Variatel Difference of Translocation of Photosynthetic Products between Flue-cured and Burley Tobacco

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Flue-cured tobacco which is used as the main material for aroma and good taste of cigarettes, is widely grown in the western districts from Kanto in Japan. On the other hand, at present, production of Burley tobacco is limited to Tohoku district. Nowadays, the demand of Burley tobacco is increasing not only as the material for harmonizing the taste of cigarette but also as an important material for new blend type of cigarette.

It has been well known as the characteristics of the maturing process of the flue-cured tobacco after topping that, with the progress of the maturing stage, starch is accumulated in the leaves. On the contrary, it was observed that starch content of the leaves of Burley tobacco decreased with the progress of the stage, and that the dry matter was more distributed to the stem and the roots than in the flue-cured tobacco.

Recently, cultivation of Burley tobacco was examined in the warmer districts, i.e. Ibaraki and Okayama Prefecture. As the results, it was found that in these districts the stem of Burley tobacco attached lower number of leaves and the yield was less than in Tohoku district.

As for the effect of light intensity, some differences on the growth and leaf quality were recognized between flue-cured and Burley tobacco varieties. The condition of abundant sunlight is desirable for good quality and high yield of flue-cured tobacco. On the other hand, in Burley tobacco, it is found that the shading gives negative effect on the yield but not large effect on the quality.

Materials and Methods

Materials

Two varieties of tobacco, Nicotiana tabacum L., Hicks and Burley 21 were grown by water-culturing in a green house. These plants in various stages (1.5~20.5 cm in height) were used as experimental materials. In all the experiment, $^{14}$CO$_2$ was administered to the fully expanded leaf, the area of which was the largest of all leaves in the plant.

Feeding of $^{14}$CO$_2$

A part of the mesophyll of the fully expanded leaf was exposed to 10 μCi $^{14}$CO$_2$ for 10 min. The apparatus for $^{14}$CO$_2$ feeding was shown in Fig. 1. The method of $^{14}$CO$_2$ feeding was described in the previous reports.

During the period of $^{14}$CO$_2$ feeding, the light intensity on the surface of the fed leaf was controlled to 50,000 Lux by iodine lamps in the growth cabinet.

Plant sampling and counting of radioactivities

After $^{14}$CO$_2$ feeding, the plants were allowed to stand for 60 min at 27°C and under the required various light intensities. In the case of the dark treatment, the plants, after $^{14}$CO$_2$ feeding, were transferred in a box and covered with
the dark cloth to keep out the light irradiation.

At 60 min after \(^{14}\)CO\(_2\) feeding, the fed leaf, the other leaves except the fed leaf, the stem and the roots were sampled and killed with hot 99\% ethanol. These samples were homogenized in a Waring Blender, and 80\% ethanol-soluble fraction was introduced into a vial with 10 ml of liquid scintillator solution (PPO 5 g, POPPOP 0.1 g, toluene 700 ml, ethanol 300 ml).

The 80\% ethanol-insoluble fraction was dried under infrared lamps and ground by hand in a mortar. An aliquot of the powder was admitted into 10 ml of liquid scintillator solution for emulsion and gels (PPO 5 g, POPPOP 0.1 g, Cab-O-Sil 40 g, toluene 1,000 ml) in a vial. The radioactivities were measured by a liquid scintillation counter (Beckman LS-200).

RESULTS

Table I shows the total amounts of the \(^{14}\)C fixed by a part of mesophyll of the fully expanded leaf of Hicks and Burley for 10 min under 50,000 Lux light condition. As seen in this table, the amount of the \(^{14}\)C fixed by the leaf of Hicks was slightly larger than those of Burley. Table I also indicates the difference of the amount of the \(^{14}\)C recovered in the 80\% ethanol-insoluble fraction.

