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EFFECT OF CUTTING AND DEFOLIATION ON NITROGEN UPTAKE BY YOUNG TEA PLANTS (*CAMELLIA SINENSIS* L.) GROWN IN SAND CULTURE

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The uptake and utilization of nitrogen by young tea plants pruned with and without foliage was followed. There was a drop in nitrogen uptake immediately after the plants were pruned and the drop corresponded to the amount of leaf area removed from the plants. In the presence of 'retained foliage' (equivalent to lung-pruning) nitrogen uptake continued although reduced, and increased as new leaves were produced in recovery. On the other hand, there was virtual cessation when defoliation was complete (equivalent to clean pruning) and the plants failed to recover.

INTRODUCTION

The cultural practice of pruning tea plants and their subsequent recovery has been a problem of much interest and considerable amount of work has been done on this field. In most of these studies attempts were made to correlate the pattern of recovery with internal and external factors. Importance of adequate levels of carbohydrate reserves in the roots to enable satisfactory recovery from pruning has been stressed by many investigators (Tubbs, 1937; Nagarajah and Pethiyagoda, 1965). Unsatisfactory recovery and excessive die-back on pruned plants have been attributed to the lack of carbohydrate reserves in the roots. Following from this observation there developed a practice of 'lung-pruning' the function of the 'lungs' being to supplement the root reserves as they are used up in the recovery.

The effect of 'lungs' on satisfactory recovery from pruning was well established (Nagarajah and Pethiyagoda, 1965). In most of these studies the function of the lungs has been discussed in relation to carbohydrate supply to maintain adequate reserves in the roots for the satisfactory recovery from pruning. However, the role of lungs in the supply of currently synthesized assimilates for the assimilation of the absorbed N was not investigated. Lungs could play an important role in the uptake and assimilation of N from the soil by supplying the necessary carbon skeleton for the synthesis of amino acids and proteins which are essential for the vigorous growth of the recovering plant.

The experiment described here was undertaken to study the effects of retained foliage on the absorption and assimilation of N by young tea plants recovering from pruning.

MATERIALS AND METHODS

Experiment 1

Five and a half month old, vigorously growing plants of tea clone, TRI 62/9 were transplanted and maintained in sand culture for ten months before the pruning was done. During this period they received modified Hewitt's nutrient solution at half strength (Pethiyagoda, Krishnapillai and Nagarajah, 1969), with ammonium nitrate as the source of nitrogen. Before nitrogen uptake studies were commenced, the sand in the experimental pots was thoroughly flushed with demineralized water. Pots similar to those employed earlier (Krishnapillai and Pethiyagoda, 1978) were used for the collection of percolates and leachings for N analyses.

Pre-pruning studies on nitrogen uptake were done over the immediate preceding period of three weeks, samples being analysed at weekly intervals. The plants were found to absorb about 75-80% of the applied N during this period.

The plants which were approximately 60 cm high were cut at a height of 25 cm along the main stem to stimulate new growth after defoliation. In three of these plants, all remaining leaves were defoliated, while in the other three plants, branches and leaves (about 17-20 leaves) arising below the level of the cut were retained. The area of the retained leaves was found to be about 50% of the leaves that were originally on the plant before pruning was done. The number of recognisable buds along the frame of each plant was counted and found to be similar in numbers.

The pots were flushed again with sufficient demineralized water soon after pruning, to get rid of any adsorbed N in the sand medium. The plants in these two treatments received modified Hewitt's nutrient solution at half strength (105 ppm N) daily.

The percolates and leachings from these pots were analysed for total N (micro-Kjeldahl-salicylic/sulphuric acid method) at 3-day intervals during the early stages and at weekly intervals subsequently. The figure obtained by subtracting the sum of N in the percolates and leachings from the quantity of N applied, was assumed to represent N absorbed by each plant (Krishnapillai and Pethiyagoda, 1978).

Experiment 2

An observation trial was also carried out in support of the above experiment. In this study, however, no attempts were made to estimate the uptake of nitrogen.

