WP2 **Ecosystem Services** - Task 2.2. **Supporting & regulating services**
D 2.2.3. Tree functioning (60% completed)

D 2.2.3.1 - Senegal

D 2.2.3.1.1. *F. albida* water uptake (*F. Do, M.S.Sarr, A. Rocheteau, O. Roupsard, C. Jourdan*)

Methodology : *F. albida* water uptake is estimated by xylem sap flow measured (Fig. 1) by the Transient Thermal Dissipation method (Do *et al.* 2011), and the multi-species calibration assessement from Isarangkool *et al.* (2010). Five *F. albida* was selected at the Sob *Faidherbia Flux* site. The range of their trunk diameters was representative of the range of trunk mesured in the parkland.

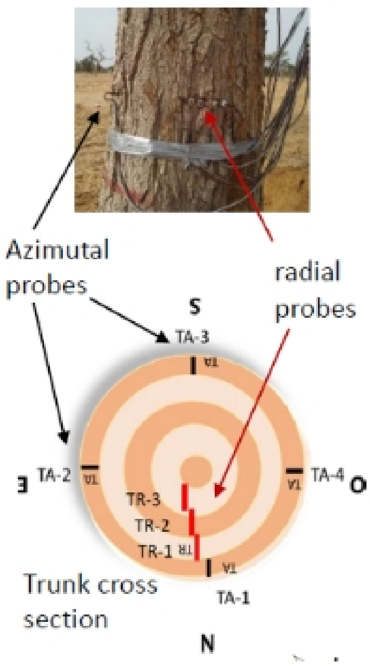

Fig.1. Sap flow measurement device for each sampled *F. albida* tree. Azimutal and radial variabilities are considered

Results : The water use (WU) strongly changes according to season and leaf phenology (Fig. 2). The maximal values are observed in December and January with large between-tree variability from 100 to 250 L.d^{-1}. *F. albida* water use (WU) decreases during the dry season to reach minimal values in rainy season avoiding thus concurrence for water with crops. The annual consumption in 2019/2020 was estimated on average at 40 000 l/tree, i.e 27 mm for a density of 6.8 trees ha^{-1}. This number represents only 5.3 % of the 2019 rainfall amount (513 mm). The between-tree variability in WU is largely determined by trunk diameter (R^2 = 0.85). This relationship is explained by both the sapwood area and an increasing sap flux density with trunk diameter (R^2= 0.78). A better access to the water table for the largest trees could be a complementary explaination. This hypothesis deserves confirmation with an higher number of trees. The relationships between WU and canopy phenology and between WU and trunk diameters support the possible conception of a statistical model to roughly estimate water consumption from simple biometric measurements (diameter at breast height DBH, projected crown surface, canopy leafing rate), and meteorological data. This model could be applied on the parkland networks were tree impacts were measured (D 2.1.1 paragraph D 2.1.1.2.1 A- p. 4, and D 2.2.1 paragraph D 2.2.1.2.1, p. 8), and at regional transect scales. The low tree water consumption related to already the significant effect observed on crop yield (LER: 1.16, D 2.1.1 paragraph D 2.1.1.2.1 C-) suggests that *F. albida* density can be increased and that an increase in crop yield can be expected as a consequence until a threshold to be determined.

