

A detailed examination of oxygen isotopes to increase the precision of leaf water modelling

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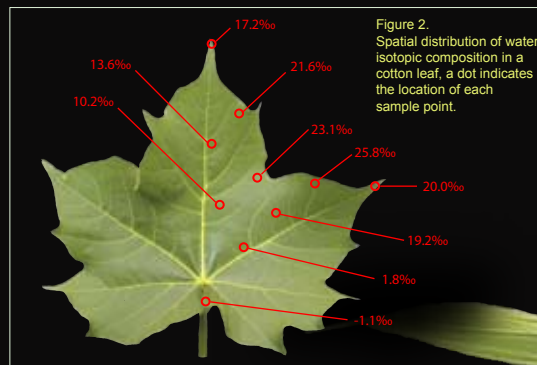
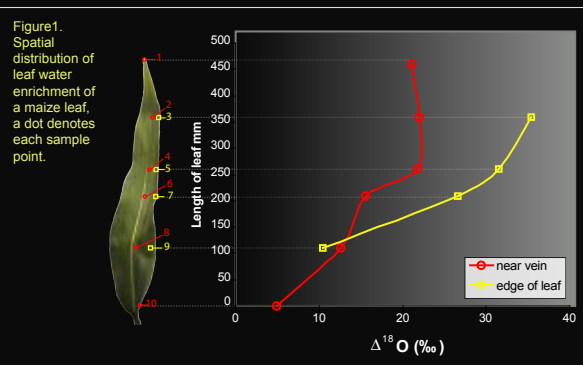
Introduction

There is much interest in understanding the fractionation processes that determine the oxygen/hydrogen isotopic relationship in leaf water. Precise data on leaf water composition is an essential input to biosphere/atmosphere modelling; with a number of factors contribute to the isotopic composition of the water at any point in the leaf. Some of the major ones are: the composition of the water entering the roots, the amount of evaporation, the composition of the vapour around the leaf and the Péclet effect (ref 1). Previous models, incorporating the Péclet effect have accounted for the 'gross' variation in isotopic enrichment of the leaf water between the petiole and the sites of evaporation, calculated as though all the processes affecting the evaporation and condensation of water, both hydrogen and oxygen isotope fractionation, change smoothly along transects of the leaf.

Our objective is to examine whether transpiration is uniform over the leaf, a one dimensional response to O and H enrichment, or whether the model needs to be modified to take into account other 'feedback' mechanisms. In this study, we are producing detailed maps of leaf transpiration to improve the modelling of the isotopic composition and reflect the spatial variation found within a leaf.

Materials and Method

- Cotton (*Gossypium hirsutum* L. var. Deltapine 90) and maize (*Zea mays* Yates, sweet corn, cv. Premium) plants were sown in 4.5L PVC pots containing sterilised garden soil mixture supplied with slow-release fertilizer (Osmocote Plus Scotts, Sierra Horticultural Products, Netherlands). Maintained in a controlled environment (27 °C day; humidity 50%; 20 °C night, humidity 40%; light/dark 16/8h), photon flux density 600-1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$.
- After 2 months growth a single leaf was randomly selected from plants for spatial mapping. Approximately 1.5 x 0.3 cm² of leaf material removed at each sample point and immediately sealed in a glass vial with CO₂.
- The leaf water was equilibrated with the CO₂ and subsequently measured by injection into a continuous-flow stable isotope ratio mass spectrometer (using a loop valve) and the $\delta^{18}\text{O}$ of the water determined relative to VSMOW (see Stuart Williams et al., 2006, poster-H19).



Results

Maize (*Zea mays*) - Fig 1.

- A progressive enrichment was observed along the blade of the leaf (4.9 - 21.1 ‰), with the highest values measured towards the tip of the leaf (21.1 - 22.0 ‰).
- Enrichment of leaf water increased from the midrib towards the edge and along the length of the leaf margin (10.4 - 35.4 ‰).

Cotton (*Gossypium hirsutum* L.) - Fig 2.

- Increased ¹⁸O enrichment along the primary veins from the distal tip to the leaf base (20.0/17.2 - -1.1 ‰).
- Greater enrichment at the margins of the leaf, especially leaf material containing secondary veins (21.6 - 25.8 ‰).

Conclusions

- Although only a preliminary study with a limited number of sample points our data shows it was possible to detect spatial variation of leaf water enrichment in both leaf species.
- A trend to more enriched waters at the leaf margins in both species and an enrichment pattern from base to tip.
- Cotton species show a trend to more enriched waters from samples taken within the venous/intercostal regions of the leaf.

Future work

The next step will be to repeat the experiment with a greater number of sample points per leaf, and detect both O and H enrichment. A similar method of stable isotope detection will be employed for hydrogen, except that the water will be cryo-distilled from the leaf in a deep-freeze, then injected onto a chromium column and reduced to produce pure H₂. By examining these effects on a micro scale we will then produce detailed maps of leaf transpiration to improve the modelling of the isotopic composition and reflect the spatial variation found within a leaf.