RELATION BETWEEN RESPIRATION AND TRANSLOCATION OF PHOTOSYNTHETIC PRODUCTS

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By

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In the experiment of translocation of photosynthetic products to roots from the leaf blade in barley plants, as seen in the former report (1), it was found that the greatest translocation rate was obtained when the top was maintained in an optimum temperature for photosynthesis and roots for its respiration.

Having maintained the root in an optimum temperature for its respiration, however, dose not always implies a direct relationship between the translocation and the respiration. If the root has a capacity for receiving and accumulating the photosynthetic products, it is considered that it requires energy in the process and the most of it is generated by respiration. Up to the present, no studies have been reported concerning the relation between roots respiration and transport. In order to clarify the point, the following three experiments were caried out.

Experimental

1) On the relation between pH of medium and translocation.

It is necessary for the normal growth of many crops to maintain pH of soil in neutral or 5.0 to 6.5 in water culture. This optimum pH has been regarded to be necessary to keep the physical and chemical form of the nutrients suitable. Up to the present time, nothing has been reported on the effect of pH to the influx of photosynthetic products into the roots.

The roots of barley plant seedling were immersed in buffer solution of pH 4—10, and the translocation rate to the root was measured by incorporating $^{14}CO_2$ from the top. Migration period was two hours, intensity of illumination was 30,000Lux and the temperature in both top and root was 25°C.

On the other hand, O_2 uptake of excised roots was measured by a Warburg's manometer. These experimental results are shown in Fig. 1. As seen in Fig. 1, ^{14}C accumulated in the root decreases in proportion with the lowering of pH. but no remarkable change was seen in the range of pH 6—8. ^{14}C exudated from the root was greatest in pH 6 and it diminished above and below pH 6. The

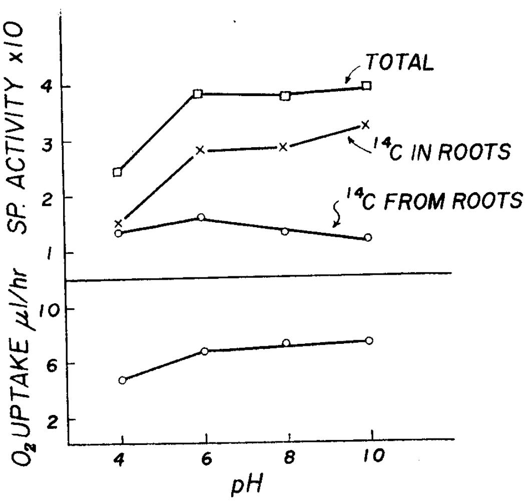

Fig. 1. Effect of pH on the rate of translocation.

apparent rate of translocation, summed up the radioactivities accumulated and exudated per unit time, declined in low pH and slightly rose in high pH.

In the measured results of O_2 uptake by the manometer, the respiration of roots was not so remarkably affected by the medium of pH 6-10 as pH 4. After all, when the medium is acidic, respiration decreases and at the same time the translocation from the top to the roots decreases. Many observations have been made on the cases of cultivating the plants in different pH medium, in which the ratio of the roots to the top in dry weight is quite different. The result made it possible to conclude that the ratio between roots and to decreases according to the tendency towards acidity. One of the reasons of this is, as in this experiment, regarded to the decline of capacity of the roots to receive the photosynthetic products. In other words, the decreases of dry weight of the roots in low pH is due largely to the decrease of quantities of photosynthetic products to translocation and not to the great loss in roots respiration.

2) The effect of inhibitors on transport:

As mentioned above, the transport rate was affected by the ability of roots respiration, then the experiment with inhibitors were carried out for confirming this phenomenon. The kinds of effect produced by inhibitors to the distribution

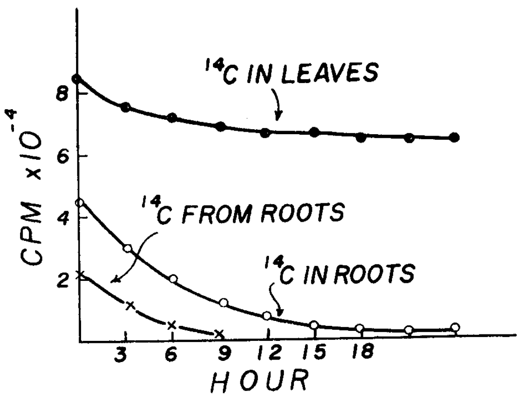

Fig. 2. Effect of monoiodoacetate on the rate of translocation.

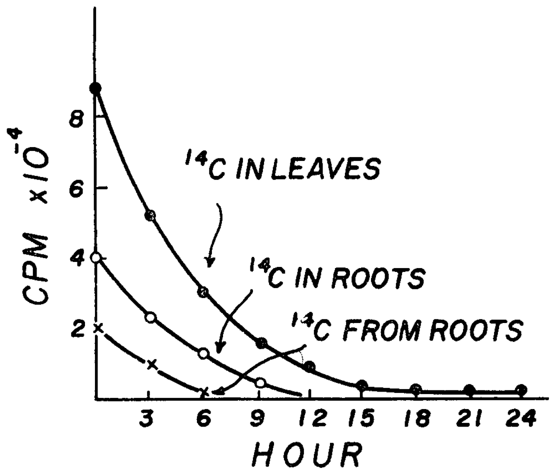

Fig. 3. Effect of sodiumazide on the rate of translocation.

of fixed ^{14}C compounds were observed. For inhibitors monoiodoacetate and sodium azide were used. To the medium were added inhibitors before carying out experiments.