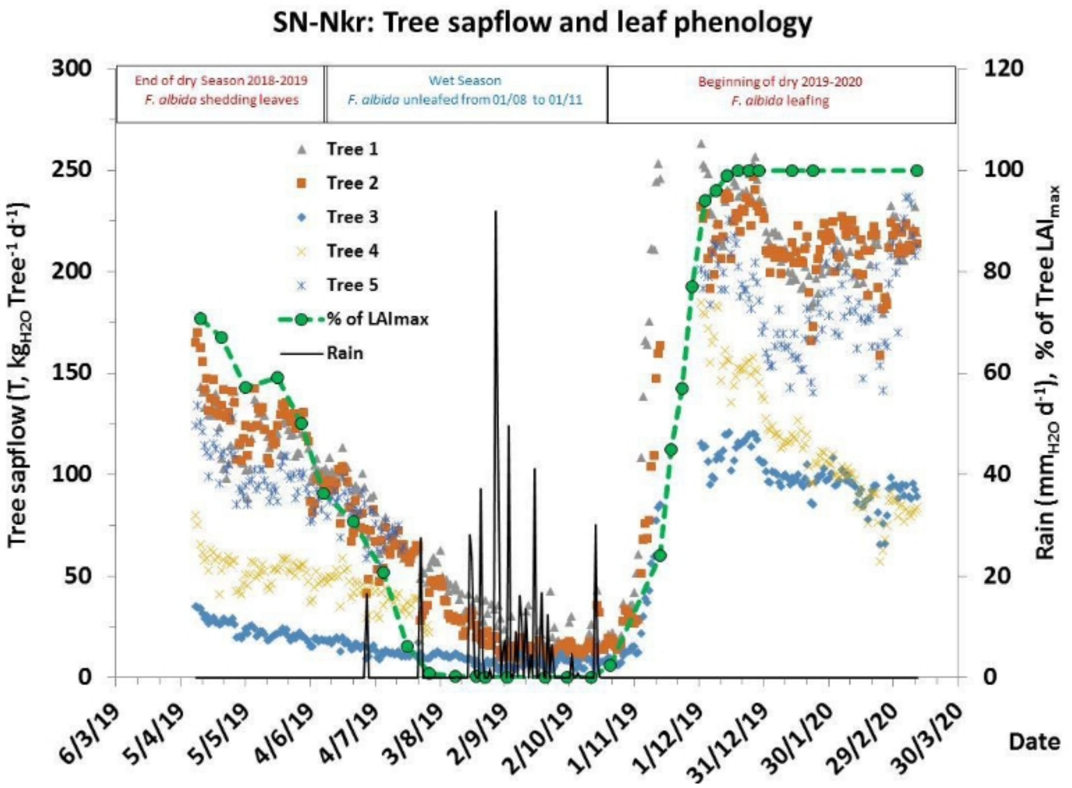

Fig. 2. *F. albida* sap flow course in relation to leaf area index (LAI) dynamics and rainfall distribution

D 2.2.3.1.2. Tree, shrub, and crop root dynamics (*C. Jourdan*)

Root dynamics of main plant species composing the studied parklands were monitored in two sites.

Methodology : Sob (*Faidherbia Flux*) site was equipped with 6 pits dug to the water table (6m), 3 under the *F. albida*, 3 far from it. In each pit, 5 scanners and 2 mini-rhizotrons were set up in 2019 thanks to the Ramses II project to monitor daily or weekly, the root dynamics of *F. albida*, pearl millet and groundnut (Fig. 3). Other pits allowed to set up root dendrometers (Fig. 4), and to perform root density maps (Fig.5).
In the second site, Keur Matar near Thiès, 9 rhizotrons (Fig. 6) were set up in a previous experiment, 3-y prior to the Ramses II project. Rhizotrons of 1x1m were placed 20 cm from each shrub in a vertical position. The roots dynamics of *G. senegalensis* and pearl millet between 0 and 1m depth were monitored according to two modalities : when *G. senegalensis* is associated to millet vs not. The effect of total aboveground part shrub pruning was also analyzed.

Results : The data on *F. albida* at Sob site are under analyses in 2021 and will be ready for the final report. Results on *G. senegalensis* showed positive impacts of the shrubs on the aerial phenology of millet (earlier heading, flowering and maturation), millet growth (stems four times larger with 1.5 times more leaves, 1.8 times more tillers) and their yield (3.8 times more spikes, 3 times more spike biomass and straw). The root dynamics of intercropped shrubs seem stalled in 0-20 cm layer during the rainy season (Fig. 6) but, when all categories are combined a pronounced higher elongation rates is measured during the wet season compared to the dry one. This seasonal variation was observed in both young 1 to 3-y old plants (0.62 cm/day in the rainy season and 0.36 cm/d in the dry season) and old plants (0.15 cm/d and 0.13 cm/d respectively the same year). On the other hand, shrub coppicing did not show any significant depressive effect on the average rate of elongation of their roots. However, a 1-month root-growth stop was observed for *G. senegalensis* 1.5 months after cutting, a condition that did not exist in uncut shrubs. In addition, these growth stops correspond to the peak of cereal root growth, and was observed for the 3 consecutive years.

