Influences of Unplucked Young Leaves on Carbohydrate and Nitrogen Content in Tea Plants

By MASATAKA YAMASHITA

Makurazaki Branch, National Research Institute of Tea
(Beppu, Makurazaki, Kagoshima, 898 Japan)

In Japan, the first crop of tea plants is harvested in April–May (spring crop), and the second and third crop in June–July and July–August (summer crop), respectively. New shoot growth in the spring crop season highly depends on carbohydrate reserves. The growth of new shoots in the summer crop season, however, increases dependency on photosynthate produced during the season as the carbohydrate reserves decrease after the 1st cropping.[5,6] Therefore, it is considered that the new leaves left unplucked on bushes after the 1st cropping may play an important role in maintaining high photosynthetic production of the plants and hence in raising yield and quality of the summer crops.[3]

In the present paper, contributions of the unplucked new leaves to carbohydrate economy and nitrogen uptake of tea plants during the summer season were studied.

Materials and method

Four-year-old plants grown up from cuttings were used for the experiment and treated as follows at the plucking time of the 1st crop (Fig. 1).

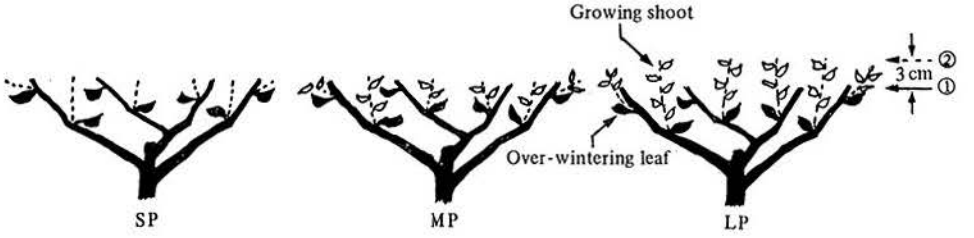
Severe plucking (SP):
New leaves above the last skiffing level were shear-plucked, and all other new leaves were removed by hand-plucking.

Medium plucking (MP):
New foliage above the last skiffing level were removed by shear-plucking.

Light plucking (LP):
Three cm thick new foliage layers were left above the last skiffing level by light shear-plucking.

Materials treated by each plucking method were sampled at the predetermined times and TAC (total available carbohydrate), total nitrogen and total amino acid were analyzed.

The 2nd and 3rd crops were harvested by shear-plucking at the last skiffing level in the plot SP and MP, and at the last plucking level in the plot LP.



① : The last skiffing level
② : The light plucking level

Fig. 1. Plucking methods

Table 1. Growth of summer crops

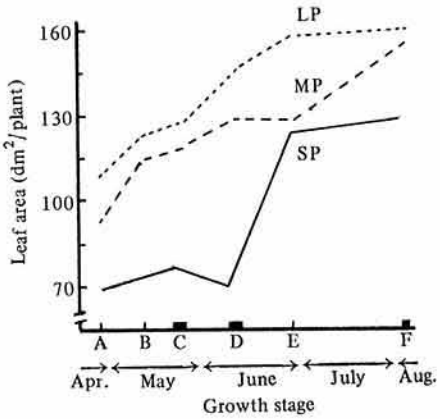
Treatments	2nd crop				3rd crop		
	Shoot* length	100-shoot* weight	Weight of** new shoots	Yield***	Shoot* length	100-shoot* weight	Yield***
	cm	g	g	g	cm	g	g
SP	1.9	35.5	143.8	68.5	2.0	40.4	99.7
MP	2.8	43.7	116.8	80.7	2.0	38.7	112.0
LP	3.1	53.5	104.0	81.1	2.5	39.8	93.7

* For whole new shoots (fresh).
** For whole new shoots (fresh weight per plant).
*** New shoots harvested by shear-plucking (fresh weight per plant).

Foliage after treatments and growth of summer crops

Changes in leaf area per plant during the experimental period are shown in Fig. 2, and growth of new shoots and yield of the 2nd and 3rd crops are shown in Table 1.

The leaf area in the plot SP and MP was reduced by the treatments to about 64% and 84% of that of the plot LP, respectively. Thereafter, the leaf area in the plot MP and LP continued to increase gradually up to the 3rd crop season but that in the plot SP showed a sharp rise only during the 2nd crop season. Eventually, although the difference in leaf area among the plots diminished somewhat, it still remained in the same order until 20 days after the 3rd cropping.



