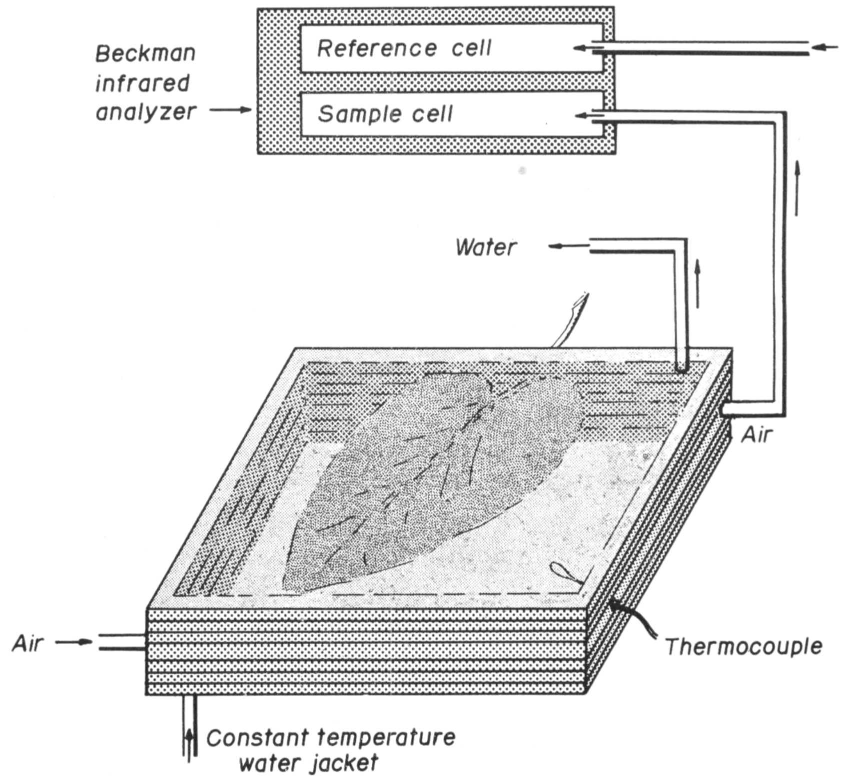
SOIL MOISTURE AFFECTS PHOTOSYNTHESIS

L. H. STOLZY · O. C. TAYLOR · J. P. MERSEREAU

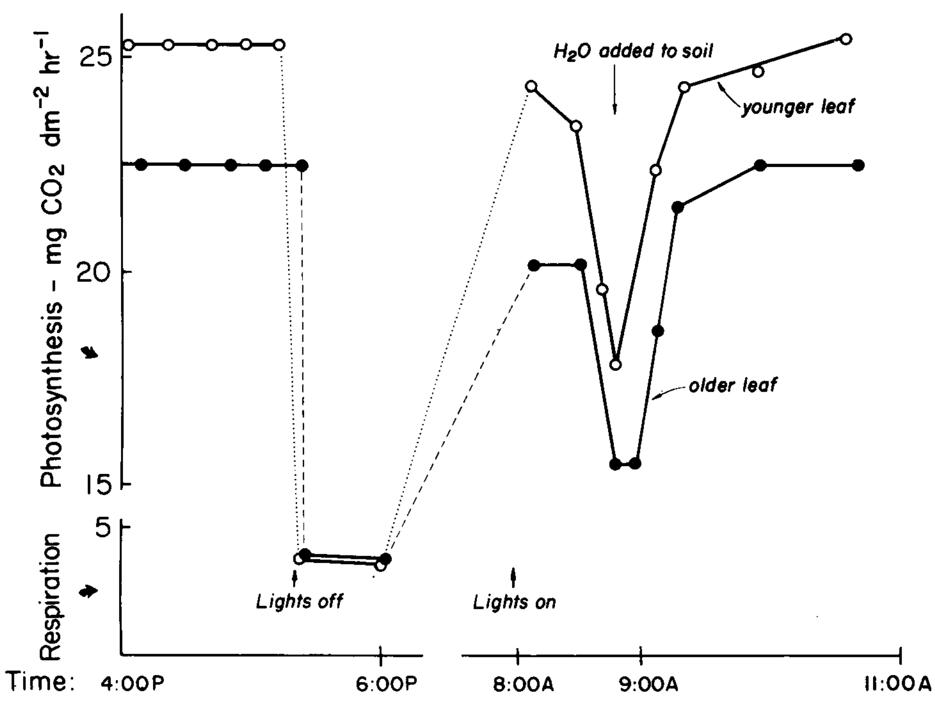
THE DEVELOPMENT of better soil and water management procedure requires understanding of plant response to various soil water relationships. It is especially important to know how the water status of plants, as affected by soil suction, influences the rate of important metabolic and synthetic reactions. This paper reports the results of a preliminary study on the effects of soil water content on the rate of photosynthesis, the exceedingly important reaction through which plants manufacture carbohydrates from atmospheric carbon dioxide (CO_2).

Several previous studies have shown that the rate of CO_2 fixation in plant leaves is greatly reduced when the soil is very dry and the leaves are wetted. This has been explained as due to stomatal closure, which prevents the entry of CO_2 into the leaf. The present work showed large reductions in apparent photosynthesis to occur as the soil dried out, but before obvious wilting took place. This suggests that some factor, other than stomatal closure, related to low soil water content may restrict the rate of carbohydrate synthesis in plants.



Leaf chamber and infrared analyzer arrangement for studying apparent photosynthesis of an individual plant leaf.

