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MICRORELIEF OF THE FLOWERING PLANTS LEAF SURFACE AND STOMATAL INTERACTIONS

by

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Abstract

The lower epidermal surface was studied in 6 species of flowering plants representing different families. Plicae of its microrelief connect stomata with each other. Application of computer modelling had shown that mechanical tensions and deformations are transmitted along these plicae from one stoma to others. The plicated structures are assumed to be involved in coordination of stomata function within the local zones of epidermis.

Key-words

Leaf, epidermis, microrelief of the leaf surface, stomatal interactions.

микрорельеф поверхности листьев цветковых растений и межустьичные взаимодействия

Реферат

Изучена поверхность нижней эпидермы листьев у 6 видов цветковых растений, представляющих различные семейства. Складки ее микрорельефа соединяют часть устьиц друг с другом. Использование компьютерного моделирования позволило установить, что механические напряжения и деформации передаются по этим складкам с одних устьиц на другие. Предполагается, что они координируют работу устьиц на локальных участках эпидермы.

Ключевые слова

Лист, эпидерма, микрорельеф поверхности, межустьичные взаимодействия.

Le microrelief de l'épiderme foliaire des plantes à fleurs et son interaction avec le fonctionnement des stomates

Résumé

L'épiderme foliaire inférieur de 6 espèces de plantes à fleurs représentant différentes familles botaniques a été étudié. Les plis constituant son microrelief connecte les stomates entre eux. Les études de modélisation montrent que les tensions mécaniques et les déformations sont transmises le long de ces plis de stomates à stomates. Ces structures plissées doivent assurer la coordination de l'ouverture des stomates dans les différentes zones épidermiques.

Mots-clés

Feuille, épiderme, microrelief de l'épiderme, stomates.

1. Introduction

Leaves of the flowering plants frequently have plicated microrelief (LANGE, 1969; DILCHER, 1974; KOCHETOVA and KOCHETOV, 1982; BARTHLOTT, 1990). Usually it is represented by plicae, which spread in both directions from the guard cells. Each of the plicae crosses a number of cells uniting them in a structural and functional complex. It consists of guard and basal cells of stomata, as well as surrounding basic cells of epidermis. Presence of plicae changes the structure and magnitude of mechanical tensions and deformations in the walls of cells surrounding the stomata and affects the width of stomatal aperture in response to water supply changes in the epidermis (PAUTOV *et al.*, 2001). In some species plicae may be found not only near stomata, but also on other epidermal cells. Current research objective was to study patterns of plicae positioning and their possible functions in epidermis.

1. - Materials and methods

The lower epidermal surface was studied in 6 species of flowering plants using method of varnish imprints (KLEIN and KLEIN, 1970) and scanning electron microscope JSM-35. The following species were selected as model objects: *Camptotheca acuminata* Decne. (Nyssaceae Dumort.), *Crataegus sanguinea* Pall. (Rosaceae Juss.), *Cynoxylon kousa*