Fig. 3. Root mini-rhizotrons tubes set up in 2019 in Sob (*Faidherbia Flux*) site in Senegal

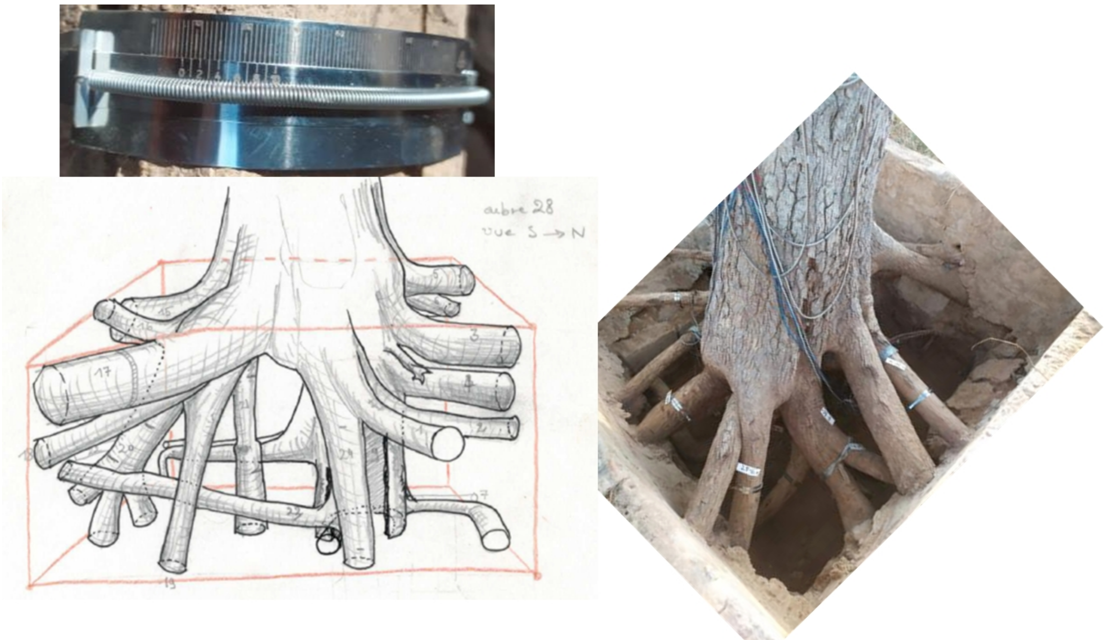

Fig. 4. Root dendrometers set up in 2019, Sob (*Faidherbia Flux*) site, Senegal

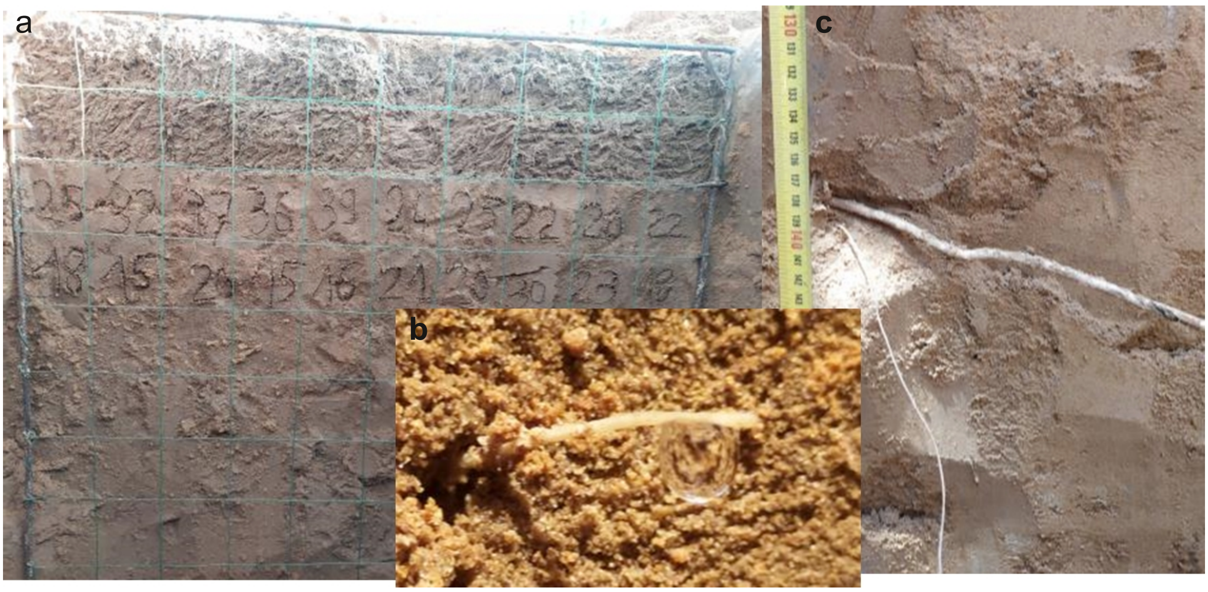

Fig. 5. Pearl millet (a & b) and *F. albida* (c) root density maps through rhizotrons, at Sob *Faidherbia Flux* site, Senegal

