Effect of Leaves Retained at the Time of Harvest on Regrowth, and Changes in Their Physiological Activity in Mulberry Tree

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Mulberry trees being cultivated to harvest leaves for diet of silkworms, the assimilatory organ is removed repeatedly in the growing season. It is well known that the removal of assimilatory organ restrains the subsequent growth and sometimes causes diseases, such as a dwarf. It is also reported that regrowth after harvest is markedly accelerated by retaining some leaves unharvested on the basal part of stem at the time of stem pruning (harvesting stems together with leaves), which has recently become popular due to the spread of shoot rearing of silkworm throughout seasons.[1)]

In this paper effects of leaves retained on the basal part of stem at the time of stem pruning on the regrowth and on the consumption of reserve substance in storage organs, such as a stump and roots, will be discussed together with changes in physiological activity of the retained leaves

Effects of retained leaves on regrowth and consumption of reserve substance after stem pruning

Young mulberry trees, planted in Wagner pots in late April and grown with one stem per one pot for about three months, were used. Each stem with about 27 leaves was pruned leaving 4 leaves on the basal part of the stem. Then, all the stems were divided into two groups. In one group, the basal 4 leaves retained at the time of stem pruning were removed (−L), while in the other group, the stems were left with their 4 leaves retained (+L).

Three to four lateral shoots developed per one stem after stem pruning. Increase in total length of newly developed shoots per one stem was rapid during 10 to 30 days after the stem pruning, and then became slow in both −L and +L plants as shown in Fig. 1. The newly developed shoots were notably longer in +L than in −L plants.

Amylase activity in the bark of the basal

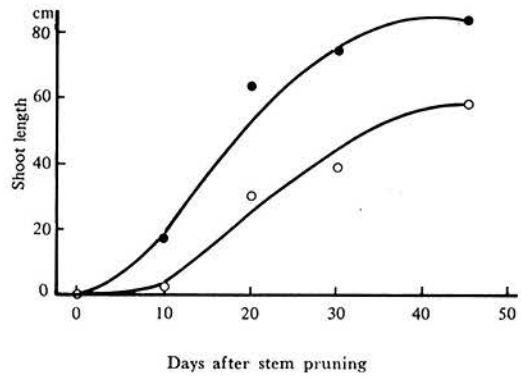

Fig. 1. Changes in length of newly developed shoots after stem pruning.
○ : Stem pruned and leaves deprived.
● : Stem pruned and leaves left retained.

stem increased to 150–200% of the initial value during 5–20 days after the stem pruning and recovered to the initial value at 45 days after the pruning. The activity in −L plants was higher than in +L plants for 30 days after the pruning.

The dry weight of storage organs, which were composed of a basal stem, a stump and roots, decreased for 30 days after the pruning and then turned to increase. The decrease in storage organs was less in +L than in −L plants. Meanwhile, the dry weight of newly developed shoots showed a steady increase in both of +L and −L plants after the pruning. However, the increase in +L plants was always about twice as high as that in −L plants (Fig. 2).

Changes in amount of soluble sugars and starch in storage organs are shown in Fig. 3. Amount of soluble sugars in +L plants decreased for 20 days after the pruning and

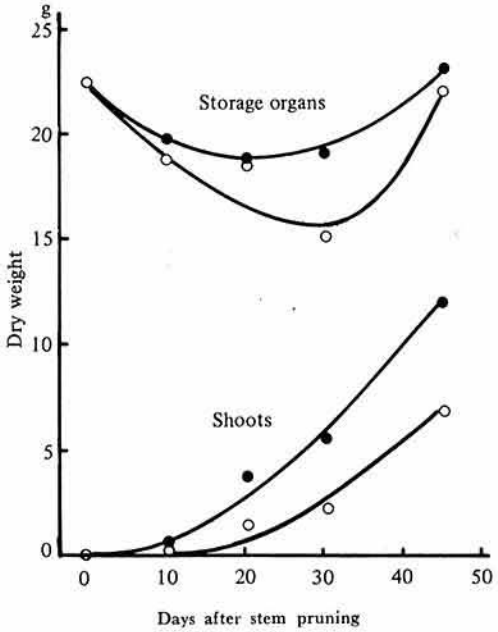

Fig. 2. Changes in weight of storage organs (a stem, a stump and roots) and newly developed shoots after stem pruning.
○ : Stems pruned and leaves deprived.
● : Stems pruned and leaves left retained.

