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BRIEF COMMUNICATION

# Water stress induced changes in anatomy of tomato leaf epidermes

O. SAM*, E. JERÉZ*, J. DELL'AMICO*,** and M.C. RUIZ-SANCHEZ**

*Departmento de Fisiología y Bioquímica Vegetal, Instituto Nacional de Ciencias Agrícolas, GP #1, San José de las Lajas, 32700 La Habana, Cuba**
*Departamento de Riego y Salinidad, CEBAS-CSIC, P.O. Box 4195, E-30080 Murcia, Spain***

## Abstract

Anatomical changes of leaf epidermes of tomato plants (*Lycopersicon esculentum* Mill. cv. INCA 9) submitted to water stress in the preflowering stage were studied. 20 d after germination, plants were subjected to three treatments: *1*) 100 % of evapotranspired water was applied every day, *2*) from 100 up to 10 % of evapotranspired water was applied every day, and *3*) water supply was completely suppressed. Trichome density was similar in apical, middle and basal zones, and adaxial and abaxial leaf surfaces. Stomatal density and length, and epidermal cell length and width had similar values on the same leaf surface, but the values were higher on the abaxial than on the adaxial leaf surface. The water deficit had little effect on number of trichomes, length and width of epidermal cells and length of stomata, and decreased the stomatal density especially on adaxial surface.

*Additional key words*: epidermal cell length and width, *Lycopersicon esculentum*, stomata density and length, trichome density.

Water deficit tolerance is observed in many plants. As appointed by Kebede *et al.* (1994), there are some wild tomato species with higher drought resistance and more efficient water use than the cultivated species. Therefore breeding is applied to obtain more tolerant tomato cultivars, and one of them is *Lycopersicon esculentum* Mill. cv. INCA 9.

When plants are submitted to water stress, they firstly reduce and then stop leaf expansion (for review see, *e.g.*, Hsiao and Jing 1997). Structure and functions of all plant organs are affected by water stress, and modifications in leaf anatomy have been also widely reported (Yamashita *et al.* 1990, Jacobsen *et al.* 1992, Premachandra *et al.* 1992, Field *et al.* 1995, Saliendra *et al.* 1995).

The aim of the present work was to determine the anatomical changes of leaf epidermes of tomato cultivar INCA 9 induced by water stress applied in the preflowering stage.

Tomato (*Lycopersicon esculentum* Mill., water stress mildly tolerant cultivar INCA 9) plants were grown in pots containing soil and organic matter 3:1 (v/v) in a growth chamber (16-h photoperiod, irradiance of 75 - 245 μmol $m^{-2}$ $s^{-1}$, temperature and relative humidity of 29/18 °C and 57/75 % during light/dark periods, respectively) and water was supplied according to plant demands. Water consumed by evapotranspiration was estimated gravimetrically. Twenty days after germination, the plants were subjected to three treatments: *1*) control (100 % of evapotranspired water was applied every day, *2*) low water stress (from 100 up to only 10 % of evapotranspired water was applied every day in order to promote moderate and progressive stress), and *3*) high water stress (water supply was completely suppressed). The leaf water potential was measured between 09:00 to 09:30 using Scholander pressure chamber according to Turner (1981), on the third and fourth leaves of four plants per treatment, with six repetitions. Seven days after the beginning of the treatments, samples of treatment *3* were taken and the others two days later. Leaf water potentials were -0.99 ± 0.07 MPa under high water stress, -0.51 ± 0.04 MPa under low water stress, and -0.27 ± 0.05 MPa in control plants. In four plants per treatment, on the fourth, fully-expanded leaf, which was divided into

*Received* 2 November 1998, *accepted* 5 January 2000.
*Present address: CEBAS-CSIC, P.O.Box 4195, E - 30080 Murcia, Spain; fax: (+34) 968 26613, e-mail: mcruiz@natura.cebas.csic.es

three zones (apical, middle and basal), impressions of adaxial (AD) and abaxial (AB) leaf surfaces were taken from the midpart of each one with a transparent glue. Twenty-five measurements of number of trichomes and stomata per unit area, length and width of epidermal cells, and length of stomata were recorded on each zone and surface.

Data were analysed by a analysis of variance (*ANOVA*). Concerning the number of stomata and trichomes, the quadratic root transformation of the value of the variable plus one was performed.

In control plants, the highest trichome density was on abaxial surface of basal leaf zone. The trichome density was not expressively affected by water stress, only on basal zone slightly lower values were observed (Table 1). However, trichome length may be more important than its frequency (Nobel 1991).

Table 1. Number of trichomes and stomata per unit leaf area [$mm^2$] in different leaf zones and surfaces of tomato plants under different water stress treatments. Means ± SE; these followed by different letter in each column were significantly different from corresponding control at $P < 0.05$.

| | Treatment | Apical zone adaxial | abaxial | Middle zone adaxial | abaxial | Basal zone adaxial | abaxial |
|---|---|---|---|---|---|---|---|
| Trichomes | Control | 1.07 ± 0.04a | 1.01 ± 0.04a | 1.11 ± 0.05a | 1.09 ± 0.04a | 1.12 ± 0.04a | 1.30 ± 0.04a |
| | Low water stress | 1.03 ± 0.03a | 1.10 ± 0.02b | 1.06 ± 0.06a | 1.06 ± 0.04a | 1.06 ± 0.02b | 1.05 ± 0.07b |
| | High water stress | 1.04 ± 0.03a | 1.01 ± 0.03a | 1.09 ± 0.04a | 1.10 ± 0.05a | 1.05 ± 0.03b | 1.11 ± 0.09b |
| Stomata | Control | 6.31 ± 0.04a | 8.61 ± 0.02a | 5.72 ± 0.02b | 8.90 ± 0.13a | 5.73 ± 0.20b | 7.32 ± 0.01b |
| | Low water stress | 5.72 ± 0.03b | 6.76 ± 0.14b | 6.14 ± 0.06a | 7.26 ± 0.14b | 6.04 ± 0.02a | 7.19 ± 0.04c |
| | High water stress | 5.12 ± 0.01c | 6.70 ± 0.10b | 6.13 ± 0.04a | 6.62 ± 0.12c | 5.75 ± 0.11b | 7.46 ± 0.03a |