The \(^{14}\)C fixed by the leaf of Burley 21 was more distributed to the 80\% ethanol-insoluble fraction compared with that of Hicks. The time-course of the \(^{14}\)C-export from the fed leaf of Hicks under the light and dark condition is shown in Fig. 2. During 120 min after \(^{14}\)CO\(_2\) feeding, the \(^{14}\)C was more exported from the fed leaf under the light condition than under the dark condition; however, little difference was observed after 180 min. It is remarkable that the positive effect of light on the \(^{14}\)C-export is recognized for initial 60 min. Consequently, in the following experiment, the comparison of the \(^{14}\)C-export was carried out for 60 min after \(^{14}\)CO\(_2\) feeding.

Table II shows the distribution of the \(^{14}\)C translocated from the fed leaf to other organs of both varieties. In the younger stage (stem length; 1.5~8.2 cm), of both varieties, the \(^{14}\)C exported from the fed leaf was mostly distributed to the roots. In the older stage) stem length; 20.5~25.0 cm), most of the exported \(^{14}\)C was distributed to the organs other than roots.

It is considered that the change of \(^{14}\)C-distribution in the whole plant with the progress of the stage shown in Table II may be due to the increase of leaf number and elongation of stem, both of which work as sinks. Fig. 3 shows the amount of the \(^{14}\)C exported from the fully

<table>
<thead>
<tr>
<th>Varieties in various stages</th>
<th>Stem length cm</th>
<th>The radioactivities of (^{14})C/cm(^2)</th>
<th>(^{14})C recovered in the 80% ethanol-insoluble fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hicks</td>
<td>3.8</td>
<td>191.3 (\times 10^{-4})</td>
<td>227.7 (\times 10^{-4}) 40.0</td>
</tr>
<tr>
<td>Burley 21</td>
<td>3.5</td>
<td>178.3 (\times 10^{-4})</td>
<td>287.9 45.6</td>
</tr>
<tr>
<td>Hicks</td>
<td>8.2</td>
<td>52.1</td>
<td>288.7 32.2</td>
</tr>
<tr>
<td>Burley 21</td>
<td>7.2</td>
<td>45.1</td>
<td>279.3 41.1</td>
</tr>
<tr>
<td>Hicks</td>
<td>25.0</td>
<td>56.4</td>
<td>413.9 42.7</td>
</tr>
<tr>
<td>Burley 21</td>
<td>20.5</td>
<td>43.4</td>
<td>308.3 50.1</td>
</tr>
</tbody>
</table>
Fig. 2. Effect of dark treatment on the export of $^{14}$C from a fully expanded leaf of tobacco plant. Hicks

expanded leaf of Hicks and Burley 21. It was observed, as shown in Table II and Fig. 3, that the $^{14}$C was always more exported from the fed leaf of Burley than from that of Hicks, and that this tendency became more remarkable with the progress of growth stage.

The effect of light intensity on the export of $^{14}$C from the fed leaf during 60 min was studied under various light irradiation (Fig. 4). As the result, it was observed that the light promoted the export of the $^{14}$C from the fed leaf in both varieties, and that the $^{14}$C was more exported from the fed leaf of Burley 21 than from that of Hicks at 50,000 Lux. The import of the $^{14}$C from the fed leaf into the roots increasing light intensity in both varieties, and this stimulative effect of light was more conspicuous in Burley 21 than in Hicks (Fig. 5). At the light intensity of 50,000 Lux, the amount of imported $^{14}$C in the roots of Burley 21 attained two times of that in Hicks.

**Discussion**

It was observed in the field experiment by Araiba et al., that carbohydrate content in the leaves of Burley 21 decreased gradually during

![Fig. 3. Export of $^{14}$C for 60 min from a fully expanded leaf of tobacco plant.](image)

![Fig. 4. Effect of the light intensity on the export of $^{14}$C from the fully expanded leaf.](image)
the maturing stage and it increased in the leaves of Hicks, and that the dry matter of Burley 21 was more distributed to the stem and roots than that of Hicks. In the present experiment, the $^{14}$C fixed by a fully expanded leaf of Burley 21 was more exported for 60 min to other organs than that of Hicks. It is noticeable that the results obtained using water-cultured tobacco in various growth stages before flower budding are consistent with the data of comparative studies with field tobacco by Araiba et al. Therefore, it is confirmed to be an inherent character that the export of photosynthetic products from the leaves of Burley is more active than from the leaves of flue-cured tobacco.