The distribution of ^{14}C was largely varied by the immersion period of the roots in the inhibitor solution. ^{14}C in the leaf blade and roots and activities of ^{14}C liberated from the roots are shown in Fig. 2 and 3. The abscissa indicates the period of roots immersion in the inhibitor, and radioactivity is shown in an ordinate. The period immersed in the inhibitor implies the velocity of inhibitor penetration to the roots, but in case of long immersion period it is sent to the top and inhibits the photosynthesis. In case of monoiodoacetate especially the inhibitory action to photosynthesis was large. Even in the short period within an hour in which no effect is produced on photosynthesis, 30 per cent inhibition of receiving ability of the roots was observed at 10^{-3} Mol in monoiodoacetate and 10^{-2} Mol in sodium azide. No effect was seen at 10^{-6} Mol.

3) The effect of removal of the roots tips on translocation:

As have been cleared by the experiment on temperature, pH and inhibitors, it is supposed that the receiving of the photosynthetic products is related to the metabolism of the roots. If true, it will be necessary to observe the receiving ability of the roots when the roots tips which are the most active section in the roots were cut off.

First $^{14}CO_2$ was incorporated in the leaf blade of the seedling of normal barley plants, and the receiving ability of the roots tips were observed by measuring the distribution of ^{14}C in the root after 3—12 hours interval. As seen in Fig. 4, it could be observed that the radioactivity in the roots was increasing with the lapse of time, and this was evident in the tips of the roots.

Second, the rate of transport was observed by incorporating $^{14}CO_2$ into a leaf blade of the seedling of barley plants whose every tips of the roots were

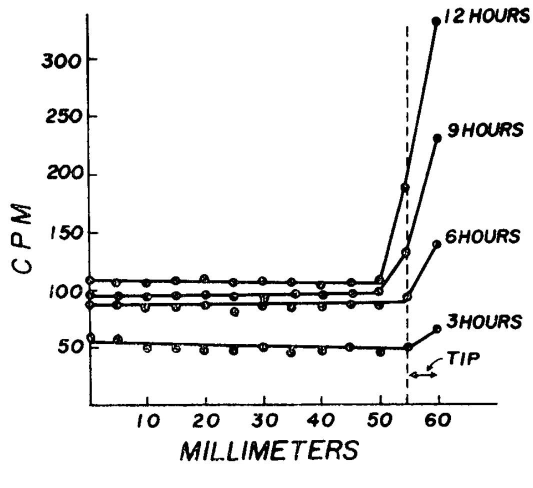

Fig. 4. Distribution of ^{14}C in the roots.

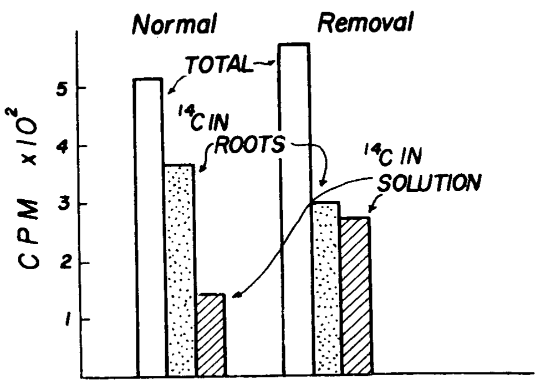

Fig. 5. Effect of the removal of root tips on the translocation.

cut at 5mm.

The effect caused by cutting the tips off was, as can be seen in Fig. 5, less than had been expected. The receiving ability was far from diminishing by the removal of roots tips and ^{14}C released outside was much more than the normal one. As seen in this experiment, it is not considered as the roots tips have no important effect on the translocation of photosynthetic products to the roots.

Discussion

The translocation of photosynthetic products can not be explained as a simple physical diffusion in general. The main reason is that the velocity of transport is much greater than the one of diffusion (2). There is no difinite opinion for the reason why such a velocity is caused, however, it can be supposed that it will be accompanied by some supplying reaction of energy.

Kursanov and others discovered several kinds of enzyme system in vascular bundles, and suggested that they might be important on the process of translocation (3).

The experiments on temperature, pH and inhibitors revealed that the rate of translocation was increased with active respiration of the roots. Therefore, it is supposed that a relationship between the translocation and the ability of supplying reaction of energy in the receiving organ may exist. There results, however, the fact that not only the active cells in the roots tips are due to the supplying of its energy.

Gage and Aronoff, in their investigation on soybean plants, carried out an experiment of cutting off the roots tips, however, no decisive result was obtained (4). This perhaps is due to the method in which ^{14}C exudated from the roots was not measured.

Summary

For making the photosynthetic products move smoothly from the leaf blade to the roots in barley plants, it was necessary for the medium pH to be maintained above 6. In pH 4, O_2 uptake of the roots was found to be declined and the translocation to the roots diminished with it.

A remarkable inhibition was found in the translocation by adding monoiodoacetate or sodium azide to the medium.

By cutting the roots tips no differences were observed in the transport rate to the entire roots.

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