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DOES POROMETRY REFLECT WHOLE-PLANT TRANSPIRATION?

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Stomatal behaviour and transpiration of plants under laboratory and field conditions are frequently assessed by porometry. Differences between porometrically and gravimetrically measured transpiration rates of leaves and plants can be attributed to several factors: Representativeness in size and position of the measured leaf segment, changes of vapour pressure deficit, wind speed and temperature between the leaf segment enclosed in the porometer cuvette and the non-chamber-encumbered leaf, and - with experiments in growth chambers - response of the stomata to increased CO_2 concentration caused by the presence of the observer. In this study, we evaluated whether porometric measurements of transpiration can reflect gravimetrically determined transpiration of maize plants.

Methods: The experiments were carried out in growth chambers with soil-grown maize plants (*Zea mays* L. var. Tuxpeño and Suwan 1) subjected to different levels of water stress. Water stress was induced by withholding water nine days after planting. We measured transpiration rates with a steady-state porometer (LI-1600, Li-Cor, Inc., Lincoln, Nebraska, USA) of the abaxial leaf surfaces on the three to five youngest fully developed leaves. Leaf area was determined with a leaf area meter (LI-3050A, Li-Cor, Inc., Lincoln, Nebraska, USA). We calculated the whole-plant transpiration rate by using a factor 0.75 for the ratio of adaxial to abaxial transpiration and averaging the transpiration rate of different leaves. Gravimetric transpiration rate was assessed by weighing the pots before and after a six hour period. CO_2 concentration was measured with an infrared carbon dioxide analyzer (LCA-2, ADC Ltd., Hoddesdon, England).

Results: Porometrically assessed transpiration rates of the adaxial leaf surfaces were much lower in comparison to the abaxial leaf surfaces. Lower conductances of adaxial leaf surfaces seemed to result from shading the leaf with the porometer. Maize plants responded to shading in less than 30 s with partial stomatal closure. The transpiration of the upper leaf surface was not measured but estimated from the ratio of abaxial to adaxial transpiration based on stomata densities (Siri 1993) and leaf-inversion experiments. No differences intranspiration rates were found in the last three to four fully developed leaves. The relationship between gravimetrically and porometrically assessed transpiration rates is shown in figure 1. Transpiration of water-stressed, weakly transpiring plants was underestimated with the porometer but was overestimated in comparison to well watered, strongly transpiring plants. Porometric assessments of strongly transpiring plants revealed a higher variance in transpiration rate than gravimetric assessments. CO_2-concentration in the growth chamber was considerably increased by the presence of the observer. The CO_2-concentration varied

during the experiment. Transpiration rates of well watered and stressed plants responded to the actual CO_2-concentration. Whereas gravimetric transpiration rates did not vary at 12, 14 and 16 days after planting, we recorded significant differences in porometric transpiration rates. These variations correlated well with the CO_2-concentration during the measurement (figure 2). The deviation of the regression line from the ideal 1:1 relationship may be explained by increased CO_2-concentrations. Strongly transpiring plants responded to elevated CO_2 concentration with a more marked decrease in transpiration than weakly transpiring plants. The number of fully developed non-shaded leaves limited the number of measurements. Transpiration rates within the same plant varied considerably. Four measurements per plant yielded only a precision of ± 40% of the estimated mean value (α=0.1). The enclosure of leaves into the cuvette seemed to cause partial stomatal closure. With respect to air humidity steady-state conditions in the cuvette were attained in about 15 s. However, calculated transpiration rates tended to decrease during a longer period (1-2 min) which might be a problem especially for maize plants measured in growth chambers.

Figure 1. Relation between porometrically and gravimetrically assessed transpiration rates of maize plants.

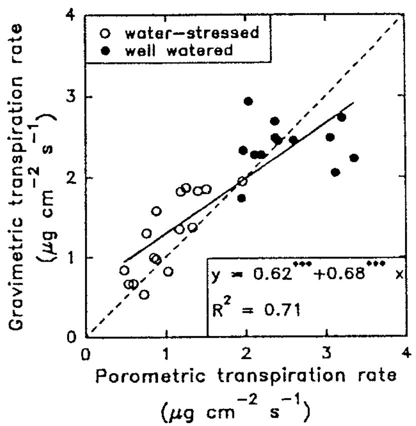
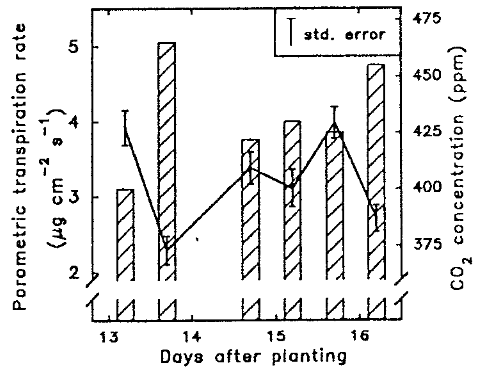


Figure 2. Porometric transpiration rates (line) and corresponding CO_2-concentrations (bars).



Conclusions: Porometry reflected only partly the gravimetrically measured transpiration rates of plants grown in climate chambers. The accuracy of porometric measurements can probably be improved in CO_2-regulated growth chambers and with an increased number of measurements.

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