CO_2 FIXATION RECORD OF TWO MATURE TOMATO LEAVES, ONE MORE RECENT THAN THE OTHER



Leaf chambers

To study the influence of soil dryness on the rate of apparent photosynthesis, leaves of a tomato plant growing in soil were placed into specially built chambers so that ingoing and outcoming concentrations of CO_2 could be measured.

Leaf chambers were constructed of 1/8-inch lucite sheets as shown in the illustration. A water jacket on both sides of the leaf controlled leaf temperature at 29°C. The chamber was designed so air could be pulled through, passing both over and under the leaf, and out the other corner of the chamber. A portion of the incoming air was passed through the reference cell of the Beckman infrared CO_2 analyzer. A similar flow of air which had gone through the chamber was passed through the sample cell of the infrared analyzer. The difference in CO_2 content of these two air streams was recorded. This difference is the amount of CO_2 fixed by the plant.

Studies on tomato plants were carried out in a 24-cubic-foot growth chamber maintained at a daytime temperature of 29°C, a nighttime temperature of 24°C, and a relative humidity of 50 to 70%. The light source was from 26, 8-ft VHO-Sylvania fluorescent lamps (22,000 to 24,000 luxes at plant height).

Two leaves of a four-week-old tomato plant were placed into the leaf chambers. The soil containing the roots of the plant was watered so that 70% of the soil pores were filled. The rate of apparent photosynthesis was recorded for a period of four days for both leaves. The graph shows a part of the CO_2 fixation record for two days.

During the first two days, the rate of apparent photosynthesis for the leaves increased slightly. The morning of the third day, CO_2 fixation was less after the lights came on than it was during the previous day. In less than an hour, there was a significant decrease in CO_2 fixation. Water was added to the soil and within a very few minutes CO_2 fixation by both leaves increased. The older leaf responded slower than the younger leaf. Within two hours both leaves were fixing CO_2 at a slightly higher rate than the day before. No visual symptoms of wilt occurred during the study.

The relationship of CO_2 fixation to soil suction, relative humidity, and the conductivity of unsaturated soils is being further investigated.

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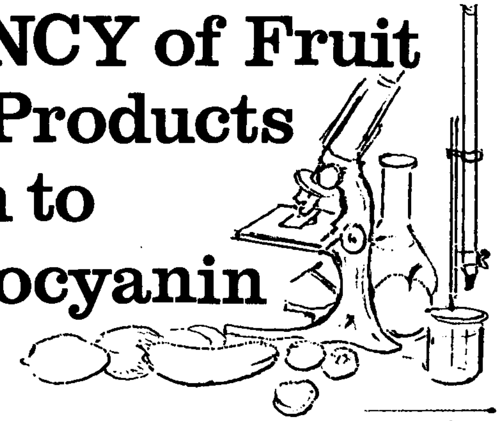
ASTRINGENCY of Fruit and Fruit Products in Relation to Leucoanthocyanin Content



M. A. JOSLYN · JUDITH L. GOLDSTEIN

THE LEUCOANTHOCYANINS occupy an important position among the water-soluble organic compounds present in the tissues of plants. They have been implicated as being responsible for the astringent taste of unripe fruits. They are responsible for the chill haze that develops in beer and for the browning of white wines. The desirable fullness of taste and body of such juices as apple, berry and grape and of fruit wines is also attributed to the astringent effect of the leucoanthocyanins. They influence the storage stability of wines and juices.

The toxicity of feeds such as Korean Lespedeza hays and carob bean meal is related to the tannins present. The presence of these compounds in fruit and plant tissue so far has been largely detected qualitatively from the anthocyanin pigment they form on heating with mineral acids. Pure leucoanthocyanin preparations have been isolated only from woody tissues, from cacao beans and recently from Japanese persimmon fruit. The chemistry and physiology of leucoanthocyanins, and related phenolics has been under investigation since 1952.

Histological examination

When examined histologically, the leucoanthocyanin and related phenolic substances were found localized largely in the vascular bundles or in isolated "tannin cells" in apple, apricot, banana, peach, pear, prune, grape, persimmon and carob tissue harvested at the immature stage, when the fruit was quite astringent. When cut, the phenolics in these tissues readily diffused out of the tannin cells so that the whole tissue became colored, when tested with specific phenolic reagents. During ripening, the total phenolic content appeared to be less, and the phenolics in the tannin cells of banana, carob, and persimmon fruit no longer diffused out.

The extractability of the fruit leucoanthocyanins in the usual organic solvents decreased in ripening. This was particularly true for methanol. The total extractable leucoanthocyanin content of unripe fruit ranged from 250 mg per gram of dry weight for green carob pods, and 200 for astringent persimmons, down to 10 to 20 for such fruit as bananas, plums, and peaches. In ripe fruit these levels dropped to 20 for carob pods, to 70 for persimmons and to 5 for bananas. While the anthocyanin pigment formed from the leucoanthocyanin of apples, grapes, peaches, and pears is cyanidin, that formed from the leucoanthocyanin of the highly astringent bananas, carob pods, dates, and persimmons is delphinidin. In green astringent cacao beans, however, the anthocyanin pigment generated is cyanidin.

Phenolic compounds

The phenolic compounds actually responsible for astringency, feed toxicity or food acceptability and stability have not been isolated and characterized. The physiological basis of the sensation of astringency also has not been defined, but preliminary observations have provided clues which are reported here because of their wide interest.

A dry puckery sensation is perceived in the mouth upon ingestion of such unripe fruits as persimmon, banana or dates. This sensation is well defined by a dry feeling in the mouth. The immediate reaction is to rinse the mouth out with water, not in thirst, but in an attempt to bring relief. Unfortunately this treatment is of no avail and the feeling of dryness or tightness persists. Although astringency is perceived in the mouth, it should be