CARBOHYDRATE METABOLISM IN CUTTINGS DURING ROOTING

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The interest for a possible role of carbohydrates in controlling rooting of cuttings originates from an observation, that tomato stem segments which had a high C/N ratio produced most adventitious roots (8). Although many experiments have been performed since then to test this hypothesis, its validity is still uncertain. One of the main obstacles is how to produce stock plants with different levels of carbohydrates.

Veierskov, et al. (9) found no apparent correlation between C/N ratio and root number in the cuttings, when using seedlings with different reserve nutrients and growing the plants under different light levels. However, altering the environment under which plants are grown, may also change important growth stimulants which makes it difficult to distinguish between the role of carbohydrates and the environmental impact. By use of pea plants with genetic lesions in their photosynthetic apparatus, it was possible to grow the plants under identical environment, and obtain plants with different levels of carbohydrates. When these cuttings were rooted, a correlation between the level of carbohydrates and root number was observed within any of the cultivars tested, but it was not possible to correlate a given level of extractable carbohydrates to a given root number, independent of cultivar (10). It is thus possible that the carbohydrate status might influence rooting of cuttings.

In order to have a horticultural significance, it has to be possible to alter the carbohydrate status of the stock plants in practice. It is not easy to try altering the photosynthetic capacity of plants directly. It has however, been observed that carbohydrates accumulate in nutrient deficient plants. Although nutrient deficiency causes diminished photosynthetic capacity, the plants accumulate large amounts of soluble carbohydrates (3). That the best rooting in cuttings was obtained when the stock plants were grown at a nutrient level below what was optimal for growth, has been observed in several nursery plants (7). The beneficial effect of growing stockplants at suboptimal nutrient supply may thus be an increase in the level of soluble carbohydrates, which in turn may facilitate root formation.

When nutrients are limiting, the photosynthetically fixed CO_2 will first go into the carbohydrate pool, then it can not be metabolized further because most organic compounds contain nitrogen, phosphate or sulphur. In this case the plant transports the carbohydrates as sucrose to long term storage locations such as the stem. Because cuttings do not have an active root system, they are unable to take up minerals, and therefore, as soon as the initial free reserves are utilized, either growth must cease or the necessary minerals have to be mobilized from organic materials. If the latter situation occurs, we observe the changes similar to senescence, which is the initial steps to death.

Although the initial level of carbohydrate may influence the subsequent rooting, more interest is put into how the cuttings behave during the rooting period. How an intact plant responds to the environment with regard to photosynthesis and carbohydrate metabolism has during the years been thoroughly investigated. In cuttings, however, our knowledge is more limited. Inasmuch as a cutting may look as an intact plant without roots, major changes occur in its physiological behaviour. It is a well observed fact that elongation of the stem decreases during root initiation, whereas dry weight increases when compared to similar tissue not made into cuttings (4). Concurrent with the increase in dry weight is a large accumulation of carbohydrates observed in all parts of the cuttings (4, 9).

Though the initial carbohydrate level of the cuttings has been given some attention, most work has been concentrated on what is occurring in the cutting during the rooting period. When cuttings are compared to attached shoots, the first carbohydrates to accumulate are the soluble sugars, followed by starch (5, 9). The accumulation of carbohydrates happens immediately after excision in photosynthetic tissue, whereas a lag period, or even a decrease is observed in the basal part.

The total level of carbohydrates in pea cuttings increased from about 8% of the dry weight to 20% during the root initiation period. Since the increase in dry weight in the cuttings is larger than the one observed in seedlings (4), either an increased photosynthetic rate has occurred, or the respiratory rate has decreased. Net photosynthesis has been determined in pea cuttings, and shows a decrease of ⅔ in the period until the root emerges (2).

Although this author was unable to find major changes in respiration, other work has shown that dark respiration decreases to 25% of the initial level during the first 24 h after excision of the cutting (1). It was notable that the decrease in dark respiration was dependent on the irradiance at which the cuttings rooted. It was shown that, independent of how little light the cuttings received, the dark respiration decreased such that the cuttings could maintain a positive net photosynthesis. It seems to be of importance for the cuttings to ensure accumulation of carbohydrates during the rooting period. A reason for this may be that many biosynthetic processes that are necessary for adventitious rooting are coupled to energy consumption.

Determinations of the energy level (ATP) during rooting has shown, that the amount of ATP doubles in the base of the cuttings, during the first days. If the cuttings had been treated with auxin which caused the root number to triple, a 5-fold increase in the ATP level was observed (6). These results, and experiments by others, indicated that one important role of auxin is to make carbohydrates available in the base of the cutting. Carbohydrate then ensures that a high ATP level can be maintained. Many biochemical reactions require a high energy level before they can occur. The increased ATP level in the base of the cuttings may thus be the reason for those alterations in metabolism that initiate the rooting process.

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