

Water Relations in Young Growing Wheat Leaves after Application of (2-Chloroethyl)trimethylammoniumchloride (CCC) to the Roots of Wheat Seedlings

Jutta Bode and Aloysius Wild

Institut für Allgemeine Botanik der Universität, Saarstraße 21, D-6500 Mainz, Bundesrepublik Deutschland

Z. Naturforsch. **40c**, 745–747 (1985);
received July 10, 1985

CCC, Growth Regulator, *Triticum aestivum*, Water Relations, Water Stress

The influence on the water relations of the third developing leaf of (2-chloroethyl)trimethylammoniumchloride, a synthetic growth regulator, applied to the roots of young wheat plants (*Triticum aestivum* L.) has been investigated. The tissue water potential and the pressure potential were found to be reduced by several bars in comparison to the untreated controls, whereas the osmotic potential remained unchanged. The content of soluble reducing sugars was considerably increased in the cell sap of CCC-treated leaves. With this accumulation, however, the turgor was not maintained. Additionally, CCC-treated leaves showed considerably lower transpiration rates and higher diffusive resistance than the controls. Thus, the application of CCC to the roots causes alterations in the water relations of developing wheat leaves, which resemble those induced by water deficiency.

Introduction

Preliminary investigations have shown that after the application of (2-chloroethyl)trimethylammoniumchloride (CCC) to the roots cellular content of soluble proteins and soluble reducing sugars is intensified and *in vitro* activity of isolated ribulose-1,5-bisphosphate carboxylase is increased in the leaves of young wheat plants (*Triticum aestivum* L.). Root growth was stopped immediately and the growth of the leaves, CO₂ fixation capacity and leaf conductance were reduced [1]. The inhibition of both cell division and cell enlargement was found to be responsible for the 40% reduction in leaf area of CCC-treated plants in comparison with the untreated control plants.

Water deficiency can cause similar changes in higher plants. Sugars and free amino acids, for example, are often accumulated during water stress. Stomata may close and transpiration and CO₂ fixa-

tion will be reduced in response to water deficits (for review see [2–4]). Therefore, a study was made of the water relations of growing wheat leaves after CCC-treatment.

Materials and Methods

Plants of *Triticum aestivum* L. (var. Kolibri) were cultivated in hydroculture boxes as described earlier [1]. 11 days after the seeds were sown, CCC was added to the nutrient solution so that the final concentration was $10^{-2} \text{ mol} \cdot \text{l}^{-1}$. At this time the third leaf was just emerging. During its development the following measurements were made. Samples were taken 1 hour after the light period had begun and transpiration was measured during the afternoon. The leaf water potential (Ψ) was measured using the pressure bomb technique developed by Scholander and colleagues [5]. The osmotic potential (Ψ_s) was calculated from the cryoscopically measured osmolarity (Osmomat 030, Fa. Gonotec, Berlin) of cell sap obtained from rapidly frozen (in liquid N₂) and thawed wheat leaves [6]. For details about the determination of soluble reducing sugars with the dinitrosalicylate reagent see Wild and Zerbe [7]. The determination of transpiration and diffusive resistance of the adaxial surface of attached wheat leaves with a steady state porometer (LI-1600, LICOR, Lincoln, Nebraska, USA) followed after the calibration of the cuvette under the conditions of the climatic chamber. In each experiment 10 to 20 leaves were investigated. The presented data are mean values taken from three experiments.

Results and Discussion

CCC applied to the roots of young wheat plants significantly influenced the water potential (Ψ) of the developing third leaf (Fig. 1). The Ψ remained relatively unchanged in the control leaves during leaf expansion, whereas a slight but continuous decrease of Ψ in the treated leaves could be observed.

Osmotic potential (Ψ_s) and turgor pressure (Ψ_p) are two other parameters closely related to tissue water status [2]. Changes in Ψ_s could be brought about by changes in the solute content of the symplasm, or in amount of water in the symplasm [6]. With the relative water content of the CCC-treated wheat leaves being depressed by about 5 to 10% as opposed to the control leaves (data not shown) and the concentration of soluble reducing sugars in the

Abbreviation: CCC, (2-chloroethyl)trimethylammoniumchloride.

Reprint requests to Prof. Dr. A. Wild.

Verlag der Zeitschrift für Naturforschung, D-7400 Tübingen
0341–0382/85/0009–0745 \$ 01.30/0



Dieses Werk wurde im Jahr 2013 vom Verlag Zeitschrift für Naturforschung in Zusammenarbeit mit der Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V. digitalisiert und unter folgender Lizenz veröffentlicht: Creative Commons Namensnennung-Keine Bearbeitung 3.0 Deutschland Lizenz.

Zum 01.01.2015 ist eine Anpassung der Lizenzbedingungen (Entfall der Creative Commons Lizenzbedingung „Keine Bearbeitung“) beabsichtigt, um eine Nachnutzung auch im Rahmen zukünftiger wissenschaftlicher Nutzungsformen zu ermöglichen.

This work has been digitalized and published in 2013 by Verlag Zeitschrift für Naturforschung in cooperation with the Max Planck Society for the Advancement of Science under a Creative Commons Attribution-NoDerivs 3.0 Germany License.

On 01.01.2015 it is planned to change the License Conditions (the removal of the Creative Commons License condition “no derivative works”). This is to allow reuse in the area of future scientific usage.

