Root to shoot signalling in maize under partial root chilling and different air humidity

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Introduction

Maize is often exposed to cool soil conditions in the northern zones of its cultivation. Under chilling conditions roots induce a signal cascade to the shoots which informs them about stress affecting roots and triggers the physiological changes in the shoots. The intensity of stress symptoms reaction is often modified by the atmospheric environment of the shoots, particularly by relative air humidity.

Objectives

The goal of the study was to investigate hormonal and hydraulic root-born signals in the root to shoot communication in maize seedlings during short-term partial root chilling combined with low and high relative air humidity (rH).

Results

Chilled parts of roots at high rH predictably reduced transpiration rate by factor three in treated and control plants as compared to low rH (Fig. 1). This dramatically decreased ABA delivery rate from roots to shoots especially in seedlings with partial root chilling, in which a strong increase in ABA content in xylem sap (Fig. 2A) and in ABA delivery rate was observed after two hours of partial root chilling (fig. 3). These changes led to a significant, although transient, increase in ABA concentration in leaves in treated plants at low rH in comparison to high rH (Fig. 4A); while in roots the opposite, a higher ABA level at high rH was observed (Fig. 4B). RWP decreased more consistently at high rH than at low rH, especially in the chilling sensitive genotype (Fig. 5).

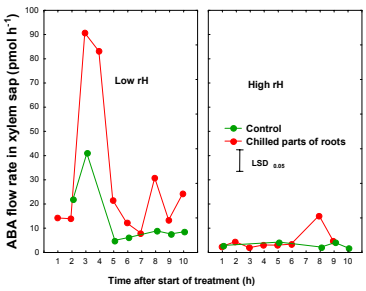


Fig. 3. ABA delivery rate of maize genotype S266 during chilling (8 ºC) part of root at low and high ambient air humidity.

Conclusions

- ✓ The root part subjected to chill rapidly communicates information about the stress to the shoots both through hydraulic and hormonal signals.
- ✓ The hormonal signals seem to be stronger in root to shoot communication at low rH while at high rH the hydraulic signals play a more significant role.
- ✓ High rH inhibits the flow of xylem sap with transpiration stream and ABA is accumulated in the roots.

Material & methods

Research was performed on one tolerant and one sensitive genotype of maize. Plants grew in a split-root system dividing the root horizontally into two parts (45% in soil, 55% protruding from the pots; Picture 1A) making it possible to chill only one part of the root. At the 3-4-leaf stage, the lower root part was chilled at 8°C for 10h (Picture 1B). Additionally plants were treated at low (ca. 40%) and at high (ca. 85%) air humidity (in transparent plastic tent; Picture 1C). During the treatment water potential of roots (RWP) was measured by pressure chamber and the xylem sap was collected from freshly de-topped and pressurized roots (Picture 1D). Abscisic acid (ABA) content was measured in roots, leaves and xylem sap by ELISA. Transpiration rate was measured by the weighting of whole seedlings.

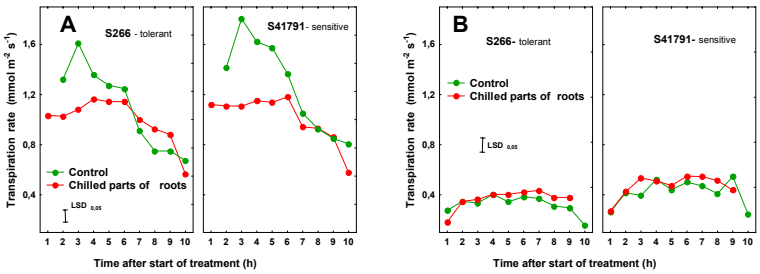


Fig. 1. Transpiration rate during the chilling (8 ºC) of a part of the root at low (A) and high (B) ambient air humidity. Vertical bars are the least statistical difference at $p \leq 0.05$.

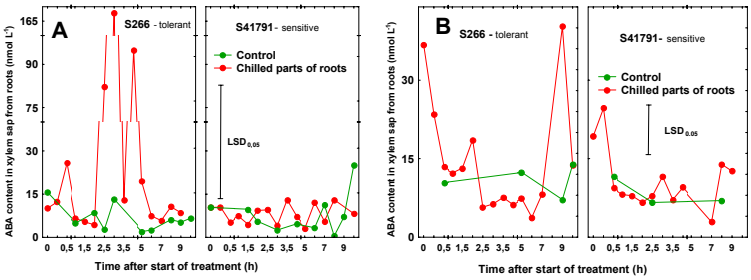


Fig. 2. Abscisic acid (ABA) content in xylem sap during the chilling (8 ºC) of a part of the root at low (A) and high (B) ambient air humidity.

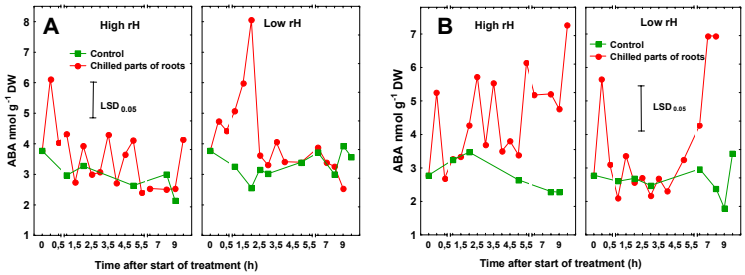


Fig. 4. Abscisic acid (ABA) content in leaves (A) and roots (B) of maize genotype S266 during the chilling (8 ºC) of a part of the root at low and high ambient air humidity.

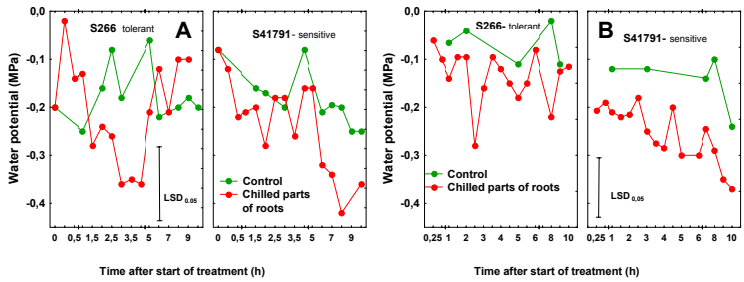
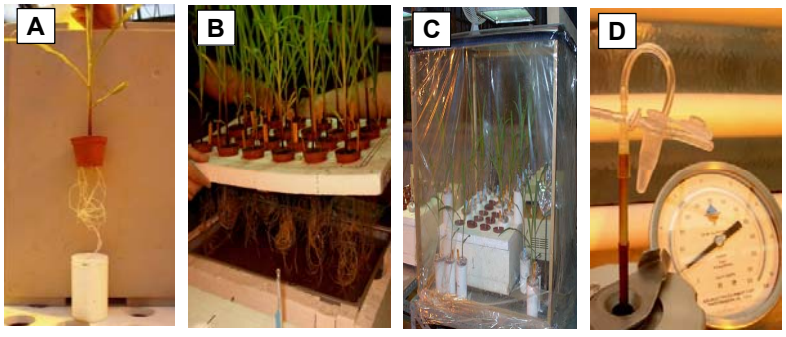


Fig. 5. Water potential of roots during the chilling (8 ºC) of a part of the root at low (A) and high (B) ambient air humidity.



Picture 1. Horizontal split-roots system (A), chilling (8°C) of the lower part of the root in nutrient solution (B), high air humidity in plastic tent (C), collecting of the xylem sap by pressure chamber (D).