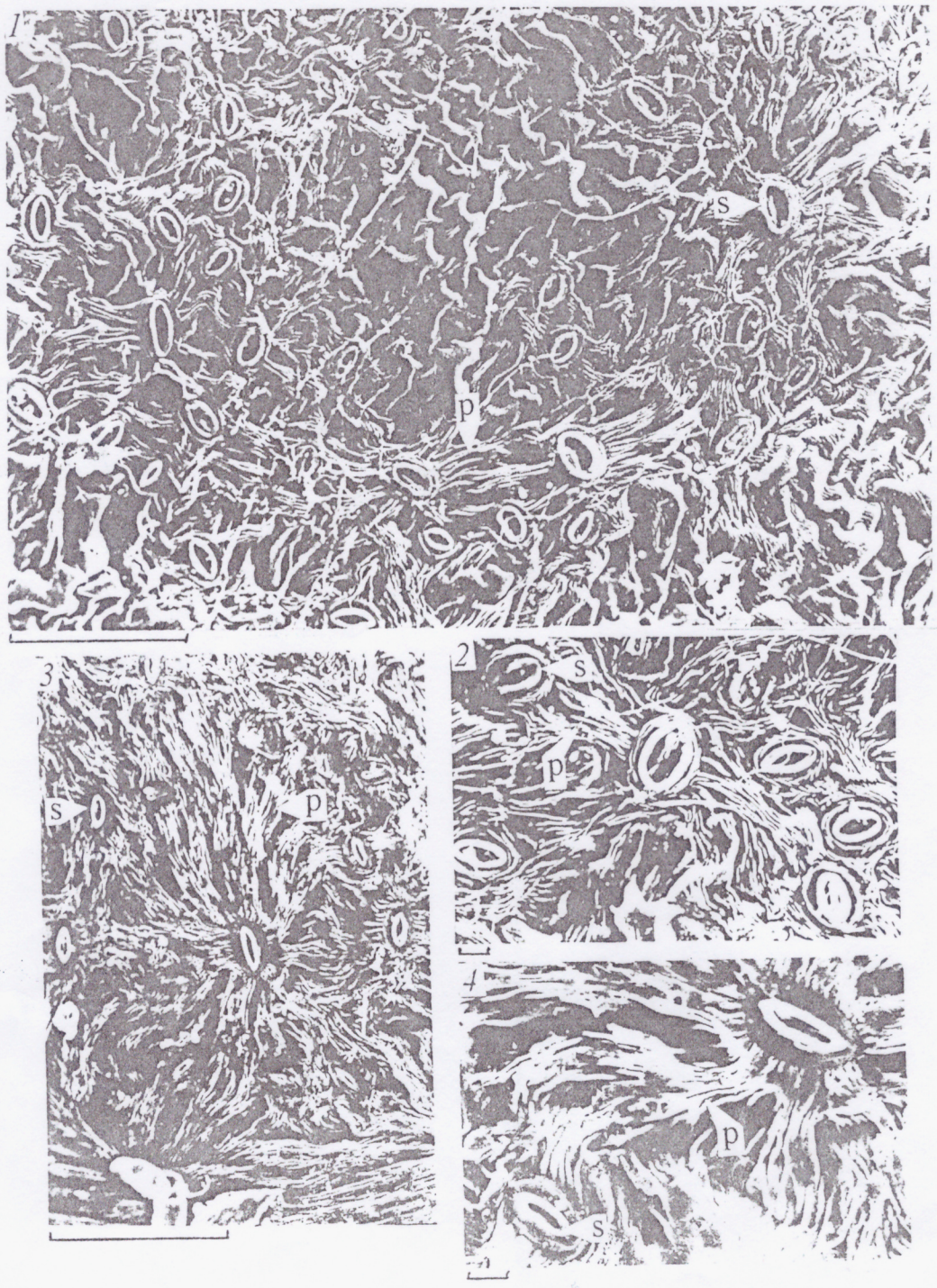

Figure 1. Microrelief of the lower epidermal surface: *Crataegus sanguinea* (1.1 and 1.2) and *Tilia cordata* (1.3 and 1.4).
s - stomata; p – microrelief plicae. Scale: fig. 1.1 and 1.3 – 100 μm, fig;1.2 and 1.4 – 10 μm.

(Buerber ex Miq.) Hance, (Cornaceae Dumort.), *Parthenocissus inserta* (A. Kern.) Fritsh (Vitaceae Juss.), *Populus tremula* L. (Salicaceae Mirb.), *Tilia cordata* Mill. (Tiliaceae Juss.) The material was collected from dendrological collections in Bishkek, St. Petersburg and Tashkent.

