Water stress detection in sunflower varieties using leaf temperature and leaf water content

Integrating water stress tolerance criteria into varietal study in Switzerland

Eve-Anne Laurent, Nathalie Wuyts, Nicolas Vuille-dit-Bille, Juan Herrera, Adrien Mougel, Matthias Schmid, Vincent Nussbaum, Alice Baux

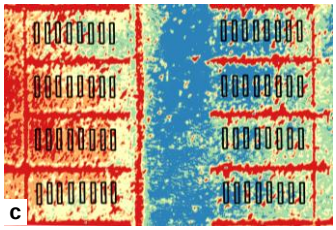
Agroscope, Route de Duillier 60, 1260 Nyon, Switzerland; www.agroscope.ch

Introduction

The sunflower production area in Switzerland is increasingly subjected to summer water deficit that may limit sunflower performance. Varieties with physiological mechanisms conferring drought tolerance at flowering and seed filling constitute the most favorable strategy to maintain domestic production. Currently, no established indicators to assess water stress tolerance are included in variety trials. The present study aims to evaluate the potential of leaf (ground-based) and canopy (airborne-based) temperature, and leaf water content to differentiate varieties in their response to water deficit.

Materials and methods

- Field trial following farmers' practices in the 2022 growing season in Nyon (CH)
- 8 sunflower varieties with 4 repetitions with a rainfed and an irrigated block (95 mm in total)
- Measurement of leaf (leaf T), canopy (canopy T) temperature, and leaf water content (LWC) around midday on days with little or no clouds (Figure 1)



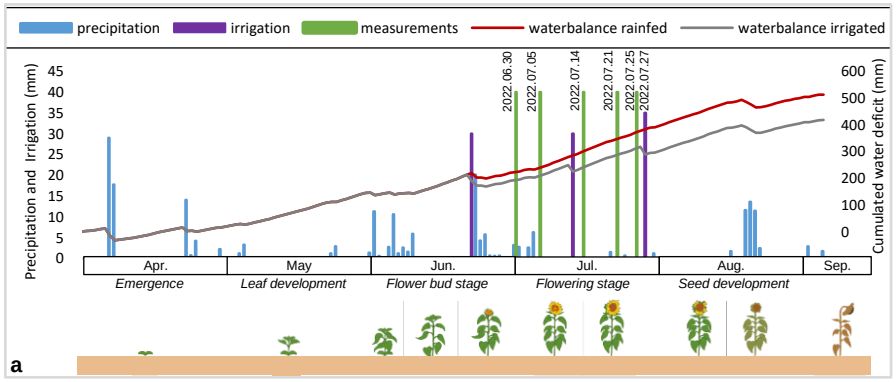


Figure 1: a. Water inputs and cumulated water deficit over sunflower growth stages with an indication of measurement dates (2022.07.25: leaf T only, 2022.07.27: canopy T only); b. leaf T measurements for the youngest developed leaf using a handheld infrared camera (FLIR Extech IRC130) used as a point sensor; c. drone surveys using a MicaSense Altum multi-spectral and thermal imaging camera performed at one timepoint on the same day to acquire canopy T (2022.07.21, left: rainfed, right: irrigated).

Results

Drought stress detection

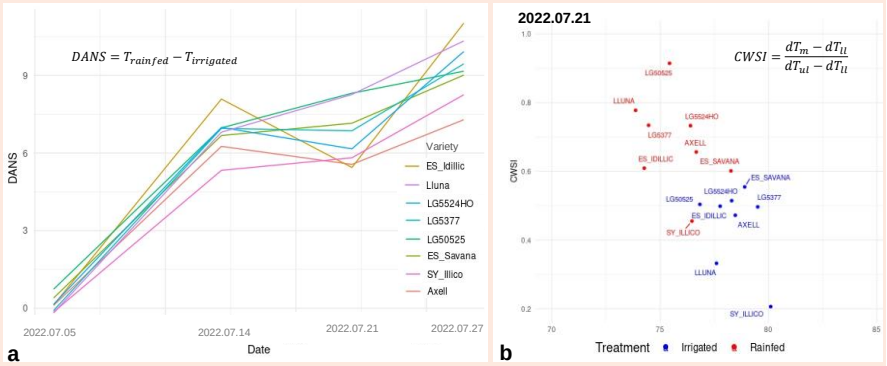


Figure 2: Indices of crop water stress based on leaf T (CWSI – Idso et al., 1981; Jackson et al., 1981) and canopy T (DANS – Taghvaeian et al., 2014); a. DANS index across measurement dates; b. CWSI over LWC for one measurement date, irrigated and rainfed plants ($T_{rainfed}$ and T_{canopy}: canopy T for rainfed and irrigated plants, respectively; dT_m: leaf T-air T, dT_{ll} and dT_{ul}: the lower and upper limits of leaf T-air T differential reached under non-water-stressed and non-transpiring conditions, respectively).

The crop water stress index (CWSI) was calculated using lower limits of the leaf T- air T differential over vapour pressure deficit (dT_{ll}) for irrigated plants and the corresponding upper limit (dT_{ul}). Drought stress was detected in rainfed plants starting from the 4th measurement date (Figure 2b). Canopy T allowed for the calculation of the degrees above non-stressed index (DANS) as irrigated and rainfed plants were measured simultaneously. Here, drought effects were detected from the 2nd measurement date (Figure 2a) and were increasing over time.

Variety differences

- Two plant water-regulation strategies were identified: reduced water loss associated with high CWSI (stomatal closure), and low CWSI associated with varying degrees of water loss presumably depending on leaf water characteristics (Maury et al., 2000).
- SY Illico with the lowest CWSI and one of the highest LWC for both irrigated and rainfed plants: a high initial water content ensures a reasonable water content for rainfed plants, despite water loss. Also the variety with the 2nd lowest DANS for most measurement dates. Leaf T, LWC and canopy T all indicate drought tolerance characteristics.
- Lluna with one of the lowest LWC for the irrigated plants, showed a small decrease in LWC without irrigation but a high CWSI increase. Also the variety with the 2nd highest DANS for most measurement dates. Leaf T, LWC and canopy T all indicate drought sensitivity.
- Both leaf T and canopy T show differences between varieties, even though variety ranking for leaf T and canopy T varies. Canopy T gives steadier variety ranking than leaf T among measurement dates.

Conclusions

Drought stress was detected for both leaf T and canopy T, with an earlier detection by canopy T. Differences between varieties were evidenced. Canopy T can provide a variety ranking and the dynamic of stress level. In combination with LWC, leaf T can be used to identify varieties' strategies in response to water deficit.

References

Idso et al. (1981), Normalizing the stress-degree-day parameter for environmental variability. Agricultural Meteorology

Jackson et al. (1981), Canopy Temperature as a Crop Water Stress Indicator. Water Resources Research

Maury et al. (2000), Leaf water characteristics and drought acclimation in sunflower genotypes. Plant and Soil

Taghvaeian et al. (2014), Conventional and Simplified Canopy Temperature Indices Predict Water Stress in Sunflower. Agricultural Water Management

Agroscope good food, healthy environment

invite

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
Agroscope