As seen in Fig. 2 and 4, the light enhanced the export of $^{14}$C during 60 min after $^{14}$CO$_2$ feeding in both varieties. Many workers have paid an attention to the effects of light upon the translocation of photosynthetic products. Promotive effect of light on the translocation was found in soybean, in wheat, and in sugar cane. On the other hand, opposite results were observed in potato, in the seedling of soybean, and Vernon et al. showed that the light had no effect on the translocation from soybean leaves. It seems that these contradictory results are due to the kind of plant used as experimental materials, and to the period from feeding of $^{14}$C to sampling. However, the fact that the light gives a promotive effect on the $^{14}$C-export for a early period as shown in Fig. 2 is not contrary to the data obtained by Hartt and Fujiwara et al.

The results shown in Fig. 4 resembles to the data found by Hartt who demonstrated the concept of phototranslocation on the basis of finding that very low light below the compensation point had an promotive effect on the basipetal translocation. For clarification of this problem, however, further studies are required.

The data in Fig. 4 and 5, indicate that light intensity gives positive effect on the translocation of $^{14}$C from fed leaf to roots rather than on the amounts of the $^{14}$C-export. This phenomenon lead us to the suggestion that light might have an effect not only on the export from source leaf but also on the function of roots as sink. In the present experiment, varietal differences between Hicks and Burley 21 were observed on the amount of the $^{14}$C fixed, on the distribution of $^{14}$C to the 80% ethanol-insoluble part, on the amount of the exported $^{14}$C from a fully expanded leaf, and on its response to light.

For clarification of light effect on the growth and leaf quality of these varieties, further studies are required from the site of photosynthesis and translocation of photosynthetic products.

**Summary**

To make clear the difference of translocation pattern of photosynthetic products between flue-cured tobacco and Burley tobacco, $^{14}$CO$_2$ was exposed to a part of fully expanded leaf of two varieties, Hicks and Burley 21, water-cultured in a green house, and the $^{14}$C exported from the fed leaf to other organs was traced under various light conditions.

Results obtained were summarized as follows. At 50,000 Lux, the $^{14}$C fixed by a fully expanded leaf of Burley 21 was more exported to
other organs, especially to roots, in comparison with that of Hicks. This difference between two varieties became more remarkable with the progress of growth stage.

\(^{14}\text{C}\)-export from the fed leaf of both varieties was more active in the light condition than in the dark condition. With rising light intensity, the translocation of \(^{14}\text{C}\) from the fed leaf into roots increased in both varieties. In this case, light had more promotive effect on the import of the \(^{14}\text{C}\) into Burley roots than into Hicks roots.

**Literature Cited**


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【和文 摘 要】
黄色種タバコとバーレー種タバコにおける光合成生成物の品種間差異

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黄色種タバコとバーレー種タバコにおける光合成生成物の品種間差異を明らかにするために、温室で水耕栽培した Hicks と Burley 21 の最大葉の一部に 14CO2 を供与し、供与葉から他の器官への 14C 移行を種々の照度条件下で追跡した。

得られた結果は次のとおりである。
50,000 Lux では、Burley 21 の最大葉で固定された 14C は、Hicks の場合に比べ、他の器官、とくに根へ、より多く転流した。両品種におけるこの相違は、生育 stage が進むにしたがって、より顕著になった。
両品種の供与葉から他の器官への 14C 転流は、光によって促進された。照度の増大とともに、14C 供与葉から根への転流は、両品種とも増大した。この場合、光は、Hicks に比べて、Burley の根への 14C 移行にたいし、より促進的効果を与えた。