For this trial, 1½ year old tea plants, growing in sand but received an irregular supply of nutrients were used. At the time of commencing the treatments they were pale and displayed moderate nitrogen deficiency symptoms. The plants were divided into two groups of three plants each and were all pruned at a height of 30 cm.

The two treatments were:

1. All foliage removed, subsequently supplied with nutrient solution.

2. Only two mature leaves retained, subsequently supplied with nutrient solution.

The above plants received modified Hewitt's nutrient solution only twice a week, as against daily application as done in the first experiment. Observations were continued for about 3½ months.

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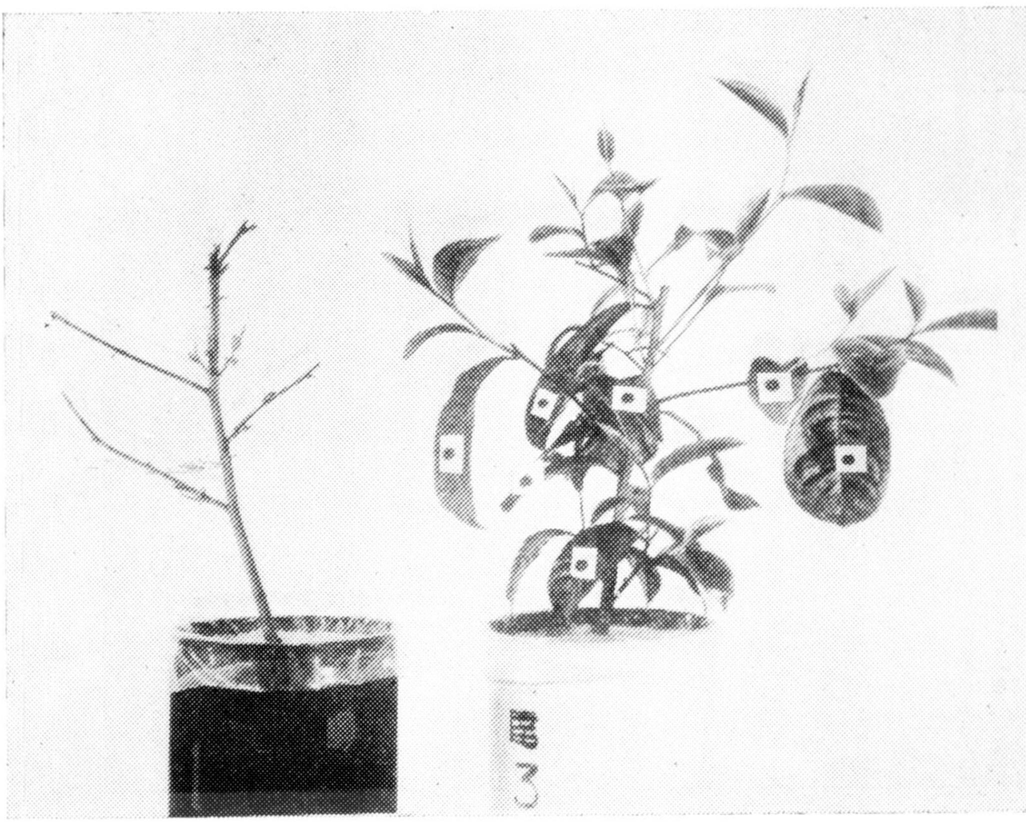

Fig. 1. — Recovery of plants after two months from pruning. No leaves retained on plants at left. □ denotes the leaves left on the frame at pruning.

Fig. 2. — Close-up view of damage to young buds on a 'clean-pruned' plant.