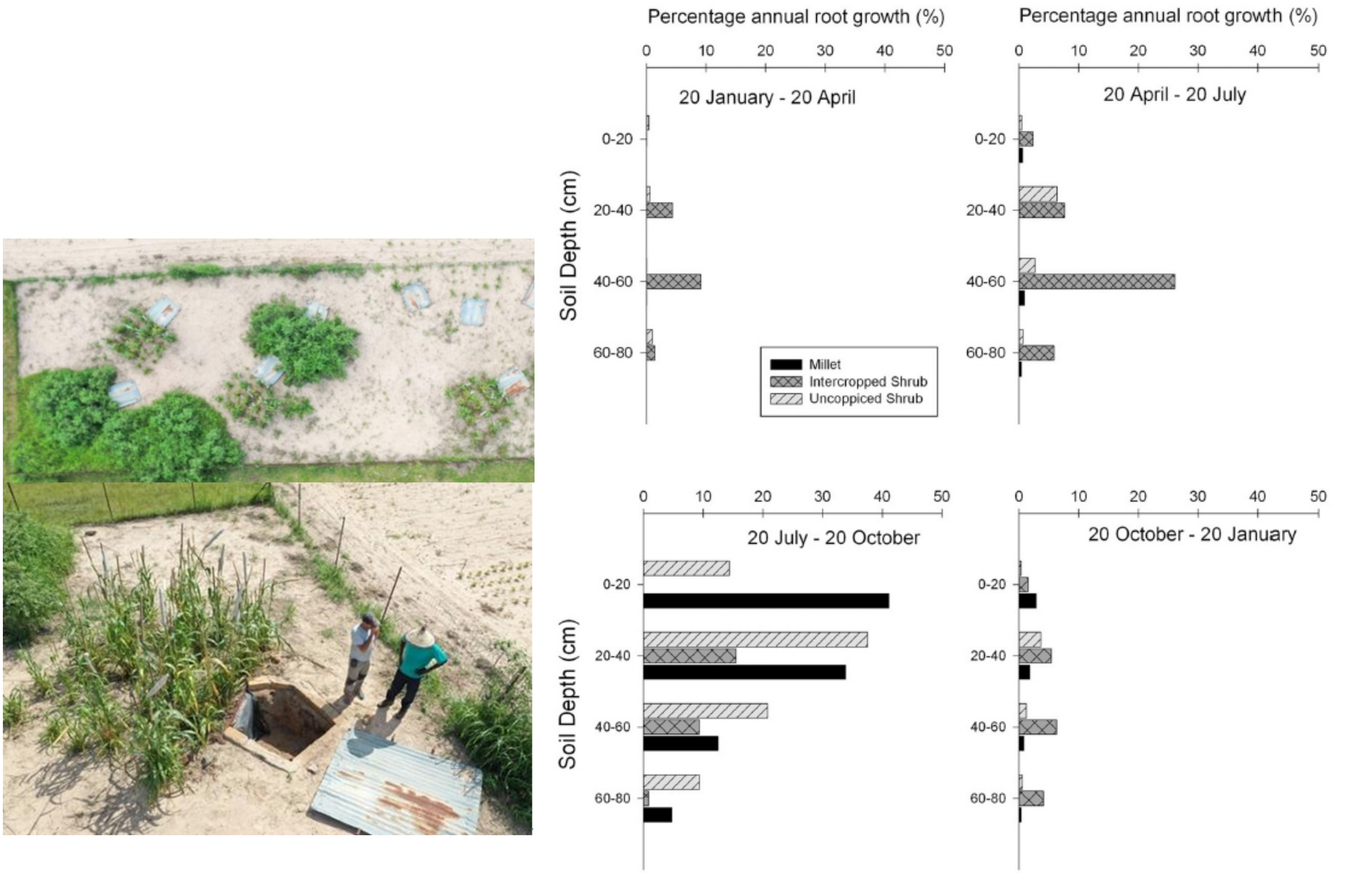

Fig. 6. Impact of coppicing on root dynamic of *G. senegalen*sis shrubs associated with pearl millet, at four periods during the year, two during the dry season (20 October-20 April), and two during the wet season (20 April-20 October) at Keur Matar site, Senegal

Spatial complementarity between species seems to be ensured by coppicing practices (Fig.6)

D 2.2.3.2 - Burkina Faso

Piliostigma and *Sorghum* root dynamics (*C. Jourdan*)

Methodology : A previous experiment was conducted, 3-y prior to the project (2017), in the 2iE Campus - Kamboinsé, Burkina Faso (see D 2.1.1., paragraph D 2.1.1.1.1 p.1). For the root studies, 12 *Piliostigma* associated to *Sorghum* were selected. Six shrubs were several decades old and six were transplanted juveniles. Half of the shrubs were coppiced, the other remained undisturbed as control. Rhizotrons 1x1m were placed 20 cm from each shrub in a vertical position. *Piliostigma* and *Sorghum* roots were observed and their dynamics were measured in 0-1m layer. Root measurements restarted in 2020 thanks to the Ramses II project.