2. – Results

Leaves of all model species have plicated microrelief of their lower epidermis with stomata connected in groups by plicae positioned between them (figure 1). The groups are composed of just a few stomata (*Camptotheca acuminata*, *Cynoxylon kousa*, *Parthenocissus inserta*), or often more than 10 (*Crataegus sanguinea*, *Populus tremula*, *Tilia cordata*). Together with such groups there are also individual stomatal complexes in the epidermis. In *Populus tremula* all epidermal cells without exception have plicated microrelief. But even in this case it is possible to distinguish regularly positioned plicae connecting stomata (figure 2).

Two possible means of stomata connections were described. In the first one the plicae provide consecutive, sometimes branching connections between stomata (fig. 1.1 and 1.2). In the second, from the central stoma the plicae go in all directions towards the peripheral stomata surrounding the central one (fig. 1.3 and 1.4).

3. – Discussion

Computer modelling was used to assess the role plicae play in connecting stomata. As a model we had employed a metal plate with two holes, which was heated. The holes were representing stomata, the plate itself – stomatal zone. The plate has a very high value of temperature coefficient. In other words, the metal expands during heating, and contracts when cooling. This was considered as an analogy to the changes in the cell volumes around a stomata during changes in their turgor. The modelling gave results, which reflected qualitative, as well as quantitative characteristics of the processes occurred. The quantitative characteristics depend mainly on the metal properties, therefore, they were not taken into account in result interpretation, and analysis was done on qualitative level.

The metal balks welded onto the main plate imitated the plicae on the epidermal surface spreading outwards stomatal apertures. Other metal balks were welded along the holes. Those ones were corresponding to more thick anticlinal walls of the guard cells facing stomata aperture.

Two cases were considered. In the first one the balks spreading from different holes were short and did not reach each other. There was a wide area of a smooth plate left between them. In the second one, the balks reached each other. The picture imitated in the second case can be seen on figure 1. In modeling experiments a fragment of the metal plate bearing a hole was heated, which are caused changing in mechanical tensions and deformations around the hole (PAUTOV *et al.*, 2001, and in this article fig.2 and 3). In the case where the holes were not connected by their balks the tensions and deformations has not been transmitted from the heated area onto unheated. When the holes were connected the tensions and deformations appearing in the heated area were transmitted along the balks onto the cold area (fig. 3).

The modeling results had shown that mechanical tensions and deformations can be transmitted along the microrelief elements from one stomata to another. This situation is possible, for example, when epidermis is saturated with water irregularly. It is known, that tensions and deformations existing in cell wall affect mechanically activated channels and ion transport (PICKARD andDING, 1992, 1993). Such channels were found in plasmalemma of epidermal cells, in particularly, in the guard cells of stomata of some plants. The data obtained allow one to suggest that elements of plicated microrelief provide structural and functional connections between stomatal complexes. Information from one stomata to others can be transmitted along the plicae as tensions and deformations, and, therefore, affect the work of ion channels.

5. – References

BARTHLOTT (W.). 1990. – Scanning electron microscopy of the epidermal surface in plants. *Syst. Assos. Spec.*, **41** : 69 - 94.

DILCHER (D.L.). 1974. – Approaches to the identification of angiosperm leaf remains. *Bot. Rev.* **40** (1) : 1-157.

KLEIN (R.M.), KLEIN (D.). 1970. – Research method in plant science.: *Natur. History Press.* New York ,756 p.

KOCHETOVA (N.I.), KOCHETOV (Yu.V.). 1982. – Adaptive features of plant surface. Moskov: *Kolos.* 176 p. (in Russian).

LANGE (R.T.). 1969. – Concerning the morphology of isolated plant cuticles. *New Phytol.*, **68** (2): 423 – 426.

PAUTOV (A.A.), LABERCHE (J.-C.), YAKOVLEVA (O.V.), KOLODJAZHNII (S.F.). 2001. – Plicated microrelief of leaf surface of poplars. *Rev. Cytol. Biol. Bot* **23** (1/2): 7-13.

PICKARD(B.G.), DING (J.P.). 1992. – Gravity sensing by higher plants. Mechanically activated channels in a model plant system. *Comparative and Environmental Physiol.*, **10**: 82 – 110.

