LOCALIZATION OF THALLIUM IN STOMATA IS INDEPENDENT OF TRANSPIRATION*

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The specific locations of the evaporating surfaces in the leaf are not yet known. However, Maercker (1965) repeated successfully the early experiments of Stahl (1894) and concluded from her evidence that the cuticular component of transpiration could be further divided into "cuticular" and "peristomatal" transpiration, where the latter term refers to transpiration from the surfaces of the guard cells and their subsidiary cells. Peristomatal transpiration has been the subject of considerable recent interest (e.g. Lange *et al.* 1971).

Using the method of Stahl (1894), Maercker (1965) placed cut leaves of *Zea mays* into 3% thallium sulphate solution and allowed the leaves to transpire in light or darkness, and in either normal air or CO_2-depleted air. Under conditions which led to stomatal opening (i.e. in light or in darkness in CO_2-free air), Tl^+ was found exclusively in the guard cells, whereas it was located exclusively in the subsidiary cells of leaves with closed stomata. This evidence, in conjunction with experiments using tritiated water, led her to suggest that the terminal site of transpiration was in the guard cells when stomata are open and in the subsidiary cells when stomata are closed. Raschke (personal communication) suggested, however, that these observations merely indicate that Tl^+ ions follow the shuttle of K^+ between the guard and subsidiary cells which occurs during stomatal movement in *Z. mays* (Pallaghy 1971; Raschke and Fellows 1971). The results briefly reported in this communication prove that Tl^+ cannot be employed as an indicator to locate the terminal sites of transpiration.

Results and Discussion

The leaf material (*Z. mays*) used was that described by Pallaghy (1971). Experiments, lasting 2–5 hr, were carried out using 0·5% thallium sulphate solution. Leaves were kept in distilled water for about 15 min prior to each experiment. Localization of Tl^+ in the leaf epidermis was observed as a black precipitate of thallium chloride when the leaf was submerged for about 5 min into a solution of 3% NaCl in 50% methanol. Control experiments were carried out in the manner according to Maercker (1965). Similar experiments, but employing either normal or CO_2-free aerated solutions, were carried out with leaves entirely submerged in the solution to prevent transpiration.

The results obtained with both transpiring and submerged leaves (Fig. 1) were similar to those described by Maercker (1965), proving that Tl^+ localization is independent of transpiration. The method of micro-autoradiography using tritiated water to localize transpiration sites near the stomatal pore is also subject to doubt. The topography of the stomatal apparatus is considerably different between the open and closed states, as has been well demonstrated in an extreme situation for *Z. mays*

* Manuscript received 8 November 1971.

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(Raschke 1970). Such a change in topography is likely to determine not only which portion of the stoma is in closest contact with the stripping film, but may also affect the pathways of water vapour flow between the stomatal pore and the exposed surfaces of the stripping film. The question of ectodesmata (Franke 1967) is beyond the scope of this paper.

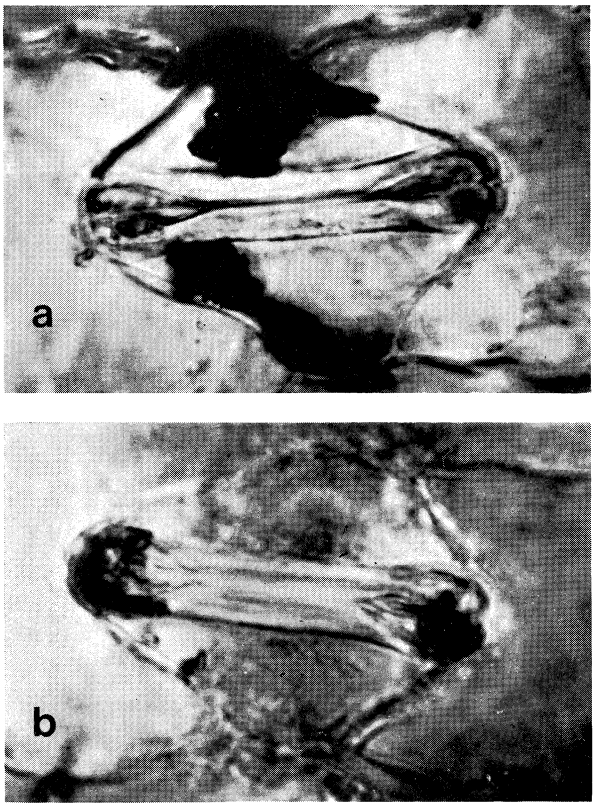

Fig. 1.—(*a*) Localization of thallium in subsidiary cells of closed stomata in detached leaves of *Zea mays*. The leaf was entirely submerged for 4 hr in aerated solution containing 0·5% thallium sulphate and kept in darkness. (*b*) Localization of thallium in guard cells of open stomata in detached leaves of *Z. mays*. The leaf was entirely submerged for 4 hr in aerated solution (0·5% thallium sulphate) under illuminated conditions. Thallium accumulation in the guard cells was markedly greater when the solution containing the submerged leaf was aerated with CO_2-free air.

Trichomes also showed a strong accumulation of Tl^+. Accumulation of K^+ in trichomes of *Z. mays* and *Vicia faba* have been frequently observed by the author in the past (Pallaghy, unpublished data).

Conclusion

These purely qualitative results have shown, even under conditions where transpiration cannot take place, that the movements of Tl^+, in response to illumination and CO_2 concentration, are closely correlated with those of K^+ observed in the

stomata of *Z. mays* (Pallaghy 1971; Raschke and Fellows 1971). The results presented in this paper further show that Tl^+ can mimic K^+ movement in leaves, even though Tl^+ is eventually toxic to leaves. This is not unexpected in view of the fact that the sulphate, nitrate, chlorate, and perchlorate of thallium are all isomorphous with the corresponding K^+ compounds (Moeller 1957). The uptake experiments of Maercker (1965) are therefore not necessarily indicative of peristomatal transpiration.

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