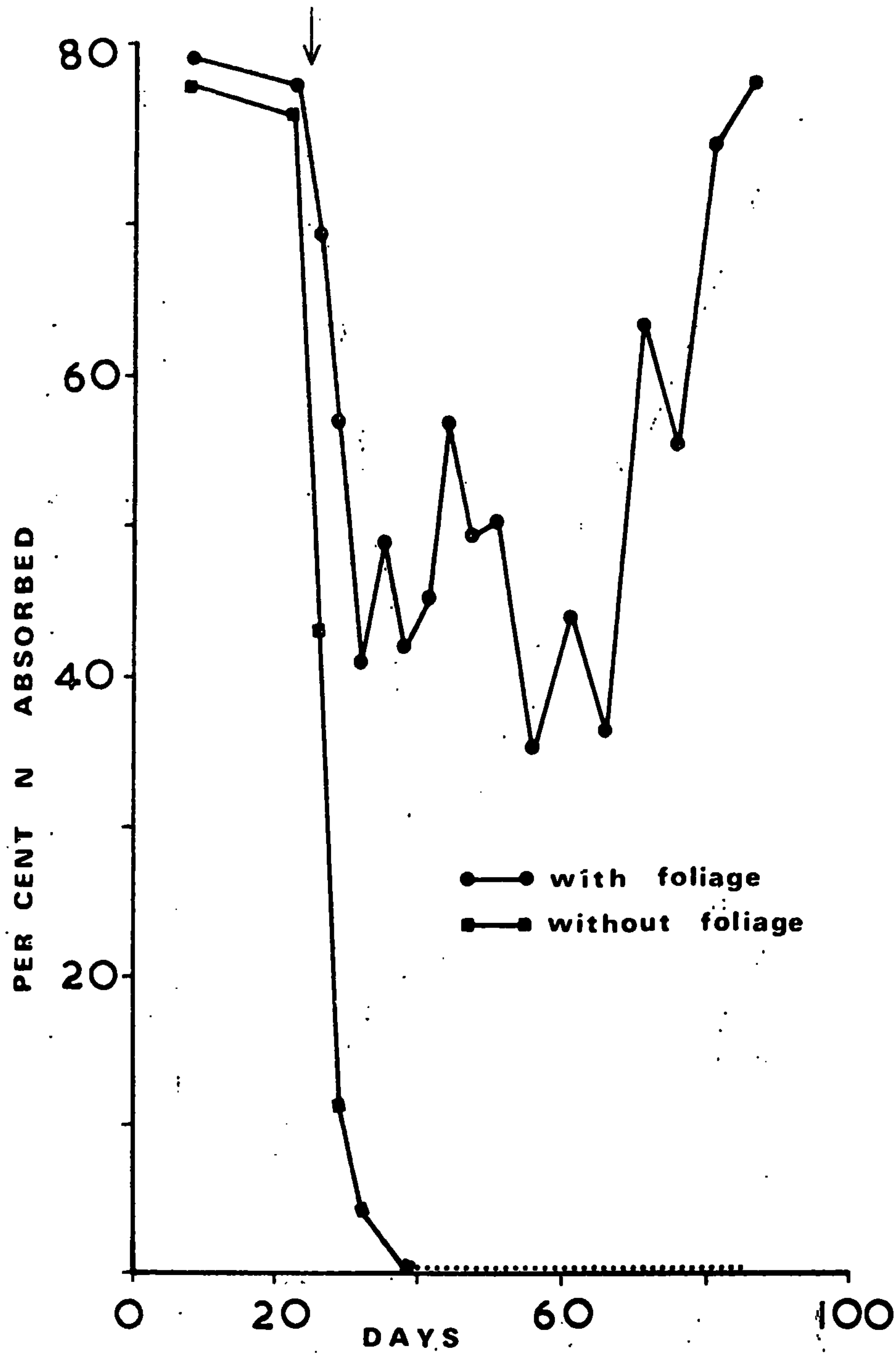

Fig. 3.— Effect of pruning and defoliation on per cent nitrogen absorbed. Arrow indicates time of pruning

