BioSolar Cells

Phloem sap flow assessed by MRI

A. Prusova[A], F. J. Vergeldt[A], H. Van As[A]
[A] Wageningen University, Laboratory of Biophysics, Department of Agrotechnology & Food Sciences, The Netherlands

Magnetic resonance imaging (MRI)

Xylem and phloem vascular tissues are extremely sensitive to experimental manipulation. Therefore a truly non-invasive and repeatable technique like MRI (a technique widely accepted as the gold standard[1]) is suitable to study the xylem and phloem sap flow velocities in intact plants in relation to water content in the surrounding tissues. Vascular tissue plays a crucial role in the distribution of water, nutrients and carbohydrates along the plant (fig. 1). Phloem sap is distributed from the source leaves to the sinks.

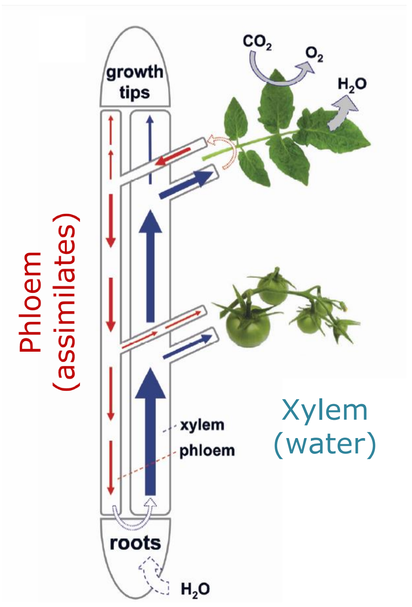

Figure 1. Location and direction of xylem and phloem vascular tissue (image: Carel Windt, modified)

Objective

Studying the xylem and phloem sap flow as a function of the sink location, light intensity and soil water content.

Results

Experiment

Sap flow in the main stem of tomato (*Solanum lycopersicum* L.) was studied in relation to the sink function of fruits. The measurement was performed below and above a truss with three unripe fruits. By use of a 3T MRI system and pulsed field gradient turbo spin echo PFG-SE-TSE pulse sequence[2] the cross-sectional images of the stem are obtained (fig.2).

Figure 2. Cross-sectional transversal slice MRI image of the tomato main stem + reference tubes.

Figure 3. Cross-sectional transversal slice MRI image of the tomato main stem with reference tubes overlapped with the phloem (red) and xylem (blue) flowing masks.

- Next xylem and phloem flowing masks (fig. 3) were obtained.
- Quantitative diurnal flow profiles were obtained on a per pixel basis, resulting in average linear velocity and total volume flow of xylem (fig. 5, 7, 9) and phloem (figs 4, 6, 8) sap flow.
- In xylem a typical day-night cycle of both parameters is clearly observed. Low water supply (fig. 5) and (too?) high water supply (fig. 7) conditions can be deduced from the xylem flow profile as well.
- Phloem flow does not show any diurnal cycle below the truss while above changes in sap flow velocity and volume flow can be observed.