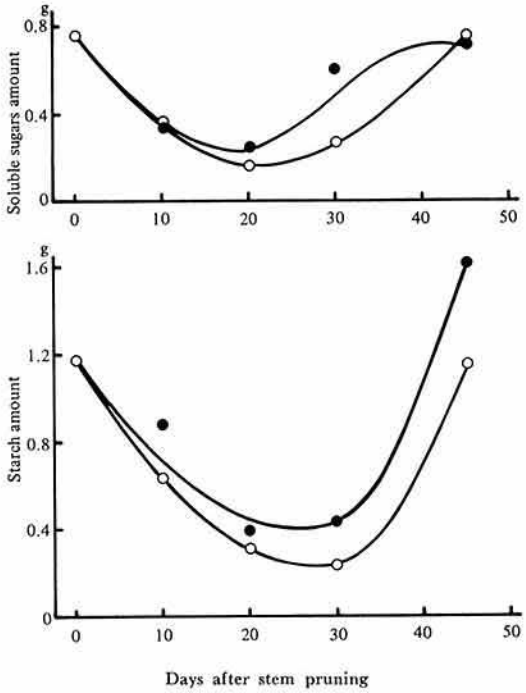

Fig. 3. Changes in amount of soluble sugars and starch in storage organs (a stem, a stump and roots) after stem pruning.
The amount is expressed by glucose equivalent.
○ : Stems pruned and leaves deprived.
● : Stems pruned and leaves left retained.

then turned to increase while that in −L plants decreased for 20 days and then recovered only a little. The amount of soluble sugars in −L plants was about half of that in +L plants on the 30th day after the pruning while the amount in −L plants became nearly equal to that in +L plants on the 45th day after the pruning.

The amount of starch in storage organs in both −L and +L plants continued to decrease for 30 days after the stem pruning. The amount on the 30th day after the pruning was about 36% of the initial amount in +L plants and 20% in −L plants. It turned to increase after 30 days following the pruning and recovered to the initial amount on the 45th day after the pruning. The amount was always

higher in +L than in −L plants.[4]

As mentioned above, only 4 leaves retained on the basal part of stem at the time of stem pruning accelerated the growth of newly developed shoots and, at the same time, alleviated the decrease in dry weight and reserve substance in storage organs. These facts suggest that photosynthetic activity of leaves retained at the stem pruning would play an important role in the regrowth after pruning.

Change in photosynthetic rate in the retained leaves after stem pruning

Photosynthetic rate of the retained leaves was compared among treatments in which stems were pruned at different heights leaving 3, 7 or 18 leaves intact on the basal part of stem, using an unpruned stem as control.

Fig. 4 shows photosynthetic rate of retained leaves in successive leaf positions at 7 days after the pruning. Photosynthetic rate of leaves on lower part of the unpruned stem was low, as the leaves had aged after their unfolding. When 3 or 7 leaves were retained on the stem, their photosynthetic rate exceeded markedly that of the corresponding leaves on the unpruned stem. In the case when 18 leaves were retained on a stem, the photosynthetic rate of the upper leaves on the upper part of the stem exceeded that of the corresponding leaves on the unpruned stem, although the lower leaves were not so different in photosynthetic rate from the corresponding leaves on the unpruned stem.

Photosynthetic rate of the retained leaves, once increased, as mentioned above, however, gradually fell down and reached the level of the unpruned stem with the growth of newly developed shoots.