A : Plucking time of the 1st crop (Apr. 27)
B : 15 days after the 1st cropping (May 11)
C : Bud opening time of the 2nd crop (May 20 - 24)
D : Plucking time of the 2nd crop (June 7 - 11)
E : Bud opening time of the 3rd crop (June 28)
F : 20 days after the 3rd cropping (Aug. 3 - 5)

Fig. 2. Seasonal changes in leaf area

The whole new shoot weight per plant in the 2nd crop season was greatest in the plot SP, followed by MP and LP. However, yield, shoot length, and 100-shoot weight of the whole new shoots showed a reversed order. New shoot growth and yield in the 3rd crop season showed no appreciable difference among the plots.

Carbohydrate economy after the treatments

Content(%) and amount(g) of carbohydrate in plants are shown in Fig. 3.

In the SP plot, the carbohydrate content in a whole plant continued to increase by the bud opening time of the 2nd crop (C), while in other plots, it turned to decrease from 15 days after the treatment (B). Consequently, the content at the time C was highest in the plot SP followed by MP and LP. After the time C, the carbohydrate content decreased in all plots, and at the time D (plucking of the 2nd crop) it showed a reversed order, LP > MP > SP, due to a steeper decrease in the plot SP than in other plots.

The carbohydrate content in the aerial part sharply decreased from the time B in all plots, resulting in a similar value in all plots at the time C. The content in the underground part was higher than that in the aerial part, and

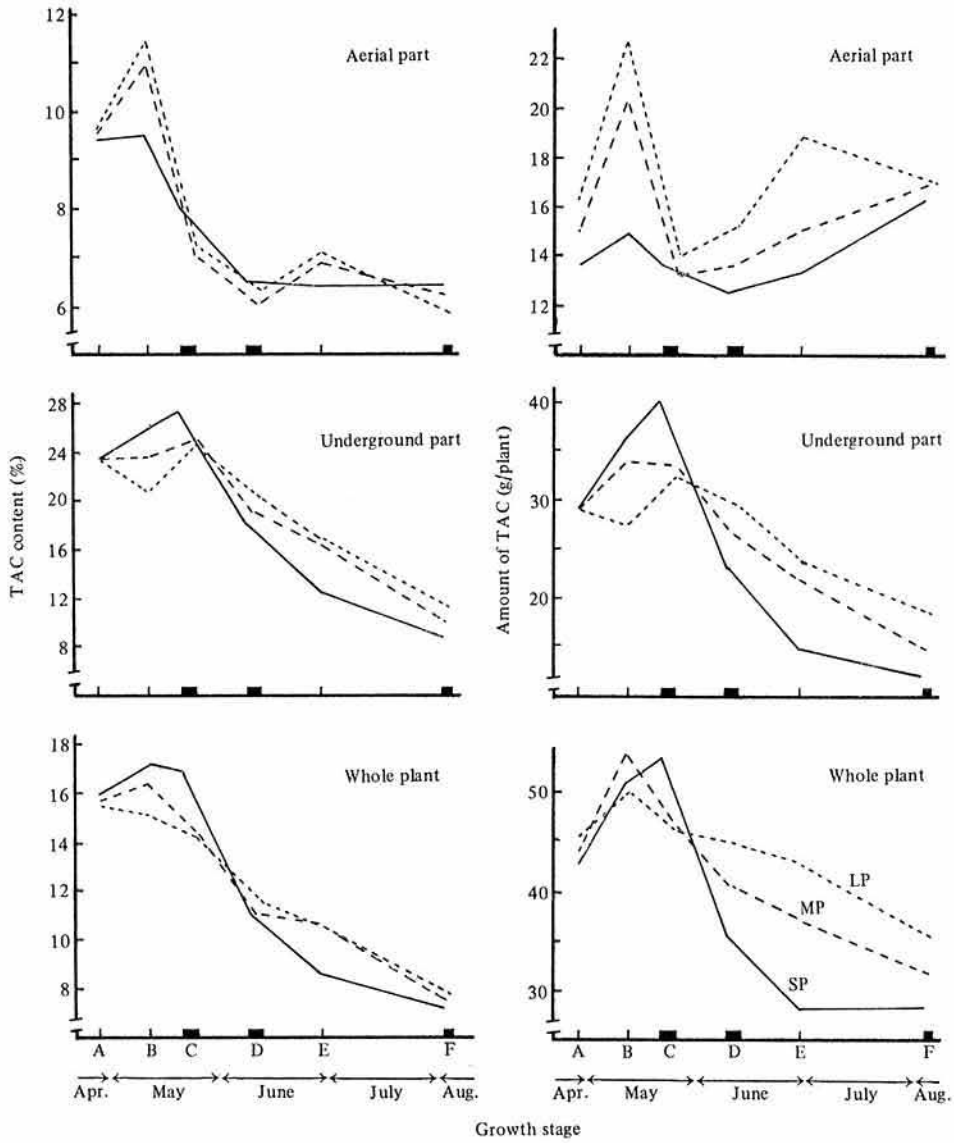


Fig. 3. Charges in carbohydrate content during summer crop season
A–F: Refer to Fig. 2.

by the time C it showed different changes according to the different treatments, namely, the content increased in the plot SP, it was kept constant in the plot MP, and it decreased in the plot LP for 15 days after the treatment. Consequently, the content at the time C was SP > MP > LP. The changes after the time C were similar to that in the whole plant.

