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Photosynthesis of Papaya as Affected by Leaf Mosaic

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INTRODUCTION

In southern and southwestern Puerto Rico, papaya (*Carica papaya*) is subject to a mosaic disease that reduces growth and yield so seriously as to limit commercial development of the crop. The disease is caused by a virus that is carried by the green citrus aphid (*Aphis spiraecola*, Patch) (*1*)[3].

Leaves of diseased plants (fig. 1) are irregularly mottled with light yellowish-green, are small in size, and often deformed to the degree of being distinctly filiform. Although photosynthetic capacity of mottled leaves would be expected to be subnormal, experimental evidence of the impairment is lacking and is the subject of this report.

METHODS AND MATERIALS

The apparatus (fig. 2) used for measuring apparent photosynthesis was essentially a duplicate of one described earlier (*2*). It consisted of a leaf chamber, a small air pump, and an infrared gas analyzer in closed series.

The leaf chamber was the top of a 15-cm. petri dish that rested on a horizontal base of rigid sheet iron. The dish had notches cut in the rim to accommodate a petiole and a thermometer. Air-sampling and return tubes were fixed in the chamber base. Air temperature in the chamber was regulated by manual control of the flow of cold tapwater through loops of copper tubing soldered on the underside of the base plate.

Illumination was provided by a 300-watt internal-reflector spot lamp fixed rigidly 20 cm. above the chamber. A flat-bottomed glass dish containing 50 mm. of cold water served as a heat filter between lamp and leaf chamber. Water in the filter was cooled by a loop of copper tubing through which cold tapwater flowed. A single sheet of thin white paper (onion skin)

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[3] Italic numbers in parentheses refer to Literature Cited, p. 150.

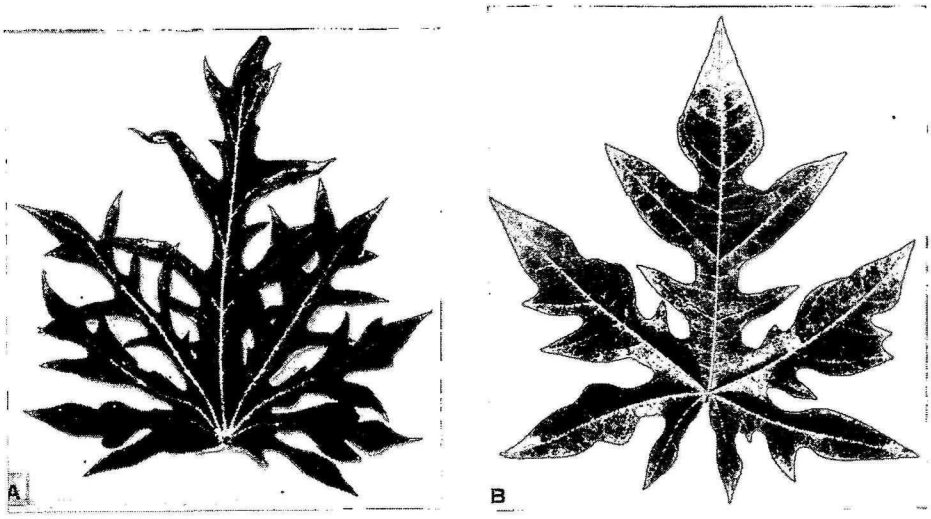

FIG. 1.—A, Papaya leaf displaying typical symptoms of papaya mosaic; B, normal papaya leaf.

