Soil moisture dynamics in silvoarable alley cropping systems

Learning from a soil moisture sensor network

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I. Introduction

- Alley cropping, i.e. the inclusion of linear rows of trees on cropland, has the potential to **make agriculture more drought-resilient** by creating a **beneficial microclimate** (Jacobs et al. 2022).
- Multiple factors influence **water availability** for crop growth.
- Soil moisture sensors installed in transects at various depths and distances from the tree row can be used to assess **spatiotemporal patterns in soil water availability** at high temporal resolution.

II. Sensor network

- **3 transects** of 18 sensors each (Teros 11 and 12, Meter Group Inc., Pullman WA, USA) were installed at JLU's research farm "Gladbacherhof" in May 2021.
- **Distances** from tree row: 1 m (grass strip), 2.5 m, 6 m and 10.5 m (middle of the crop alley) upslope and downslope (Fig. 1a).
- **Depths**: 40 and 60 cm; additionally at 10 cm in grass strip.
- Sensor cables go through a tube at 50 cm depth (below ploughing depth) to the **telemetric data logger** (ADCON RTU A723, Vienna, Austria) in the grass strip.
- A server process pushes new data to our **open-source data management system ODMF** (https://github.com/jlu-ilr-hydro/odmf) (Fig. 1b).

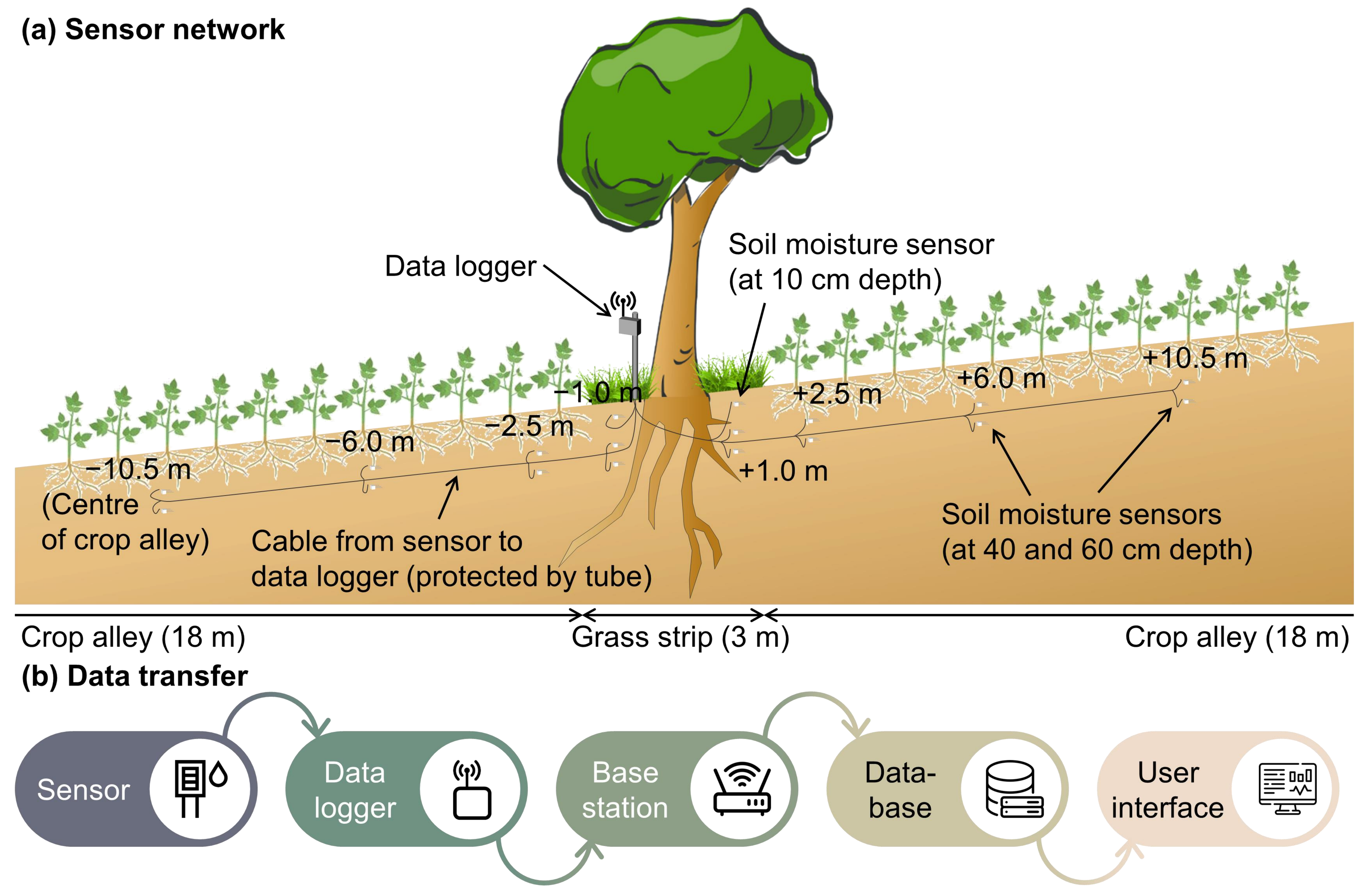


Fig. 1 Soil moisture sensor network: (a) schematic drawing of a transect with 18 soil moisture sensors, and (b) data flow from sensor to user interface.

III. Preliminary results

- During the **dry spell** of summer 2022, soil moisture was slightly higher in the grass strip at 40 cm depth (0.31±0.039 $m^3\ m^{-3}$) than in the crop alley (0.27±0.044 $m^3\ m^{-3}$) (Fig. 2a–b).
- The crop alley **dried out faster** than the grass strip (Fig. 2c).
- **Rewetting the soil** in the crop alley at 60 cm depth took 24±8 days vs. 12±4 days at 40 cm. Soil in the grass strip at 10 cm depth rewetted in 6±2 days (Fig. 2d).
- **Following rewetting**, soil moisture at 40 cm was similar in the grass strip and crop alley (0.36±0.061 $m^3\ m^{-3}$), whereas soils at 60 cm depth were wetter in the crop alley than in the grass strip (0.38±0.095 $m^3\ m^{-3}$ vs. 0.32±0.052 $m^3\ m^{-3}$).

