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Stomatal Density and Responsiveness of Banana Fruit Stomates

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Summary. Determination of stomatal densities of the banana peel (*Musa acuminata* L. var Hort. Valery) by microscopic observations showed 30 times fewer stomates on fruit epidermis than found on the banana leaf. Observations also showed that peel stomates were not laid down in a linear pattern as on the leaf.

It was demonstrated that stomatal responses occurred in banana fruit. Specific conditions of high humidity and light were necessary for stomatal opening; low humidity and darkness were necessary for closure. Responsiveness of the stomates continued for a considerable length of time after the fruit had been severed from the host.

Although studies have been made of the distribution patterns and functions of stomates on green leaves (2, 5, 7, 9), relatively little work has been done on stomates of fruit. It has been noted in the literature that stomates exist on some fruits, but it has been assumed that they probably were no longer functional (1, 8).

The commercial importance of banana fruit and its fragility in transit and storage instigated the following investigation of the nature of stomates on banana peels.

Materials and Methods

The following work employed green fruit of *Musa acuminata* L. var. Hort. Valery, a commercially important variety.

Stomatal densities were determined by microscopic observations using silicone rubber impressions (General Electric RTV-11) (6) of surfaces of greenhouse-grown fruit. This compound, which vulcanizes at room temperature, gives a perfect negative impression of a surface without any physical damage to that surface. At each stage of maturity, the central finger of the outer fruit row of a hand, located about halfway up the stem, was chosen. Duplicate impressions were made from 4 of the faces of each finger. Clear nail polish, painted on these impressions to create a positive print, was peeled off when dry and floated onto microslides and the stomates counted. The general appearance of banana leaf and fruit surfaces using this technique is shown in figure 1.

The ability of stomates to open and close in response to light and darkness was investigated with fruit of 3 categories: intact hanging fruit in the greenhouse; freshly picked greenhouse fruit; and 10-day-old fruit harvested in the tropics and shipped on the hand through normal commercial channels.

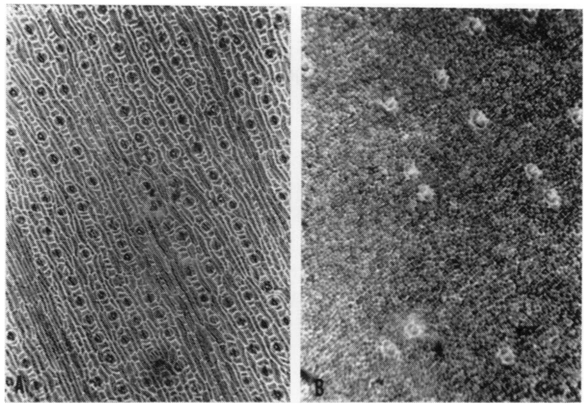

FIG. 1. Positive prints of epidermal surfaces taken from silicone rubber impressions. A. Banana leaf surface. B. Banana peel surface. (Both photographed at same magnification.)

Although silicone rubber impressions were effective for counting stomates, the degree of stomatal opening was difficult to ascertain. Therefore, relative stomatal opening was determined every 15 minutes after exposure to light or darkness by a chloroplast-bleaching technique using chlorine gas (4). Previously, this technique was used on green leaves wherein it was found that portions of leaves with open stomates bleached to a pale yellow after exposure to chlorine gas for a few seconds; portions of leaves with closed stomates, however, remained green after at least 1 hour's exposure.

Results

A summary of the stomatal density counts and the statistical variation is given in table I. These data show fewer stomates on the peel than Skutch (7) found on banana leaves. His counts averaged

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18,520 cm^{-2} near the midrib and 14,890 cm^{-2} near the margin. As seen in figure 1 the stomates on the peel are not arranged in a linear fashion as on the leaf.

The results of the chlorine bleaching are summarized in table II. The stomates were closed on hanging fruit in the greenhouse (29–30°, 20–30 % relative humidity) after 1 hour of darkness. Stomates remained closed after 2-hours exposure to the 500 ft-c of sunlight which filtered through the leaves. A subsequent 2-hour exposure to 4000 ft-c of light from a floodlight caused stomatal opening. Similar results were obtained from a number of stems of varying stages of development.

Fruit severed from the stem in the greenhouse showed startling differences between those fingers held in darkness and those held in light. Also, the bleaching effect was more intense than that of hanging fruit. Direct sunlight produced open stomates in 2 hours and 1 hour of darkness caused stomatal closure.

Fruit received from the tropics was placed in a holding chamber (at 13°, 90–100 % relative humidity) for 24 hours before transference to a ripening chamber (at 16°, 90–100 % relative humidity) and exposure to 1000 ppm of ethylene gas. Light intensity in both chambers was 10 ft-c.

When the fruit was taken from the holding chamber and treated as in the previous experiments, light treated fingers had open stomates; darkened fingers closed stomates after 2 hours. Fingers taken directly from the 10 ft-c light of the holding chamber also had open stomates. Fingers taken from the ripening chamber on the day following exposure to ethylene gas showed the same responses.

Discussion

Stomatal function on the peel of banana fruit is an interesting phenomenon in view of the assumption made on other fruit (1, 8); that this function persisted after banana severence from the stem was even more interesting. Probably, this was due to turgor maintenance in the fruit by the self-sealing effect of latex bleeding after finger severence. A severed leaf, however, continues to lose water and stomates close in a very short time (3). Compared with the leaf, the fewer number of stomates on the peel makes water loss through open stomates less critical.

It might be expected that stomates on hanging or freshly picked fruit would open in response to lower light intensities and close faster in darkness than would stomates on stored fruit. That the opposite was observed may be due to the relatively high humidities in the holding and ripening chambers (see table II).

Therefore, apparently the amount of light was not the important factor for initiating and sustaining stomatal opening but was necessary only as a trigger, providing the other conditions were favorable. At a very high humidity, the stomates tended to open at lower light intensities, whereas at low humidity,

Table I. *Number of Stomates cm^{-2} on Valery Fruit*

Face	Immature	Three-quarters full	Full
Top (concave face)	1106.2 ± 216.8	915.9 ± 146.0	646.0 ± 141.6
Bottom	309.7 ± 57.5	376.1 ± 75.2	327.4 ± 92.9
Left	455.7 ± 110.6	358.4 ± 92.9	327.4 ± 101.8
Right	526.5 ± 92.9	460.2 ± 88.5	451.3 ± 146.0

Table II. *Summary of Stomatal Behavior Results*

	Environment conditions at source			
Source of fruit	Temp (°C)	Relative humidity %	ft-c	Stomatal condition
Intact hanging in greenhouse	29–30	20–30	Dark	Closed in one-half hr
			500	Closed
			4000	Opened in 2 hr
Severed from greenhouse	29–30	20–30	Dark	Closed in 1 hr
			4000	Opened in 2 hr
Holding chamber	13	90–100	10	Open
			Dark	Closed in 2 hr
Ripening chamber	16	90–100	10	Open
			Dark	Closed in 3 hr

higher light intensities appeared to be required. Williams (9) found this same effect to be true in the case of the leaf of *Pelargonium*. He observed that in darkness, stomates in a dry atmosphere close very quickly, whereas closure in a wet atmosphere is slow and incomplete.

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