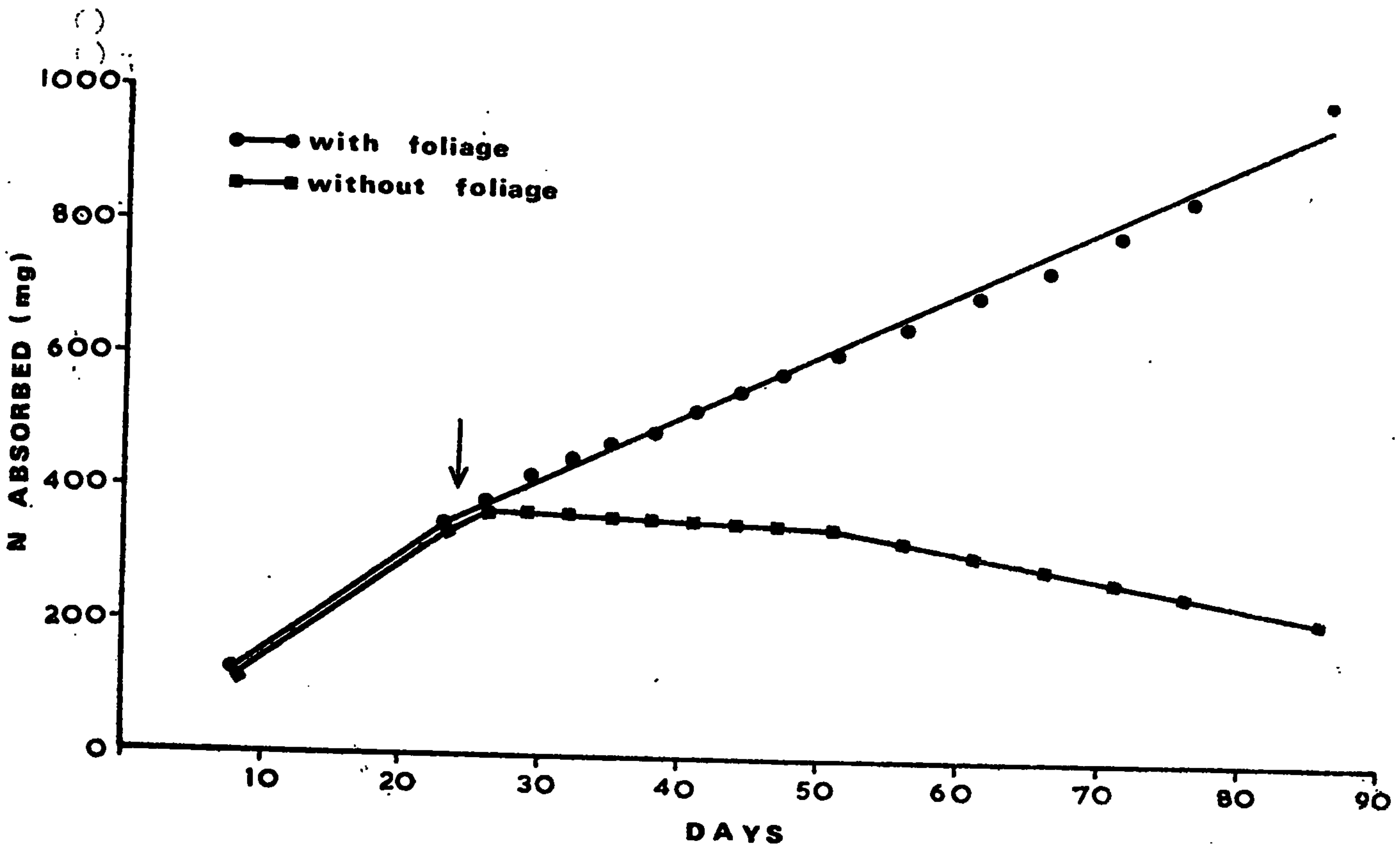

Fig. 4.— Effect of pruning and defoliation on cumulative nitrogen absorbed (symbols same as in Fig. 3).

