Translocation and Accumulation of Assimilates in Forage Plants

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A series of experiments was conducted using radioisotopic techniques to elucidate the assimilation and translocation of assimilates in ladino clover (Trifolium repens L. race giganteum) which is one of the most popular legumes grown in Japan.

The brief interpretation and summary of main research findings are as follows:

Assimilation and translocation of ^{14}C in ladino clover

The apparatus for treating single intact leaf and the whole plant of ladino clover with $^{14}CO_2$ were made for the following experiments and ^{14}C-assimilates were traced with radioautographs and counting of radioactivities:

1) The direction of the movement of ^{14}C-assimilates are to both sides from the treated leaf showing most clear contrast with translocation of ^{32}P which revealed mainly acropetal translocation[3]. In general, the basipetal translocation of the ^{14}C-assimilates is faster and more dominant than the acropetal in ladino clover.

There are differences among age or position of leaves fed $^{14}CO_2$ in translocation. The younger leaves export their assimilates chiefly to the growing point of the main stem, i.e., acropetal. The older ones transmit assimilates to the older parts of the stolon or lateral buds and roots, i.e., basipetal[4].

2) At the favorable temperature for growth (15° to 25°C), speed of translocation is about 30 cm/hr. At 10°C, speed is reduced and the assimilates move at about 20 cm/hr. The low temperature, particularly below 10°C, reduced the speed of translocation, especially in the case when the plants were exposed to the low temperature suddenly (see Page 167).

3) Assimilates translocate and accumulate to the growing points of the main stem, lateral buds, developing leaves, and roots especially elongating root tips and nodules. It is found that these developing organs are main sinks of ladino clover.

4) The stolons of ladino clover are considered as an important reserve organs of the plant. Although the contents of carbohydrate in the older part of stolons are higher than those of the younger part, ^{14}C-assimilates translocate and accumulate into the younger part of stolons, where the functions of structure formation and storage of reserves are going on in parallel[5].

5) When the growing point of the main stolon was removed, apical dominance disappeared and ^{14}C was distributed to lateral buds near the ^{14}C-fed leaf.

Defoliation of the leaves except the ^{14}C-fed leaf influenced the translocation and distribution of the assimilates. When all the leaves except ^{14}C-fed leaf were defoliated, ^{14}C was translocated and heavily accumulated into the growing point of the main stolon, emphatically showing the apical dominance of distribution.

6) The leaves of ladino clover are one of the strongest sinks at the early stage of development. When developing leaves attain about 65 to 70 per cent of their maximum leaf area, they start the export of assimilates.

In the fully developed leaves the younger the leaves, the higher is the ability of assimilation except leaf Number 1. As for the release rate in respiration, younger leaves utilize a larger portion of assimilates in respiration, and they also retain a higher portion of assimilates in their leaves.

The total amount and rate of translocation of assimilates are the greatest in leaves at the middle stage (leaf Nos. 3 to 6 from growing point), followed by the older leaves.

Translocation of ^{14}C-assimilates in relation to regrowth in ladino clover

The regrowth of forage plants after cutting has great significance on the practical field and a detailed report would be furnished here.

^{14}C was used as a tracer of movement of assimilates in the stage of regrowth after cutting. The following two experiments were conducted.

Experiment 1: Utilization of ^{14}C-reserves by the leaves of regrowth.

By exposing the plants which had abundant leaves, in the assimilation chamber, the reserve assimilates were labeled with ^{14}C. Two days after labeling, all the plants were completely defoliated. Selected plants were harvested at the time of defoliation and others were harvested 1,3,6,9,12,15, and 18 days later.

After havesting the plants, their radioautographs were made and the activity of ^{14}C in newly developed leaves were measured.

Experiment 2: Uptake and export of ^{14}C-assimilates by the newly grown leaves after defoliation.

By cutting plants grown in pots on different dates, plants of different stages of regrowth were prepared. Namely, they were on their 18th, 15th, 12th, 9th, 6th, and 3rd days of regrowth and immediately after cutting. These plants were fed $^{14}CO_2$ for two hours in an assimilation chamber at the same time. The plants were harvested two days after $^{14}CO_2$ feeding, radioautographs were made and ^{14}C activity in various parts of the plants were counted.