The amount of carbohydrate in each part of plant showed almost the same seasonal trend as the content in each part of plant in each plot.

The carbohydrate contents in the aerial and the underground part appear not to start decreasing immediately after the treatments but to temporarily increase preceding a rapid decrease. It was observed at this stage after

the treatment that the more unplucked leaves remain, the lower the carbohydrate content in the whole plant. This suggests that consumption of carbohydrate reserves by growth is greater in plants with a larger amount of new leaves. However, after the time D (plucking of the 2nd crop), the content and amount of carbohydrate became higher in plants with more unplucked leaves. This may be due to an increased photosynthetic production caused by maturing of unplucked new leaves.

The amount of new shoot produced in the 2nd crop season was not proportional to the amount of new leaves left unplucked. This may be due to a compensation for lost new leaves. The carbohydrate consumption by the compensational growth seems to be a factor which induced the above-mentioned inversion

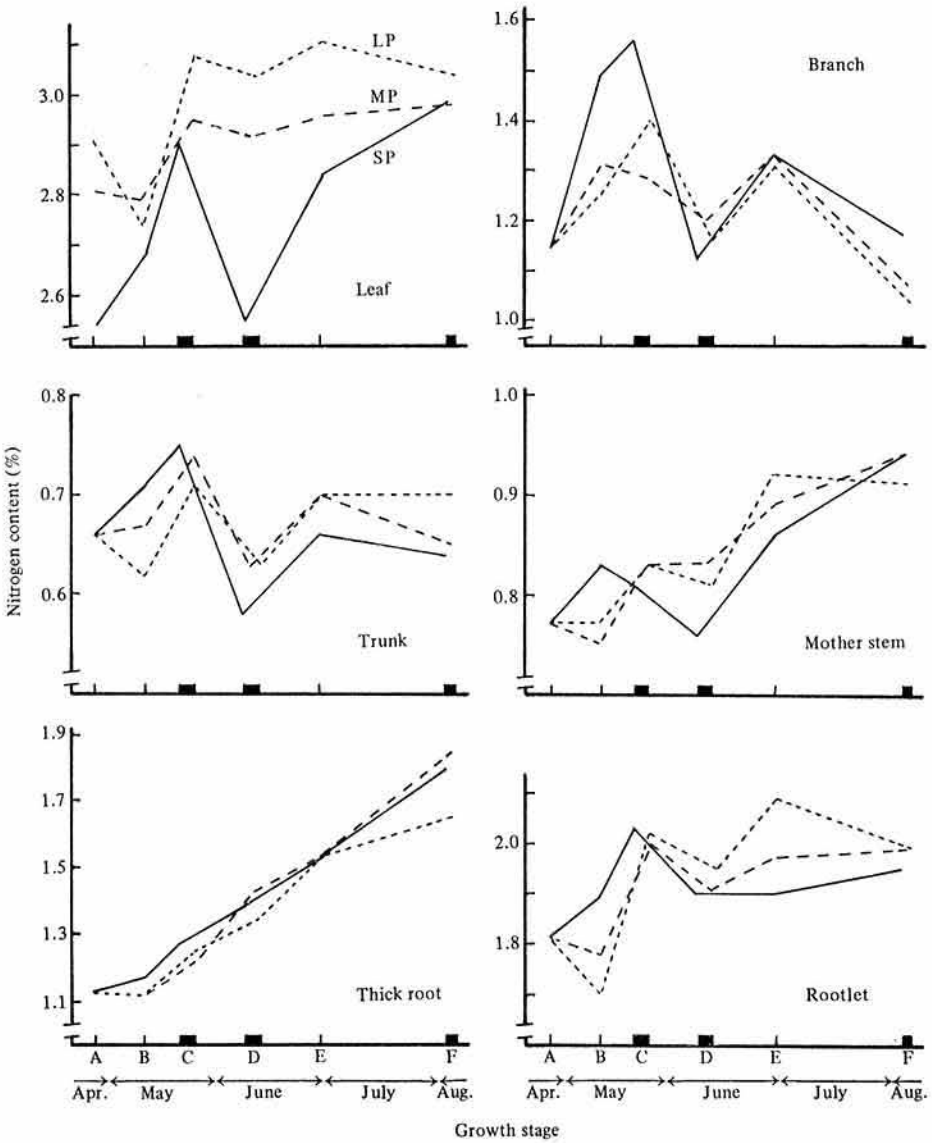


Fig. 4. Changes in nitrogen content during summer crop season
A–F: Refer to Fig. 1.
Content in leaf at the stage D was analyzed for mature leaves except new shoots.

of carbohydrate content among plots. The compensational growth seems to induce small-sized new shoots and production of new shoots inside the crown, resulting in reduced yields by shear-plucking.