RESULTS

Experiment 1

There were marked differences between the plants receiving different treatments in their pattern of recovery after cutting and defoliation. Though there were comparable numbers of buds available on the frame at the time of cutting their subsequent growth was very varied. Recovery of the plants pruned without foliage was very poor, whereas in the other treatment buds commenced growth early and produced normal shoots with healthy leaves. The differences became more marked with time (Fig. 1). In addition to retardation of bud growth, the shoots of the plants without foliage bore small buds and leaves which subsequently displayed tips scorch leading to black discolouration and progressive death (Fig. 2).

On the other hand, in the other treatment where some foliage was retained the growth was vigorous and the shoots were larger with dark green leaves.

Nitrogen uptake in relation to recovery

In Figs (3) and (4), nitrogen absorbed by the experimental plants is expressed as (a) per cent N absorbed and (b) cumulative N absorbed for the period of the experiment.

In both treatments where nutrients were supplied, there was a gradual drop in N uptake immediately after pruning, the drop being more marked in the treatment where all the leaves were removed. In the plants with foliage, after the initial drop to about 40%, approximately constant quantities of N was continued to be absorbed upto about 45 days. With the progressive increase in foliage of these plants the capacity to absorb and assimilate more nitrogen from the medium was regained. In the plants with no residual foliage, there was some uptake of N for the first 10 days after pruning, but the value dropped to zero thereafter. Fig. 4 shows that, in fact, there was a release of nitrogenous material from these plants about a month after pruning. This was found by paper chromatography, to be due to the release of amino acids from the medium. The release of amino acids was found to coincide with death of the aerial portions, suggesting that death or severe damage to the roots had taken place simultaneously.

Experiment 2

Within three weeks of commencement of treatment noticeable differences were evident between the experimental plants. Plants left with two leaves and supplied with nutrients showed the best growth with early initiation of many buds which grew into shoots that were more succulent, larger and darker than the few buds in the other treatment (Fig. 5). Plants with no residual foliage but receiving nutrients showed delayed bud-break but once sufficient new foliage had been produced, growth of shoots was rapid and no scorch or die-back was noted. However, since the plants left with two residual leaves initiated bud growth much earlier than those in the other treatment, their total growth was comparatively high (Fig. 6).

DISCUSSION

This study has served to emphasize the importance of foliage in the uptake and utilization of N by tea plants recovering from pruning. Removal of leaves affected the uptake of N by the plants, supporting our earlier observations on the effect of leaf area on N uptake (Krishnapillai and Pethiyagoda, 1978). This agrees with the observation made by Kathiravetpillai and Kulasegaram (1977) who have also reported that artificially defoliated young tea plants showed poor response to applied nitrogenous fertilizers than the corresponding undefoliated control plants. While complete removal of leaves resulted in negligible N uptake, a partial removal had enabled the plants to absorb proportionately reduced amounts of N. The leaves, in addition to helping the plants to draw N from the medium would have also played an important role by supplying the necessary carbon skeleton for its assimilation.

Adequate levels of starch reserves in the roots have been suggested to be an important factor for satisfactory recovery from pruning (Priestley, 1962; Nagarajah and Pethiyagoda, 1965). Carbohydrate depletion during recovery from pruning has been attributed to its direct consumption in the synthesis of amino acids (Selvendran, 1971) and also its utilization for other metabolic activities such as 'root respiration' which was shown to be high soon after pruning (Kandiah, 1971). The N necessary for the synthesis of amino acids is absorbed from the medium.

