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BRIEF COMMUNICATION

Heterogeneity of stomatal density in the second wheat leaf

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Abstract

The stomatal density on abaxial epidermis of the second wheat (*Triticum aestivum* L.) leaf increased step by step from the leaf base to its tip. On adaxial epidermis, this increasing tendency was generally maintained, but close to both the base and the apex two maxima were determined. In the direction perpendicular to leaf length, maximum stomatal density was close to the edges, and minimum one was in the central part of the leaf blade.

The stomata of the leaves in cereal plants are arranged in single and double rows parallel to the leaf length. Only little is known about the stomata distribution on the whole leaf blade area, *i.e.* parallelly and perpendicularly to the leaf axis. A large heterogeneity in the stomatal density on the leaf blade is known (for review see *e.g.* Tichá 1982). An increase in the stomatal density from the base to the tip of the grass leaves is reported *e.g.* by Kisser (1927), Salisbury (1927), Milthorpe and Penman (1967), Pazourek (1969), Yoshida (1978); nevertheless, a decrease in stomatal density was also described, *e.g.* by Frenyó (1969) and Miranda *et al.* (1981).

Therefore, the stomatal distribution in wheat was analysed in greater detail concerning both leaf sides.

Triticum aestivum L., cv. Grana plants were cultivated individually in Knop's nutrient solution in a growth chamber at temperature 20 °C, 16 h photoperiod and irradiance of 200 μmol m^{-2} s^{-1} (400-700 nm).

Replicas were prepared from both sides of fully developed second leaves. Two different methods were confronted for sampling the leaves. The first method (I): a larger number of leaves with a lower number of measurements (20 leaves, both leaf sides, 25 values from predetermined positions on each leaf side).

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The second method (II): a lower number of leaves with a considerably higher number of positions measured (5 leaves, both leaf sides, *ca.* 370 values on each side the number of values depending on the lengths of respective leaf blades). The values obtained by II were further adjusted taking into consideration the contribution of all neighbouring positions. The final values were calculated as arithmetical means of two adjacent positions along the leaf longitudinal axis. Summarizing the results of I and II, theoretical mean leaves were constructed.

The relations between the stomatal density and the leaf length and width, respectively, were calculated using the methods of regression analysis. The degree of polynome was selected according to a pre-sketched curve and the significance test of regression coefficients.

In the second wheat leaf a higher stomatal density was found on the adaxial side than on the abaxial one, the distances between the stomata in the respective rows were shorter and double rows of stomata could also be found.

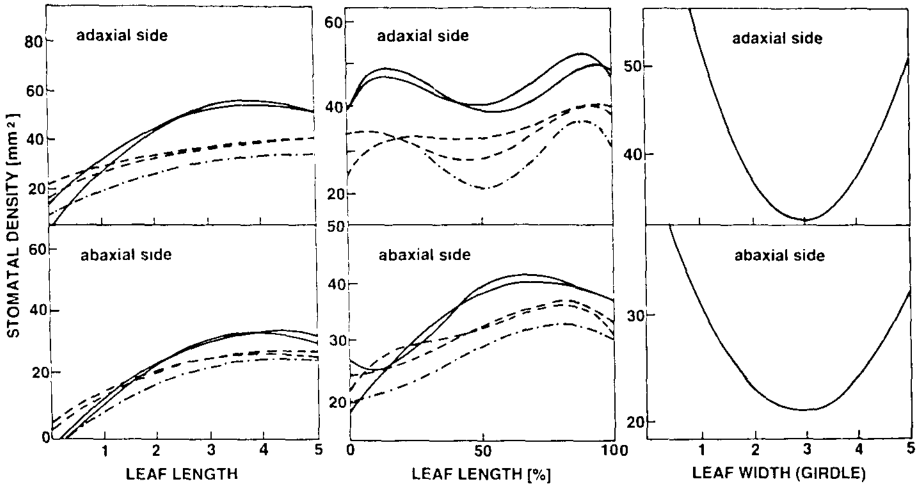

Fig. 1: Gradients in stomatal density on both leaf sides. (*a*) using method I (*1*-base, *3*-middle, *5*-apex), (*b*) using method II (*full line* - edge, *dashed line* - part between the edge and the central part, *dashed-and-dotted line* - central part), (c) transverse gradient of the stomatal density on both leaf sides (*1*, *5* - edge, *2*, *4* - part between the edge and the central part, *3* - central part).

The gradients in stomatal density based on I showed a similar shape for both leaf sides. The stomatal density increased step by step from the leaf base to its tip. A slightly noticeable maximum was located close to the apex (Fig. 1a). By the more detailed II, a different situation was found on the adaxial side. Generally, an increasing tendency from the leaf base to its tip was maintained. But close to both the base and the apex, two maxima were determined non-perceptible by I (Fig. 1b). Thus the increase in stomatal density from the leaf base to its tip described *e.g.* by Salisbury (1927), Sawyer (1932), Migahid and Abu Raya (1952), Yoshida (1978), Miranda *et al.* (1981) was confirmed by I and II. A decrease in stomatal density was observed in the central part of the leaf blade. In the elongated leaves the maximum density located close to the apex shifts to the middle parts of the leaf (*e.g.* Salisbury 1927, Migahid and Abu Raya 1952, Pazourek 1969).

The transverse gradient can be modelled as a parabola with its minimum in the central part, and with the maximum stomatal density near the edges of the leaf (Fig. 1c). Differences in the stomatal density on the edge, in the centre and near the midrib of the leaf blade were usually found insignificant (*e.g.* Slavík 1963 in *Nicotiana sanderae* and *Beta vulgaris*, Pazourek 1966 in *Hordeum distichon* and *Vinca minor*). The vascular bundles located in the central zone of the blade probably cause the shifting of stomatal rows towards the edges of the leaf blade.

The number and aperture of stomata are important for CO_2 supply and water vapour efflux. The very heterogeneous distribution of stomata on both leaf sides, as was found in our material, is thus a pre-condition for the functional heterogeneity of the stomatal apparatus, where the structural gradients in the stomatal distribution are combined with the non-uniform stomatal closure resulting in the so-called "stomatal patchiness" (*e.g.* Downton *et al.* 1988, Terashima 1989).

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