PICKARD(B.G.), DING (J.P.). 1993. – The mechanosensory calcium – selective ion channel: key component of a plasmalemma control centre. *Austral. J. Plant Physiol.*, **20** (4/5):555 – 570.

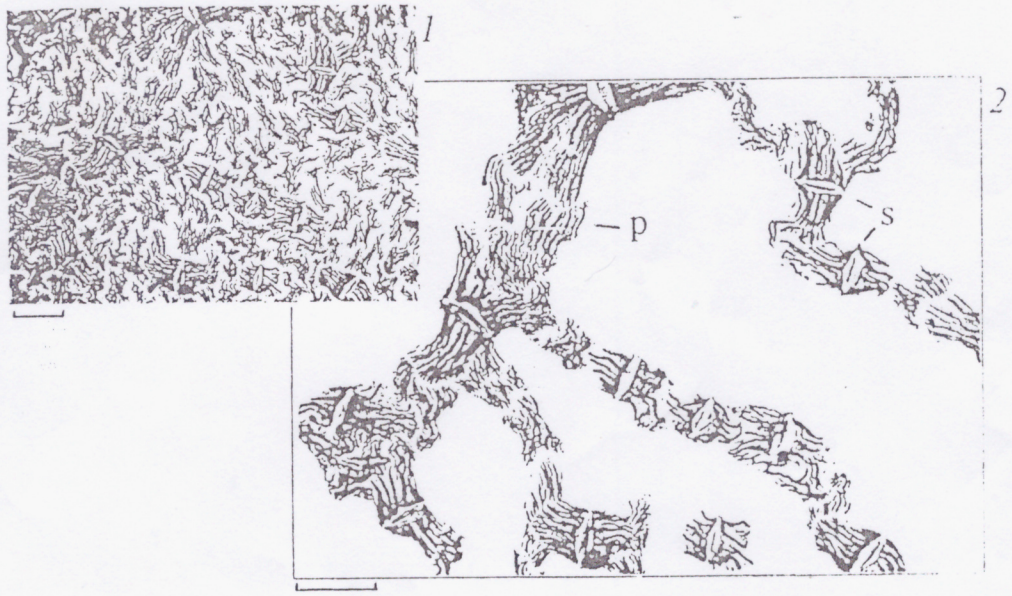

Figure 2. Microrelief of the lower epidermal surface *Populus tremula*.
1 – general view of the surface area,
2 – the plicae connecting stomata complexes are kept.
s- stomata ; p- microrelief plicae. Scale: 25 μm.

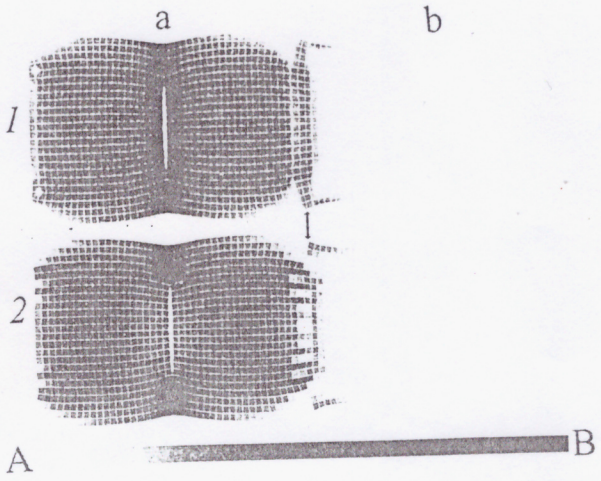

Figure 3. Model imitating mechanical tensions (1) and deformations (2) transmission along the microrelief plicae in epidermal surface.
An arrow shows the border between heated (a) and unheated (b) areas of the metal plate. Shading of different intensity denotes different values of deformation in the plate: A – minimum, B – maximum values of deformations.