The differences in recovery between plants with and without foliage may be associated with the carbohydrate status of the plants during the time of recovery. Since most of the plants grown under glass-house conditions, produce vigorous growth and fleshy feeder roots, the carbohydrate reserves in their roots are generally low. Plants showing vigorous growth have been found to contain low starch reserves (Alberda, 1957). In such plants, recovery from pruning depends largely on the availability of newly synthesized carbohydrates and therefore those plants which had the capacity to synthesize carbohydrates had grown better by absorbing and utilizing more N from the medium. On the other hand, when photosynthesis was interrupted by complete removal of the green parts (foliage), whatever reserves that accumulated before the pruning would have declined and although the levels of starch reserves might be sufficient to maintain the existence of the plant for sometime, the total recovery was ultimately affected resulting in scorch and die-back. This was further aggravated by the frequent addition of N which would have promoted the rapid utilization of starch reserves and also resulting in the accumulation of unassimilated nutrients to cause direct toxicities as reported by Pethiyadoga (1966). Application of increased quantities of N was found to deplete the starch reserves in tea roots (Krishnapillai and Pethiyagoda, 1979; Selvendran and Selvendran, 1973). It has also been shown that an application of N is of little use in subsequent growth unless the plant has an available supply of carbohydrate or is capable of manufacturing it (Harrison, 1931). Thus, in the absence of current assimilates the available starch reserves in the roots of the clean pruned plants would have got exhausted rapidly thereby starving the plants resulting in scorch and die-back of the new buds and plant itself. The observation that die-back of shoots is often more severe on fields which are more productive and receive generous application of nitrogenous fertilizers support the above findings. In the presence of sufficient 'lungs' on the frame, even in the absence of adequate starch reserves in the roots, the current assimilates produced from the 'lungs' may be rapidly utilized for the various metabolic processes including N uptake and assimilation. Such assimilation from the 'lungs' could also detoxify any free N nutrients getting accumulated within the plants.

The observation trial carried out on pruning while confirming most of the above findings, supplied further information on the carbohydrate - nitrogen relationship. Three important innovations made in this study were:

1. The retention of only two leaves (as against 17 to 20 leaves in the other experiment).

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Fig. 5.— Effect of retention of two foliage leaves on new bud growth at three weeks (Left — without foliage, Right — with two residual leaves of which one is observed in the photograph).

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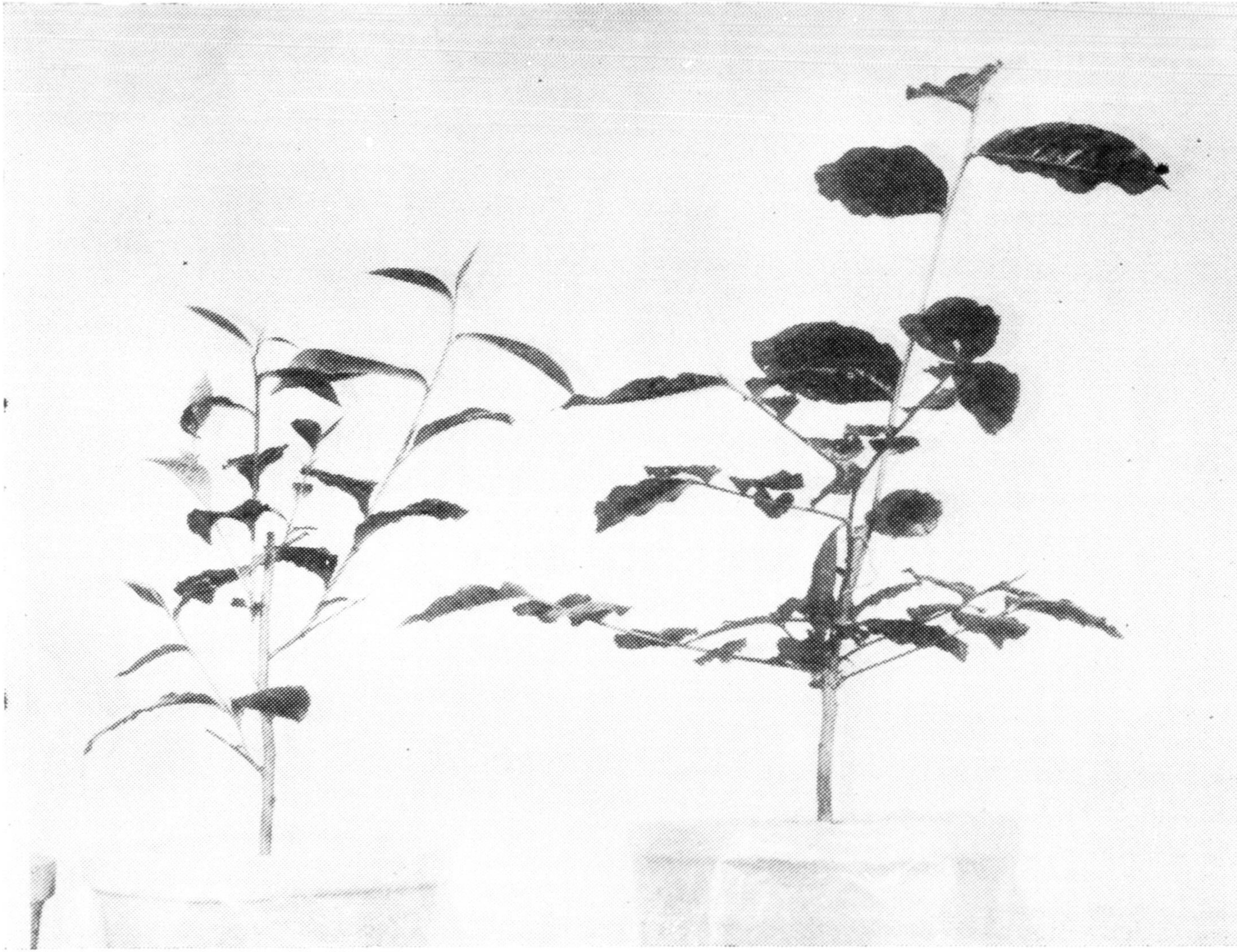