Uptake and utilization of nitrogen after the treatments

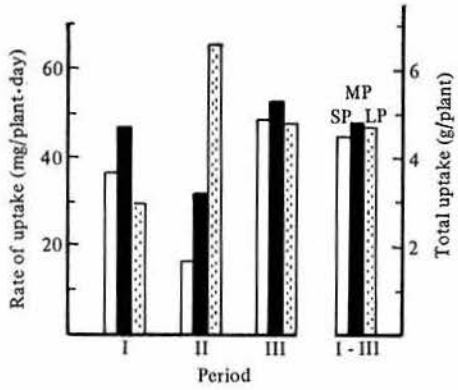
Nitrogen content of each organ, and nitrogen uptake rate and total nitrogen uptake during the experimental period are shown in Figs. 4 and 5 respectively.

The nitrogen content of leaves was highest in the plot LP followed by MP and SP over the whole experimental period. But, the content in other organs except leaves showed an inversion in the order among plots before and after the time C (flushing of the 2nd crop). Before the time C, it was SP > MP > LP, but after that it changed to LP > MP > SP. The nitrogen content in all organs except thick roots decreased in every plot, especially in the plot SP, during the 2nd crop season. After the 3rd cropping, differences of nitrogen content among plots tended to diminish except in branches and thick roots.

Although the total amount of nitrogen absorbed during the whole experimental period was slightly less in the plot SP than MP and LP, uptake rate of nitrogen during the Period II (from the time B to C) was evidently higher in the plot LP, followed by MP and SP. However, uptake rate of nitrogen during the Period III showed no great difference among 3 plots.

Although the total nitrogen content in the 2nd crop shoots was the highest in the plot SP, followed by MP and LP, the total amino acid content showed an inversed order among the plots. However, both contents of the 3rd crop shoots showed no definite difference among the plots (Table 2).

As shown above, the more the new leaves left unplucked, the lower was the nitrogen content of organs except leaves until the 2nd flushing. This implies that more amount of young leaves required more active translocation and supply of nitrogen from other organs for their growth.[2] However, the nitrogen



Period I : 15 days after the 1st cropping
Period II : From the end of Period I to the bud opening time of the 2nd crop
Period III : From the end of Period II to 20 days after the 3rd cropping.

Fig. 5. Nitrogen uptake during summer crop season

Table 2. Total nitrogen and amino acids content in new shoots

Crop season	Treatments	Total nitrogen (%)	Amino acid (mg%)				
			Theanine	Glutamic acid	Aspartic acid	Arginine	Total
2nd	SP	4.44	369.4	63.4	55.3	8.9	563.6
	MP	4.36	371.2	49.4	69.4	5.7	584.8
	LP	4.25	393.9	83.4	74.0	6.2	664.3
3rd	SP	3.98	162.4	40.1	48.6	1.9	321.3
	MP	3.91	134.9	33.8	46.9	1.8	281.2
	LP	3.98	249.6	46.7	43.4	3.2	418.0

content in the MP and LP plots turned to increase to a higher level than SP after the 2nd flushing. It shows that new leaves remaining unplucked are effective to maintain a high level of nitrogen content during the summer crop season.

A great decline in nitrogen level of various organs in the plot SP may be attributable to the poorest uptake of nitrogen just before the 2nd flushing (Period II), which is not enough to meet the nitrogen demand for growth of new shoots in the 2nd crop season. Diminished differences in nitrogen content among the treatments observed after the 3rd cropping seems to be caused by the effect of newer leaves developed during the summer crop season. This assumption is supported by the seasonal increase of leaf area per plant and small difference in nitrogen uptake rate among different plots during the 3rd crop season (Period III).

These changes in uptake and utilization of nitrogen caused by different amounts of new leaves left unplucked exert an influence on chemical composition, such as total amino acid and nitrogen content of the summer crops.

Conclusions

The amount of new leaves left unplucked on bushes at the time of harvesting the first crop evidently changed the carbohydrate economy and the pattern of uptake and translocation of nitrogen during the following summer crop season. These physiological changes may not necessarily show any immediate effects on yield and quality of the following summer crops but it is inferred that they have an important significance to maintain and increase plant vigor from the long-term point of view, as pointed out by Ghosh[1] and Rahman[4] in experiments on plucking method.

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