Stomatal density was significantly higher on abaxial than on adaxial leaf surface from the three leaf zones. The higher stomatal density on abaxial surface represents well known advantageous adaptation for higher water use efficiency. In control plants, the higher stomatal density was found in apical and middle zones than in basal zone while in leaves under low water stress the stomatal density was higher in middle and basal zones than in apical zone and under high water stress the highest stomatal density was on basal zone (Table 1). The higher stomata density on middle and lower zones probably indicated a reduction in leaf area in these zones. This coincides with the statement of Hsiao and Jing (1997), who indicated that water stress firstly reduces expansion rate.

The characteristics of leaf epidermis from potato (Sam 1993, Sam *et al.* 1995) and tomato plants (Sam *et al.* 1996) have been studied so far in well water supplied plants. In tomato submitted to severe water stress many stomata seen under a light microscope were very narrow, with its pore closed and as they lying very near the borders of epidermal cell surrounding them, sometimes they were difficult to be visualised (Fig. 1).

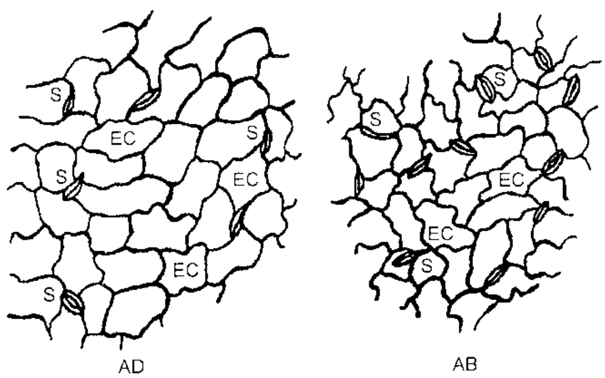


Fig. 1. Drawing of adaxial (AD) and abaxial (AB) leaf epidermes of tomato plants grown under severe water stress for 9 d (S - stomata, EC - epidermal cells; ×280).

The length of epidermal cells was only affected in the adaxial surface of the leaf upper zone where epidermal cells were larger in leaves of plants under severe water stress. The width of tomato leaves did not show significant differences in any treatment (Table 2); this implies an adaptation to stress conditions imposed to the plants of the cultivar chosen to be cultivated under non-optimal conditions in Cuba.

Table 2. Length and width of epidermal cells and stomatal length [μm] in different leaf zones and surfaces of tomato plants under different water stress treatments. Means ± SE; these followed by different letter were significantly different from corresponding control at $P < 0.05$.

| | Treatment | Apical zone adaxial | abaxial | Middle zone adaxial | abaxial | Basal zone adaxial | abaxial |
|---|---|---|---|---|---|---|---|
| Length of epidermal cells | Control | 48.76 ± 3.02b | 49.00 ± 4.63a | 47.51 ± 2.06a | 43.30 ± 3.82a | 48.94 ± 2.83a | 44.30 ± 3.54a |
| | Low water stress | 53.44 ± 3.09ab | 54.72 ± 3.98a | 48.86 ± 2.84a | 48.76 ± 3.19a | 49.34 ± 2.48a | 48.68 ± 3.18a |
| | High water stress | 59.22 ± 3.25a | 54.46 ± 3.89a | 48.28 ± 2.35a | 46.80 ± 2.96a | 51.42 ± 2.59a | 44.26 ± 3.72a |
| Width of epidermal cells | Control | 32.92 ± 4.18a | 26.76 ± 2.99a | 34.60 ± 1.99a | 28.22 ± 1.89a | 33.48 ± 2.18a | 28.14 ± 2.25a |
| | Low water stress | 35.16 ± 3.16a | 31.56 ± 3.18a | 33.10 ± 2.35a | 29.36 ± 1.34a | 33.50 ± 2.03a | 28.72 ± 2.31a |
| | High water stress | 40.88 ± 5.02a | 33.10 ± 3.21a | 34.40 ± 2.27a | 29.16 ± 1.52a | 34.06 ± 2.10a | 27.14 ± 2.56a |
| Length of stomata | Control | 29.66 ± 0.56b | 34.56 ± 1.35a | 30.60 ± 1.62a | 32.20 ± 1.36a | 29.20 ± 1.21a | 32.28 ± 1.79a |
| | Low water stress | 32.00 ± 1.53a | 31.62 ± 1.03b | 29.82 ± 1.34a | 31.54 ± 1.54a | 29.46 ± 1.17a | 33.81 ± 1.93a |
| | High water stress | 31.52 ± 1.06a | 31.96 ± 1.09a | 29.72 ± 1.25a | 33.28 ± 1.21a | 28.92 ± 1.28a | 29.70 ± 2.89a |

Stomatal length showed significant differences only in the upper zone on both leaf surfaces with a variable behaviour: on adaxial surfaces longer stomata in both the water stressed plants were found, and on abaxial surface there were no differences between the control plants and those under severe water stress conditions (Table 2).

In conclusion, characteristics of leaf epidermis of tomato cv. INCA 9 under used treatments showed that this cultivar is adapted to water stress.

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