Fig. 6.— Same plants as in Fig. 5, at 3½ months from pruning.

2. The use of plants which were not regularly fertilized for a long period before pruning.

3. The infrequent application of N (twice a week as against daily application) after pruning.

The better recovery of the clean pruned plants in this experiment without any noticeable symptoms of scorch and die-back might be due to the following reasons:

Firstly, by using nutritionally starved plants (plants that received nutrients irregularly and showed N deficiency) sufficient starch reserves might have been allowed to accumulate in the roots and this would have served in the subsequent recovery. By growing plants in water culture lacking N, abundant starch contents have been shown to be present as reserves in the roots of tomatoes and apples (Tiedjens, 1934). Though the root starch of these experimental plants was not estimated at the time of pruning, from the findings of other workers and from the pattern of recovery of the experimental plants it is possible to conclude that these nutritionally starved plants contained sufficient starch reserves at the time of pruning, which could have been subsequently utilized resulting in satisfactory recovery even in the absence of leaves to supply them with newly synthesized carbohydrates. The fact that the presence of even two leaves caused better recovery than in plants with none suggests that additional carbohydrates from these two leaves enhanced N uptake and utilization during recovery.

Secondly, the application of N twice a week would have not depleted the available reserves as rapidly as in the case of daily applications. Under such conditions, even limited quantities of starch reserves may be able to ensure satisfactory recovery. From the results obtained in the present investigation it can be seen that the status of the plants before and the conditions afforded them after pruning are important factors that can greatly affect recovery after pruning.

In field practices, it is usual to avoid N application 2 to 3 months before and after the pruning operation. This practice would enable the plants to build up sufficient starch reserves in the roots before the pruning and also prevents its rapid depletion soon after pruning. Though N fertilizers are not applied during this 4 to 6 months gap, the quantity available through the process of natural mineralisation of abundant amount of organic matter available in the tea soil is probably sufficient for the synthesis of amino acids and proteins used for the initiation and enlargement of buds. However, the vigorous growth that occurs subsequently needs additional application of nitrogenous fertilizers. By this time the recovering plants would have produced sufficient foliage for the uptake and utilization of the applied N.

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