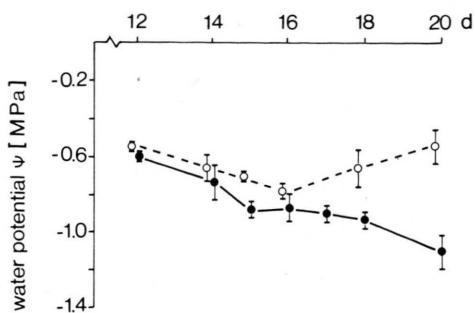


Fig. 1. The water potential (Ψ) of the third growing leaf of untreated (\circ --- \circ) and CCC-treated (\bullet — \bullet) wheat plants. $10^{-2} \text{ mol} \cdot \text{l}^{-1}$ CCC were added to the nutrient solution at the 11th day of development. The bars represent the standard deviation.

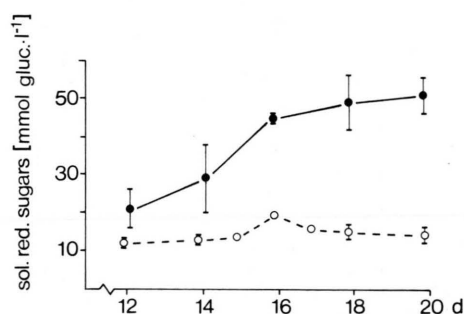


Fig. 2. The increase of the content of soluble reducing sugars in the cell sap extracted from the third wheat leaves after CCC application at the 11th day (\bullet — \bullet); (\circ --- \circ): untreated controls. The concentration of sugars is given as equivalents to a glucose standard.

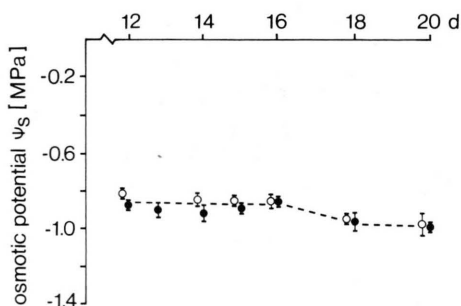


Fig. 3. The effect of CCC on the osmotic potential (Ψ_s) of the third wheat leaf during its development. The open symbols represent the control values, the closed symbols represent the data obtained from leaves after CCC application at the 11th day. Ψ_s was estimated on extracts of sap obtained from rapidly frozen leaves by the cryoscopic technique.

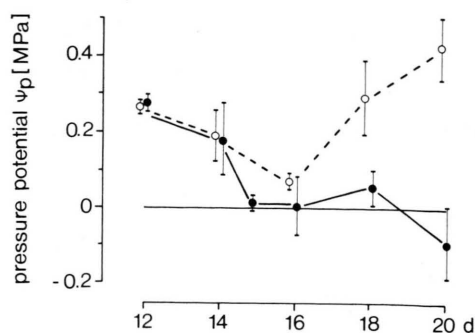


Fig. 4. The pressure potential (Ψ_p) of the third wheat leaves after CCC application to the plant roots (closed symbols). The open symbols represent the control values. Ψ_p was calculated from the cryoscopically measured data of Ψ_s : $\Psi_p = (-) \Psi - (-) \Psi_s$.

cell sap being markedly raised (Fig. 2), one might expect a lowering of the osmotic potential of the cell sap after CCC had been applied. But as shown in Fig. 3, the growth retardant did not affect the Ψ_s of the third wheat leaf.

As a consequence of the unchanged osmotic potential and the decrease of leaf water potential, the turgor of the third leaf was lowered from the third day after the addition of CCC (Fig. 4). Calculated from the cryoscopically measured data, Ψ_p even assumed negative values in the CCC-treated tissue. The actual existence of negative turgor pressures in wheat plants, however, has to be doubted. These probably arise from dilution errors in the measurement of the osmotic potential on cell sap from frozen and thawed tissue [6, 8].

The transpiration determined at the adaxial surface of attached wheat leaves under the conditions of the climatic chamber, was less in the CCC-treated leaves as compared to the control leaves (Table I).

Table I. Transpiration and stomatal resistance in CCC-treated wheat plants and untreated controls. The measurements of transpiration and stomatal resistance were performed with the adaxial surface of the third attached leaves at the 20th day of development in the climatic chamber. The data presented are mean values (mv) from 50 different plants, s = standard deviation.

	Untreated control	$10^{-2} \text{ mol} \cdot \text{l}^{-1}$ CCC
	mv s	mv s
Transpiration [$\text{g} \cdot \text{m}^{-2} \cdot \text{h}^{-1}$]	249 \pm 6	35 \pm 11
Stomatal resistance [$\text{s} \cdot \text{cm}^{-1}$]	0.9 \pm 0.03	9.1 \pm 3.3

Our results suggest that the application of CCC to the roots causes alterations in the water status of developing wheat leaves which resemble those induced by water deficiency. These might be a conse-

quence of the sudden stop of root growth observed in our experiments after addition of CCC to the nutrient solution [1].

- [1] J. Bode and A. Wild, *J. Plant Physiol.* **116**, 435–446 (1984).
- [2] K. J. Bradford and T. C. Hsiao, in: *Encyclopedia of Plant Physiology*, **Vol. 12 B**, pp. 263–324, Springer, Berlin–Heidelberg–New York 1982.
- [3] A. D. Hansen and W. D. Hitz, *Ann. Rev. Plant Physiol.* **33**, 163–203 (1982).
- [4] T. C. Hsiao, *Ann. Rev. Plant Physiol.* **24**, 519–570 (1973).
- [5] P. F. Scholander, H. T. Hammel, E. D. Bradstreet, and E. D. Hemmingsen, *Science* **148**, 339–346 (1965).
- [6] M. T. Tyree and P. G. Jarvis, in: *Encyclopedia of Plant Physiology*, **Vol. 12 B**, pp. 36–77, Springer, Berlin–Heidelberg–New York 1982.
- [7] A. Wild and R. Zerbe, *Biochem. Physiol. Pflanzen* **171**, 201–209 (1977).
- [8] N. C. Turner, *Plant and Soil* **58**, 339–366 (1981).