By the way, areal weight of leaves retained on the pruned stem exceeded that of the leaves

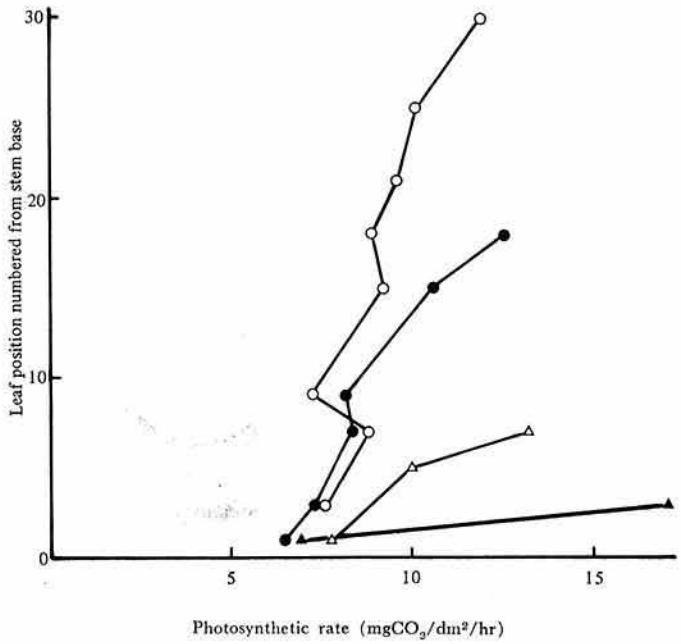

Fig. 4. Photosynthetic rate of retained leaves in successive leaf positions 7 days after stem pruning.
○ : Unpruned
● : Pruned retaining 18 leaves
△ : Pruned retaining 7 leaves
▲ : Pruned retaining 3 leaves

Table 1. Areal weight (mg D. W./cm^2) of leaves in successive leaf positions 28 days after stem pruning

Leaf positions*	Unpruned	18 leaves retained	7 leaves retained	3 leaves retained
35	6.67			
30	6.68			
25	6.21			
21	7.24			
18	6.11	6.97		
15	5.62	6.15		
12	6.03	5.63		
9	5.95	5.60		
7	6.23	5.83	7.79	
5	6.41	6.73	7.38	
3	6.84	6.46	8.31	7.30
1	—	—	—	7.67

* Leaf positions were numbered from the stem base.

Table 2. Photosynthetic rate of retained leaves after stem pruning. Rates were compared between the uppermost leaves on pruned stems and corresponding leaves on unpruned stems, and were expressed in mg CO_2/dm^2/hr

Treatment	Days after treatments						
	0	3	6	13	18	27	40
Unpruned	18.1	17.9	19.6	15.1	11.9	8.4	8.4
Pruned (buds retained)		19.5	23.2	19.8	16.1	11.0	10.0
Pruned (buds removed)		18.1	22.5	20.2	19.0	16.2	17.8

on unpruned stems after the pruning (Table 1). In addition, nitrogen content of retained leaves was also higher than that of the leaves on unpruned stems.[2)]

Physiological activity of the retained leaves after stem pruning with or without axillary buds

The leaves retained on the stems were examined as to physiological and anatomical changes with the progress of aging for 40 days, using three kinds of stems; stems pruned at the middle part, stems pruned at the middle part and axillary buds disbudded, and stems unpruned.

The leaves on the unpruned stems were characterized by gradual decrease in photosynthetic rate from 18.1 mg $CO_2 \cdot dm^{-2} \cdot hr^{-1}$ at the time of treatments to 8.1 mg $CO_2 \cdot dm^{-2} \cdot hr^{-1}$ at 40 days after the treatments. On the contrary, the photosynthetic rate of leaves of the pruned and disbudded stems showed no significant change so that it was more than double that of the former leaves at 40 days after the treatments. Photosynthetic rate of leaves of the pruned, but not disbudded stems increased marginally faster than that of the pruned and disbudded stems, showing only a temporary rejuvenation before it turned to decrease as axillary shoots grew (Table 2).