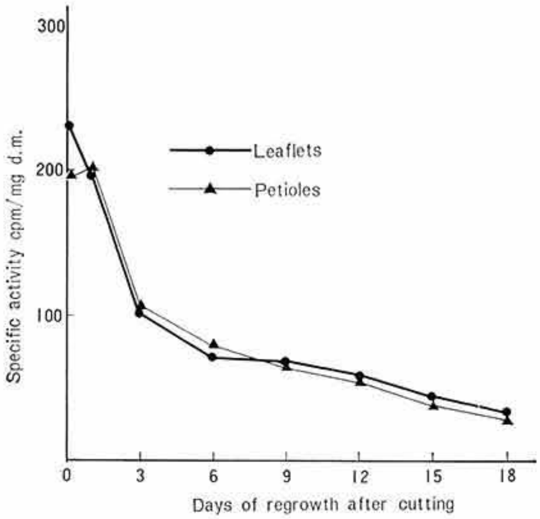

Fig. 1. Changes of specific activity of ^{14}C in the newly developing leaves after defoliation

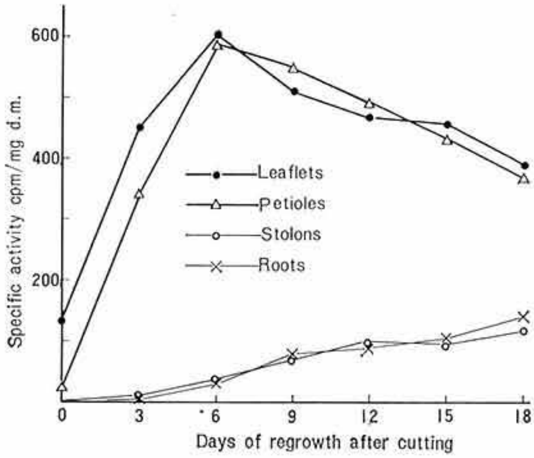

Fig. 2. Uptake and translocation of ^{14}C by plants in the different stages of regrowth

From these experiments, the following conclusions might be induced:

1) Since specific activity of ^{14}C in the newly developed leaves decreased rapidly in the first six days, it seems that new growth of leaves depends mainly on reserves for about one week after defoliation[7] (Fig. 1.).

2) The data on the uptake of ^{14}C by the newly developing leaves and the export of assimilates to reserve organs, namely, stolon and root, showed that the newly developed leaves start to send out assimilates one week after defoliation[6] (Fig. 2.).

These facts indicate that emerging leaves are dependent upon reserve assimilates during their first week of development. Although they continue to utilize reserves during the second week, the young leaves themselves are sending out assimilates during this period and presumably are no longer relying on reserves.

Effect of the environmental factors on the translocation of ^{14}C-assimilates

One of the serious disadvantages of white clover is considered to be its short growing season as compared with companion grasses[2]. To extend the growing season, it is important to understand the feature of assimilation, translocation and distribution of assimilates at low temperature, low light intensity and short-day condition which are related to the climatic condition of autumn, early winter and early spring seasons.

1) The effect of temperature, especially low temperature on the movement of assimilates was examined. When plants grown at 20°C were transferred to low temperature, speed of translocation was reduced, particularly below 10°C.

At 0° to 2°C, and 5°C translocation was almost completely ceased. But plants grown at low temperature, 5°C, showed the adaptation to the condition of low temperature, and the inhibition of the low temperature on the translocation was reduced.

2) When ladino clover was grown at low temperature, it was found that the concentration of soluble sugars in the plant reached a considerably high level, particularly in the leaflets and petioles.

At the favorable temperature, considerable amount of ^{14}C is distributed into structural fractions. While at low temperature the conversion of ^{14}C-assimilates to structural components seemed to be disturbed, thus making higher concentration of soluble sugars in the plant body.

3) In the plants grown at low light intensity, the concentration of TAC (total available carbohydrates) in the leaflets and petioles reduced greatly. And when these plants were fed $^{14}CO_2$, the ^{14}C-assimilates in the plants were heavily accumulated into the leaflets and petioles.

The translocation of ^{14}C-assimilates to the roots was remarkably reduced at low light intensity, particularly in the case of the combination of low light intensity and high temperature.

4) When plants were exposed to long-day condition, the weight of stolon, ratio of branching per node of stolon and weight of laterals were reduced as compared with the plant under short-day condition.

In other words, the long-day treatment reduced the development of such characters relating to persistency of the plant[1]. The large portion of ^{14}C-assimilates was accumulated into the leaves and petiole under long-day condition. And their distribution to the roots and stolon was reduced, especially in the case of the combination of long-day and high-temperature treatment.

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