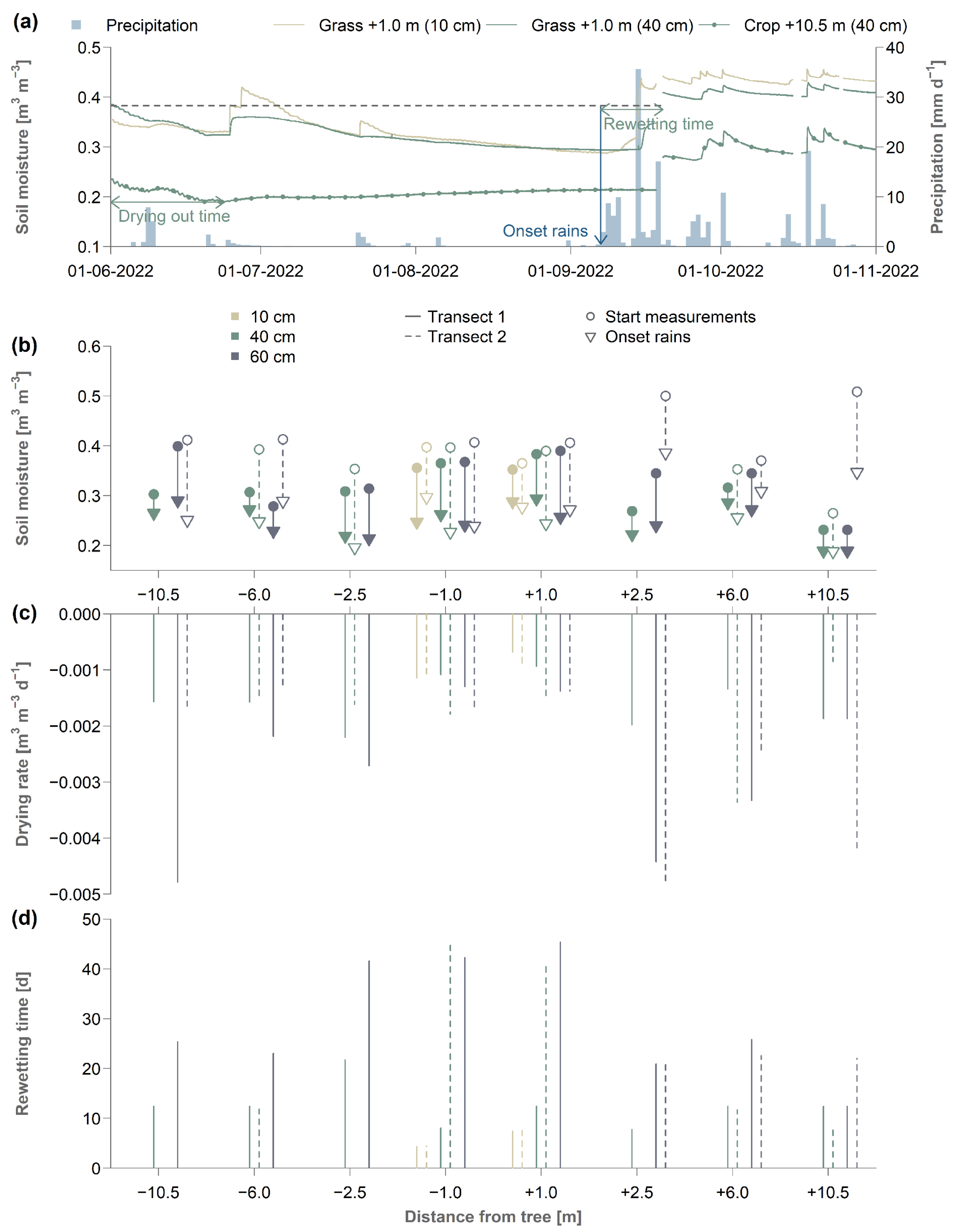
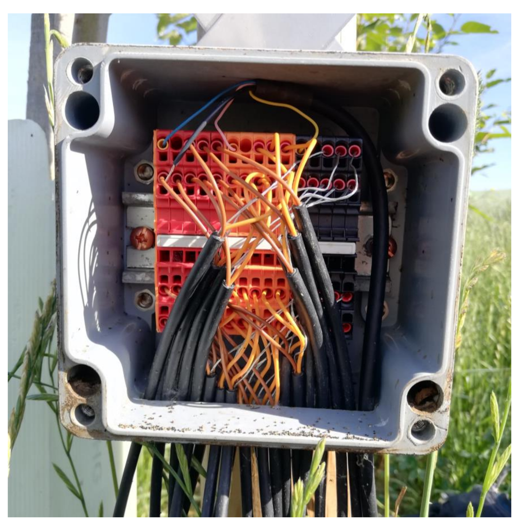


Fig. 2 Analysis of soil moisture data for June to November 2022: (a) example data from Transect 1 as illustration of the analysis, (b) change in soil moisture from start of the measurements until the onset of the rains, (c) drying rate during the dry spell, and (d) number of days until original soil moisture content is reached (rewetting time).

IV. Considerations for installation and management

- Digging causes major **soil disturbance** and potentially destruction of crops. Reliable soil moisture data can be obtained after approx. 6 months.
- Animals, vegetation management (e.g. mowing) and soil management (e.g. ploughing) can **damage sensor cables**. Protective tubing can help, but tubes can also cause **preferential flow** towards sensors.
- Connecting many sensors requires a compatible **data logging and transmission system** as well as sufficient **power supply**. Trees can shade solar panels.
- The large amount of data requires a dedicated person for **data management** and **quality control** as well as network maintenance.



V. Outlook

- Other **indices for rainfall-soil moisture dynamics** can be used to infer on groundwater recharge and infiltration.
- Robust sensor networks installed in multiple alley cropping systems across Europe can help to **identify optimal designs** for drought-resilient alley cropping systems for a range of climate and soil conditions.

Literature: Jacobs, S.R., Webber, H., Niether, W., Grahmann, K., et al. (2022) Modification of the microclimate and water balance through the integration of trees into temperate cropping systems. *Agric. Forest Meteorol.* 232:109065. https://doi.org/10.1016/j.agrformet.2022.109065

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