Little difference was recognized in stomatal resistance to carbon dioxide diffusion between the leaves of the unpruned stems and those of the pruned and disbudded stems while mesophyll resistance differed distinctly between them, with the former showing an increase

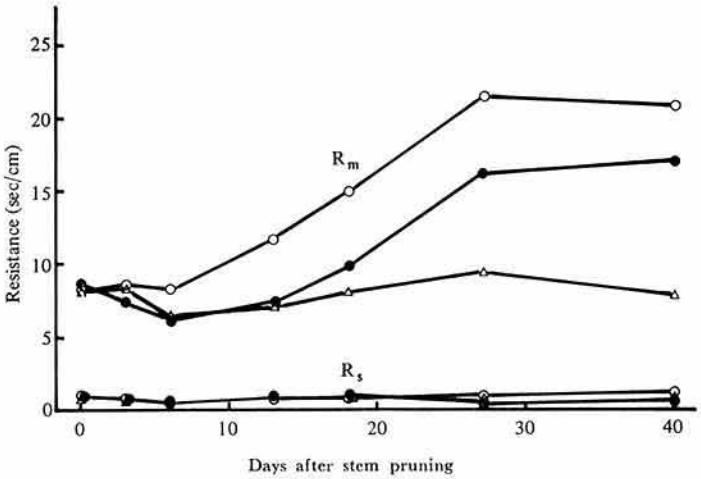

Fig. 5. Changes in gaseous diffusive resistance of retained leaves after stem pruning. R_s and R_m represent stomatal resistance and mesophyll resistance, respectively.
○ : Unpruned
● : Pruned
△ : Pruned and disbudded

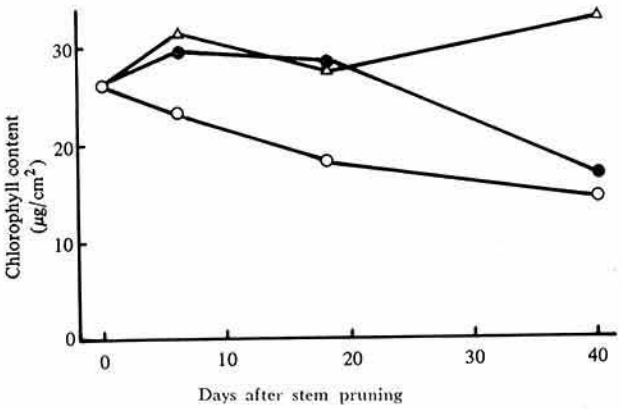

Fig. 6. Changes in chlorophyll content of retained leaves after stem pruning.
○ : Unpruned
● : Pruned
△ : Pruned and disbudded

and the latter being almost unchanged (Fig. 5). Contents of starch and growth inhibitors such as abscisic acid and phaseic acid in leaves were lower in the pruned and disbudded stems than in the unpruned stems, while chlorophyll content was higher in the former than in the latter (Fig. 6). In addition, the leaves of the pruned and disbudded stems were featured by the increase in leaf thickness and in length of palisade and spongy parenchymal cells. For the leaves on the pruned, but not disbudded stems, these changes described above were approximately intermediate between the unpruned ones and the pruned and disbudded

ones.

These changes observed in the leaves retained on the pruned stems suggest the rejuvenation of the leaves caused by the removal of upper stems bearing young leaves. Foliar levels of cytokinin-like substances were assayed because of their well established role in rejuvenation. Content of cytokinin-like substances measured on the 13th day after the treatments, when the effect of pruning on the photosynthetic rate and chlorophyll content became distinct, were higher in the leaves retained on the pruned stems with or without their axillary buds than in the leaves on unpruned stems[3].

It is conjectured from the above mentioned results that the rejuvenation of leaves retained after stem pruning, as expressed by the enhancement of their physiological activity, is attributed to cytokinin, which has most probably its origin in roots, accumulates in the retained leaves and promotes chloroplasts multiplication as well as protein and chlorophyll synthesis in the leaves.

To evade the adverse influence of removal of assimilatory organ, it may be one of the most important factors that the growth of newly developed shoots is accelerated and, at the same time, the exhaustion of reserve substance in storage organs is alleviated through the increased supply of photosynthetic products to newly developing shoots from the retained leaves which have enhanced photosynthetic capacity.

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(Received for publication, March 31, 1981)