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Evaluating stemflow infiltration through time-lapse ground-penetrating radar surveys on a Faidherbia albida tree in Senegal's Sahel

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In the Sahel region, agroforestry is a land-use system widely adopted as a more sustainable agricultural production system. In this type of system, woody perennials that are grown in association with agricultural crops and pastures, constitute spatially disconnected zones where microclimate and soil's infiltrability, physical, chemical, and biological conditions are assumed locally improved. Particularly the stemflow concentrates a part of the intercepted rainfall from the canopies to the stems. Hence stemflow can induce preferential infiltration around the stem base and promote groundwater recharge.

In the West African Sahel, *Faidherbia albida* (Delile) A.Chev. is commonly adopted as multi-purpose woody perennial in agroforestry systems. It is a deciduous tree with an inverse phenology as it loses the leaves during the rainy season. Although, the absence of leaves during the rainy season is expected to decrease the interception and to consequently decrease stemflow, evidence of stemflow at the base of *F. albida* trees were reported in the literature when the stems were partially covered with green leaves (Chinen, 2007).

In this study, we carried out timelapse ground penetrating radar (GPR) surveys in conjunction with a simulated stemflow event to investigate stemflow-induced infiltration by an *F. albida* tree trunk and root system. We established a survey grid (2.1 m × 2.1 m) around an *F. albida*, consisting of twelve horizontal and ten vertical parallel survey lines with 0.3 m intervals between them. Two stemflow pulses, each of 20 L, were poured on the tree trunk using a PVC pipe with a 1-mm-diameter hole every 50 mm. The pipe was connected to a plastic funnel and positioned around the tree trunk at 0.4 m from the soil surface. One grid GPR survey was carried out before the stemflow simulation experiment. A total of 40 L of water was used during the experiment. A second survey was carried out after the injection of the first 20 L, while the last survey was carried out after the second stemflow pulse. We collected a total of 66 (3 GPR surveys × 22 survey lines) radargrams using a GSSI (Geophysical Survey System Inc., Salem, NH) SIR 3000 system with a 900-MHz antenna. We therefore obtained for each survey line a pre-wetting and two post-wetting radargrams. Next, we created other forty-four matrixes

based on absolute differences between pre- and post-wetting amplitude values. Higher differenced values occurred because of amplitude changes and time shifts related to wave propagation.

The analysis of the differentiated radargrams provided evidence of deep infiltration along the tap roots. The wetted zone extended mainly in-depth providing evidence of the potential role played by the *F. albida* trees in groundwater recharge processes due to their deep rooting, preferably reaching the groundwater table. Put all together, this study shows a first signal of the importance of accounting for stemflow infiltration in the water balance of agroforestry systems with *F. albida* trees.

References

Chinen, T., 2007. An observation of surface runoff and erosion caused by acacia albida stemflow in dry savanna, in the south-western republic of Niger 10.

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