High-resolution monitoring of soil moisture dynamics in a silvoarable alley cropping system

Jacobs S[1,2], Golicz K[2], Kraft P[2], Minarsch E-ML[3], Weckenbrock P[3], Gattinger A[1,3] & Breuer L[1,2]

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Abstract

The introduction of trees on agricultural land is expected to change the availability of soil water due to changes in evapotranspiration and soil hydraulic properties. We installed a soil moisture sensor network in a silvoarable alley cropping system in central Germany to assess both spatial and temporal variations in soil moisture. This contribution provides a description of the design of the soil moisture sensor network, as well as preliminary results that demonstrate the use of such data.

Introduction and objectives

Alley cropping, i.e. the inclusion of linear tree rows on cropland, has the potential to increase the drought resilience of agriculture. However, trees have higher evapotranspiration rates than annual crops and could therefore reduce soil water availability. On the other hand, the trees could also create a beneficial microclimate that reduces crop evapotranspiration (Jacobs et al. 2022). Soil moisture sensors installed at various depth and distances from the tree row are a very useful tool to assess spatiotemporal patterns in soil water availability. Here we present the design of a soil moisture sensor network installed in a silvoarable alley cropping system at the research and teaching farm "Gladbacherhof" of the Justus Liebig University Giessen (Hesse, central Germany).

Methods

Three transects consisting of 18 sensors each (Teros 11 and 12, Meter Group Inc., Pullman WA, USA) are installed perpendicular to a tree row. Along each transect, sensors are deployed at 1 (grass strip), 2.5, 6 and 10.5 m (middle of the crop alley) upslope and downslope of the tree at 40 and 60 cm depth, with additional sensors at 10 cm depth at 1 m distance from the tree, where no soil management takes place (Figure 1a). Sensor cables run through a plastic tube at 50 cm depth to the data logger (ADCON Radio Telemetry Unit A723, Vienna, Austria), located in the tree row.

Results and discussion

Preliminary data from summer 2022 suggests that the soil dries out faster in the crop alley (Figure 1b). Across all transects, the minimum soil moisture level is reached within 43±31 days in the crop alley compared to 96±1 days in the grass strip. After the onset

[1] Zentrum für internationale Entwicklungs- und Umweltforschung (ZEU), Justus-Liebig-Universität Gießen, Senckenbergstr. 3, 35390 Gießen, Deutschland, suzanne.r.jacobs@zeu.uni-giessen.de

[2] Institut für Landschaftsökologie und Ressourcenmanagement, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 26, 35392 Gießen, Deutschland

[3] Institut für Pflanzenbau und Pflanzenzüchtung II, Justus-Liebig-Universität Gießen, Karl-Glöckner-Str. 21C, 35394 Gießen, Deutschland

of the rains, soil in the crop alley at 60 cm depth takes longer to reach the same soil moisture level as at the start of the monitoring period (1st of June), with a mean of 24±8 days vs. 12±4 days at 40 cm depth. The fastest response is at 10 cm depth in the grass strip (6±2 days). Overall, soil moisture is slightly higher in the upper layers in the grass strip (0.36±0.062 $m^3\ m^{-3}$ and 0.33±0.052 $m^3\ m^{-3}$, at 10 and 40 cm depth respectively) than in the crop alley at 40 cm depth (0.30±0.064 $m^3\ m^{-3}$), whereas the difference is smaller at 60 cm depth (crop alley: 0.34±0.052 $m^3\ m^{-3}$; grass strip: 0.32±0.049 $m^3\ m^{-3}$).

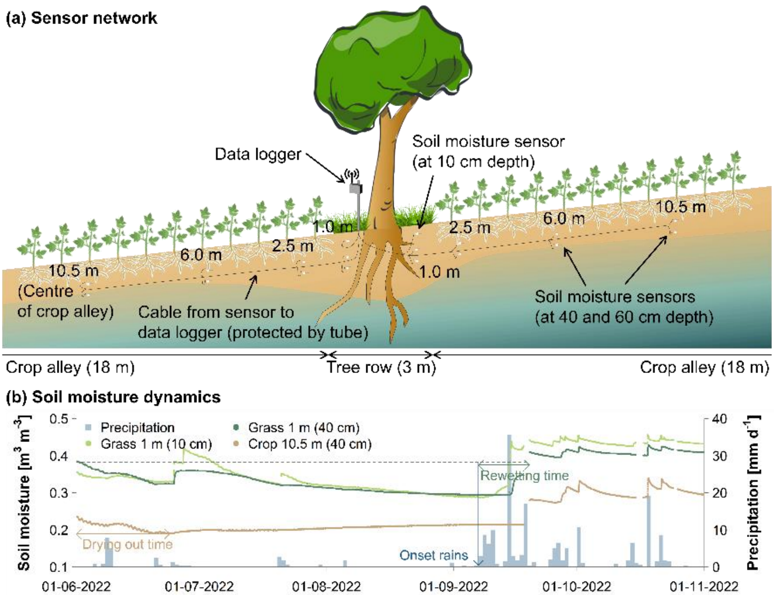

Figure 1: (a) Design of a soil moisture sensor transect and (b) differences in soil moisture dynamics between depths (10 and 40 cm in the grass strip at 1 m upslope) and locations (40 cm depth at 1 and 10.5 m upslope) along a transect.

Conclusions

The analysis of soil moisture data collected along transects will contribute to our understanding of spatiotemporal soil moisture dynamics and will support the evaluation of the potential contribution of alley cropping systems to drought resilient agriculture.

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Literature

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