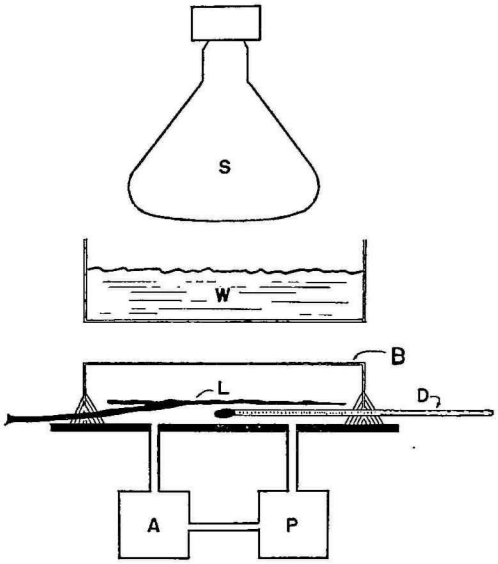

FIG. 2.—Diagram of the apparatus for measuring photosynthesis used in this work. Intact leaf (L) is sealed under glass dish (B) with modeling clay. Air is pumped (P) from chamber to analyzer (A) and back. Leaf is illuminated by overhead spot-lamp (S). Glass dish of water (W) acts as a heat filter. Thermometer (D).

was placed on top of the chamber as a diffuser. Light intensity ranged from 4,400 foot-candles at the center of the chamber to 2,400 near the edges.

The air pump was of the pulsating diaphragm type (Thiberg No. 1). It circulated air between chamber and analyzer at a rate of about 1,000 ml. per minute.

The gas analyzer was a model 15A Liston-Becker. It indicated continuously the CO_2 concentration of the system. The sample stream of air returned unaltered to the leaf chamber. The rate of decrease of concentra-

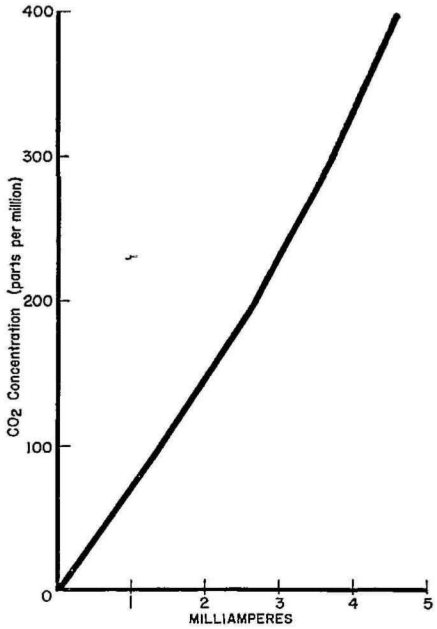

FIG. 3.—Calibration curve utilized for the infrared gas analyzer.

tion in the system was a direct measure of rate of uptake of CO_2 by a leaf, that is, of apparent photosynthesis.

The analyzer was calibrated as follows: Zero was set as the equilibrium reading obtained by recycling air through a system consisting of the analyzer, pump, and a scrubbing bottle of aqueous NaOH. The sensitivity control was then set so that a reference gas (compressed air containing about 344 p.p.m. of CO_2) gave a convenient reading, 4.1 ma. Next a recycling system consisting of a 2,400-ml. flask, pump, analyzer, and scrubber was set up and was run for about 20 minutes, 10 minutes after the analyzer indicated no CO_2 in the system. The scrubber was removed and the system

was run for several minutes to test for last traces of CO_2. The pump was stopped. A pre-set syringe fitted with a 27-gage needle was used to inject 0.251 ml. of CO_2 directly into the closed system through thick-wall rubber tubing. The pump was started and the equilibrium reading taken. The volume of the system was 2,510 ml.; thus, injections increased concentration in steps of 100 p.p.m.

The procedure was repeated and a calibration curve was drawn (fig. 3). Although the analyzer was slightly sensitive to water vapor (the difference between readings for dry and saturated nitrogen was equivalent to 20 p.p.m. of CO_2), measurements of changes of CO_2 concentration are free of error due to changes of humidity because the system remained constantly saturated, or nearly so.

