 30.
Y : No. of apical buds per initial shoot.
X : Mean ± SD

Table 4 Relationship between sizes of apical buds and flower bud formation in Fuji/MM106 trees.

Bud width(cm)	Flower buds/Total buds	Percent of flower buds
0.10−0.20	0/6	0
0.21−0.30	2/14	14.3
0.31−0.40	7/20	35.0
0.41−0.50	11/18	61.1

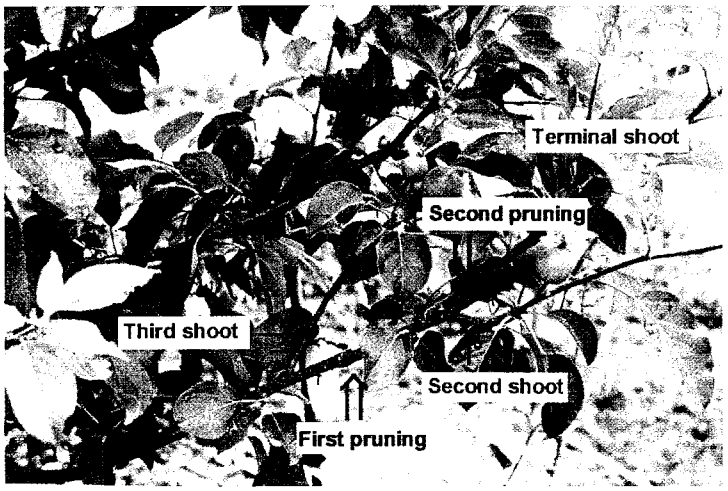

Fig.11 Fruitlets from apical buds of the regenerated second and third shoot by double summer pruning in Fuji/M26 trees in another experiment.

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準矮化台木に接いだ細形紡錘形リンゴの主幹近くでの頂芽数の増加に及ぼす夏季剪定の効果

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摘　　要

準矮化台木（MM106またはM７）に接ぎ、細形紡錘形に整枝したリンゴ‘フジ’樹を用いて、夏季剪定が枝の再生と頂芽数に及ぼす効果を調査した。５月から８月まで新梢を基部から10cmのところで剪定すると枝の再生が見られたが、９月の剪定では再生力は小さかった。最終的な枝の長さは剪定前の枝の長さより短くなった。剪定によって頂芽数は増加した。５月に新梢の長さの１/２と１/４となるように剪定し、さらに再生した先端枝を同じように１/２と１/４に剪定すると頂芽数が増加した。また、５月、６月、７月に剪定強度を変えて新梢を枝の長さの１/３、１/２、２/３（強～弱）となるように剪定をしたところ、５月、６月の剪定では全て頂芽数を増加させた。しかし、７月剪定では剪定強度が最も強い区でのみ効果があった。再生した先端枝では枝の伸長停止期の早さと頂芽の大きさの間には正の相関があったが、再生した第２、３枝では相関は小さかった。頂芽のサイズが大きいほど花芽形成率は高かった。従って、準矮化台木に接いだ‘フジ’の細形紡錘形リンゴ樹では、花芽の着いた頂芽を主幹の近くに確保する上で、夏季剪定が有効であることが明らかになった。

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