Results : analysis of 2020 data are ongoing. The previous years showed a positive impacts of the shrubs on the aerial phenology of *Sorghum* (earlier heading, flowering and maturation), their growth and yield. The root dynamics of shrubs shows a pronounced higher elongation rates during the wet season than the dry one whatever the root categories. This seasonal variation was observed in both young and old plants. On the other hand, shrub coppicing show a significant depressive effect on the average root elongation. Temporal complementarity of both root dynamics appeared when pruning is carried out (Fig. 7). This suggested that pruning contributes to decrease the potential competition for ressources between *Piliostigma* and *Sorghum*. Therefore, this practice could improve the overall performance of the agroforestry system.

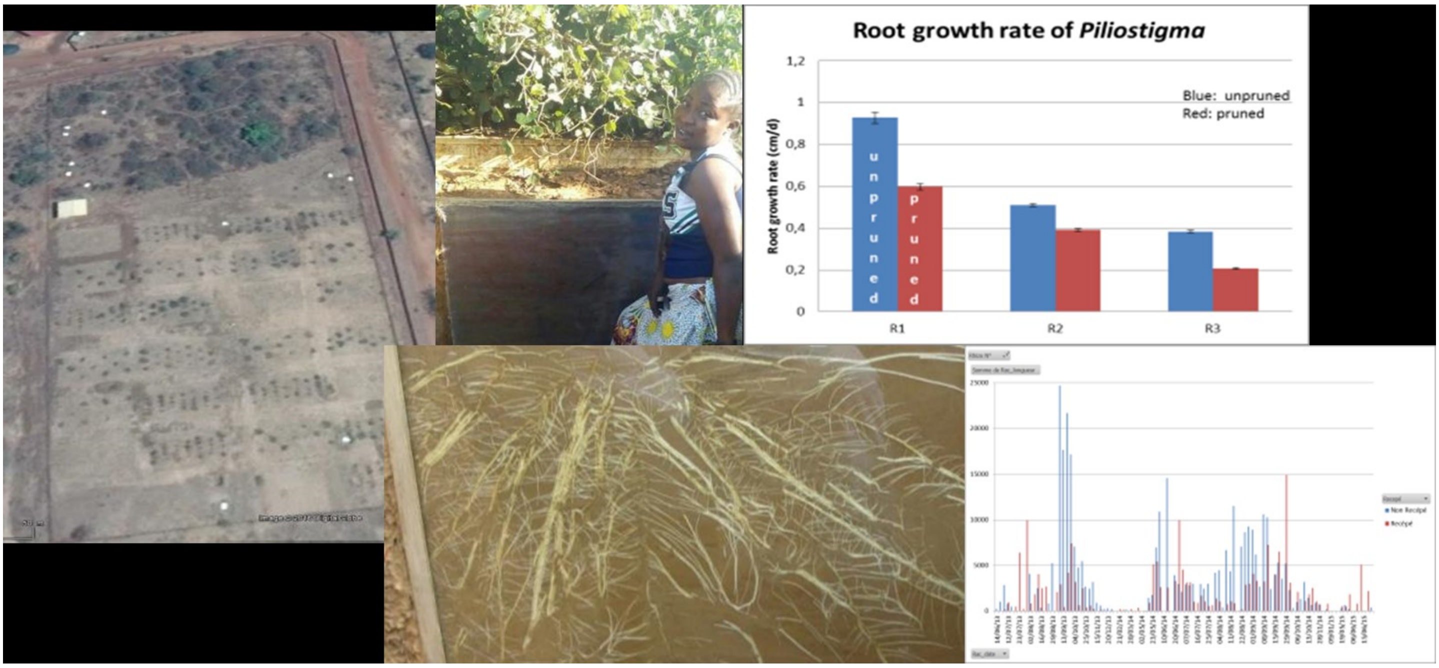

Fig. 7. Impact of coppicing on root dynamic of *Piliostigma* and *Sorghum*, 2iE Campus - Kamboinsé, Burkina Faso