The routine operating procedure was as follows: A leaf still attached to the plant was sealed in the chamber with modeling clay and left, with the system closed and operating, for 10–20 minutes at 32° C. and about 4,000 ft.-c. before measurements were started. An excess of CO_2 was added. Surges caused by the rapid introduction of CO_2 smoothed out in about 1 minute, then concentration began to fall smoothly and rapidly as the leaf removed CO_2 from the system. The fall was timed over a fixed interval of concentration, and the procedure was repeated until the apparent photosynthetic rate became constant.

Quintuplicate runs were made with 10 leaves of 5 healthy plants and with 10 leaves of 5 diseased plants. The plants were potted seedlings about 4 months old and from 50 to 60 cm. tall. They had grown in 15-cm. clay pots under natural light in a greenhouse. On December 6, 1956, some were inoculated by abrasion of leaves with carborundum powder and an inoculum extracted from diseased leaves. At the time of the experiments reported here (February 5 to 7, 1957) all inoculated plants showed characteristic symptoms of papaya mosaic, and all control plants appeared normal.

Leaf area was computed from the weight of a piece of heavy aluminum foil that had been cut to match the leaf. The leaf was flattened on the foil blank and stapled to hold it firmly while the foil was cut. The foil weighed 0.956 gm./dm^2.

Results were computed in terms of micrograms of CO_2 consumed per second per square decimeter of leaf area. Each run represented consumption by the leaf of 55.31 μg. of CO_2 at a mean CO_2 concentration of 300 p.p.m. The constant was computed as follows: Density of CO_2 at the calibration temperature of 27° C. is 1.7989 mg./l., and 1 p.p.m. is equivalent of 1.8 μg./l. From the calibration curve (fig. 3), the concentration interval 200–400 p.p.m. is equivalent to a meter interval of 1.95 ma. The meter interval for each run was 0.7 ma., thus a run represented a decrease of 55.31 μg. in the 428-ml. system ($0.7 \times {}^{200}/_{195} \times 1.8 \times 0.428 = 55.31$).

RESULTS AND DISCUSSION

Photosynthetic rates (in μg./sec./dm^2) ranged from 0.32 to 2.03 for diseased plants and from 2.30 to 3.46 for normal plants (table 1). The mean

TABLE 1.—*Apparent photosynthesis of mosaic and normal leaves of papaya*[1]

Plant and leaf no. and condition	Leaf area	Time	Apparent photosynthesis
	Dm.^{2}	*Sec.*	μg. CO_2/sec./dm.^{2}
Mosaic			
1-1	0.431	301	0.43
1-2	.811	211	.32
2-1	.497	110	1.01
2-2	.321	180	.96
3-1	.551	122	.82
3-2	.321	139	1.24
4-1	.544	50	2.03
4-2	.372	199	.75
5-1	.399	79	1.75
5-2	.350	129	1.23
Normal			
1-1	.686	35	2.30
1-2	.657	36	2.34
2-1	.482	39	2.94
2-2	.363	44	3.46
3-1	.552	35	2.86
3-2	.576	35	2.77
4-1	.645	28	3.06
4-2	.650	26	3.27
5-2	.356	52	2.99
5-2	.608	27	3.37

[1] Times given are means of quintuplicate observations.

rate for diseased plants was 36 percent of that for normal plants. Results varied widely because diseased leaves ranged from nearly normal to acutely abnormal.

Impairment of growth and development associated with papaya mosaic is evidently caused, at least in part, by a reduction of photosynthetic capacity.

SUMMARY

Comparative studies were made of the photosynthetic rates of leaves on normal papaya plants and of leaves on plants showing characteristic symptoms of papaya mosaic, a serious disease in southern Puerto Rico. The mean rate for diseased leaves was 36 percent of that for normal leaves.

RESUMEN

Se hicieron estudios comparativos sobre las proporciones de fijación fotosintética en las hojas normales del papayo y en las hojas que demonstraban tener sintomas características del mosaico del papayo, la cual es una enfermedad grave en el sur de Puerto Rico. La proporción media de fijación para las hojas enfermas fué un 36 por ciento comparada con la de las hojas normales.

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