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Spatial Characterization of Agroforestry System Performance in Faidherbia/Pearl Millet Intercrops Using a Probabilistic Atlas of UAV Data

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Background: In the groundnut basin in Senegal, agroforestry is based on Faidherbia albida parkland. The overall positive influence of the tree on the Pearl millet crop has been demonstrated (Roupsard et al., 2020). Optimizing these systems requires a spatial and quantitative description of this influence. However, Faidherbia does not follow regular implantation patterns. Therefore, the interpretation of remote sensing data from cultivated Pearl millet/Faidherbia plots is a challenging task.
Objectives: In this study, we aim to characterize the spatial influence of Faidherbia on Pearl millet yield and stand density by analyzing remote sensing data using advanced geostatistical methods.
Methods: In Senegal, we acquired multispectral UAV imagery in the agroforestry parkland of Niakhar. We extracted Faidherbia trees and their surroundings from images. We manually identified trees and computed their approximate area of influence (Voronoi diagram) to guide a weighted average-based fusion of the airborne images into a probabilistic atlas to map the average Faidherbia influence on the surrounding crops. We assessed the effect of tree canopy size on millet crops. Additionally, we investigated the effects of interaction between nearby and distant trees.
Results: We measured a positive influence of the Faidherbia in the proximal area (crops located at a distance between R and 3R from the tree) on fraction of green vegetation cover (Fcover), correlated with the Faidherbia crown radius. The maximum influence was observed around the tree canopy, with a decreasing effect as one moves away from the tree. Large F. albida trees, exhibiting a wide canopy, have an effect that extends up to 20 meters around the canopy, while smaller Faidherbia trees have an effect oriented towards the northwest. F. albida that are not in interaction exhibit a more homogeneous effect around the canopy, with a decrease as one moves away from the tree crown.
Conclusions/implications: This method provides elements for high throughput performance assessment of intercrop agroforestry management plans. The method is agnostic to the spatial distribution of the crops. It could be derived to study other UAV-observed experimental setups, including other modalities of intercropping, and could be used for breeding panel studies.

Mots clés : agroforestry; photogrammetric; image analysis; probabilistic atlas; UAV