Diurnal flow profiles

watered every 48hrs 0.5L water, light 50μE $m^{-2}s^{-1}$ at the soil level

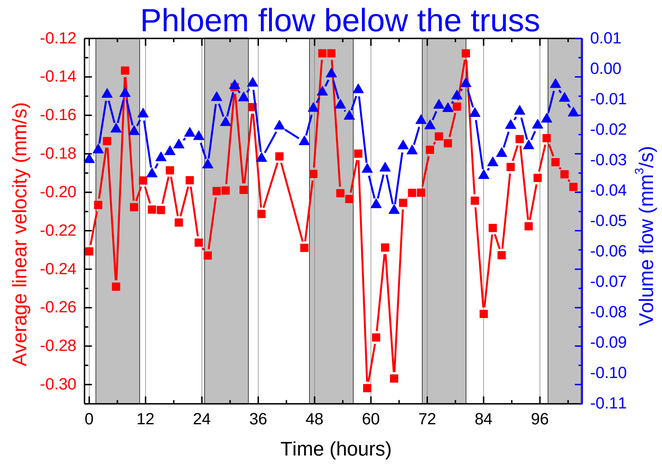

Figure 4. Phloem sap flow below the truss

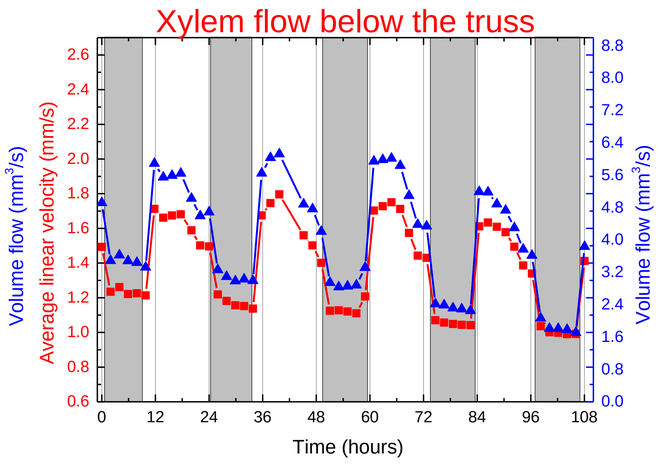

Figure 5. Xylem sap flow below the truss

watered every 24hrs 0.5L water, light 300μE $m^{-2}s^{-1}$ at the soil level

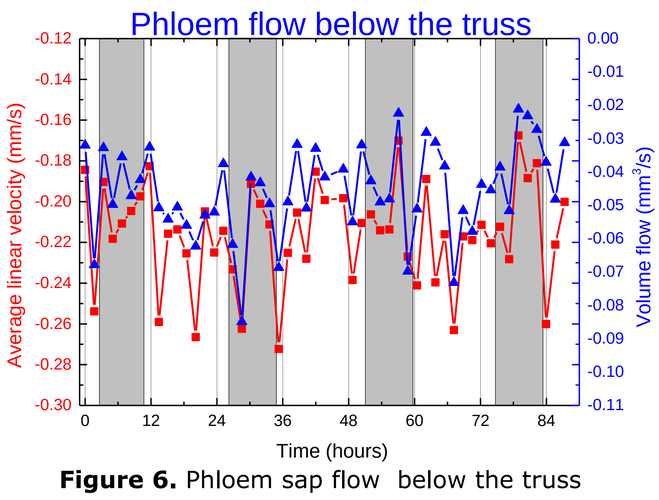

Figure 6. Phloem sap flow below the truss

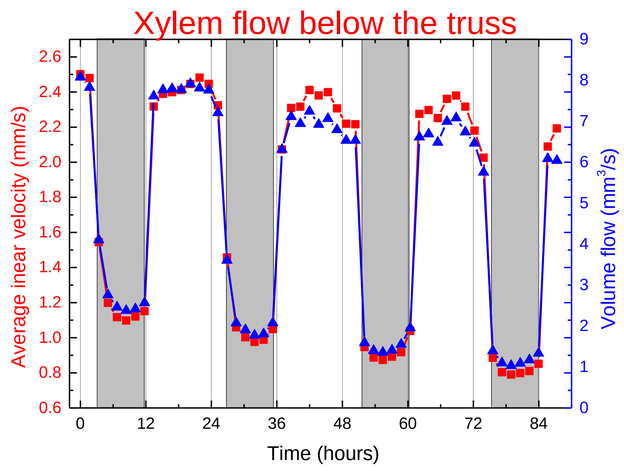

Figure 7. Xylem sap flow below the truss

watered every 24hrs 0.25L water, light 300μE $m^{-2}s^{-1}$ at the soil level

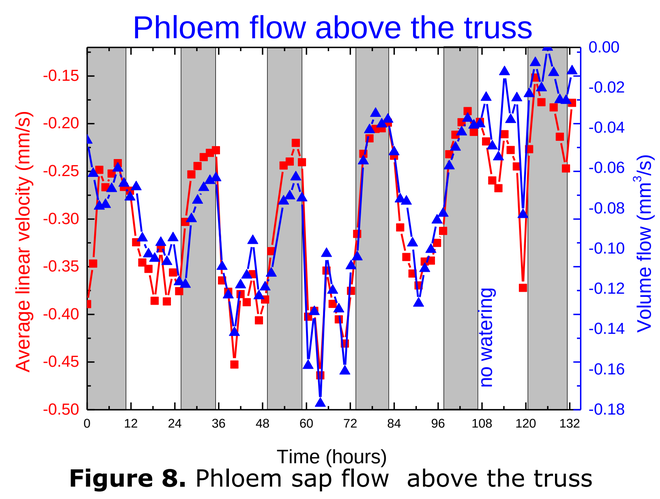

Figure 8. Phloem sap flow above the truss

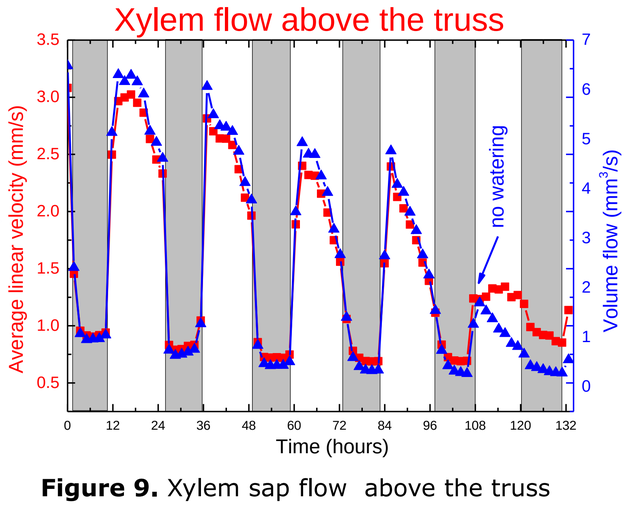

Figure 9. Xylem sap flow above the truss

Conclusions

- Diurnal xylem flow profile is very informative about soil condition (drought, (too) wet), and can be used to determine the total water evaporation.
- The volume flow of phloem tends to increase at increasing light intensity, average velocity does not show much dependence.
- Diurnal phloem flow profile clearly reflect sink function (fruits, wounds).

BioSolar Cells
Project Office
P.O. Box 98
6700 AB Wageningen
office@biosolarcells.nl
T + 31 (0)317 48 10 96
www.biosolarcells.nl

WAGENINGEN UR
For quality of life

Wageningen University - Laboratory of Biophysics,
Department of Agrotechnology & Food Sciences,
Dreijenlaan 3
6703 HA Wageningen
The Netherlands
alena.prusova@wur.nl
T + 31 (0)317 482026
www.wageningenur.nl

References

1 Van As H. et al., Journal of Magnetic Resonance, 2013, 229: 25–34.
2 Scheenen et al., Journal of Magnetic Resonance, 2000, 142:207–215.

Acknowledgement

Authors would like to thank to Edo Gerkema and John Philippi for technical help with measurements and setup.