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The rooting patterns of woody and herbaceous plants in a savanna; are they complementary or in competition?

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Summary

Root patterns of three woody plants are described in relation to water profiles and average root depth of annual species on three contrasted soil types along a toposequence in a watershed of northern Cameroon. This watershed is in a Sudano-Sahelian savanna where mean annual precipitation is 800 mm, entirely restricted to the period May–June to September–October. Results show great variations of root structure of woody plants according to the distribution of water in the soil during one year. Consequently, under the same climatic conditions, soil depths exploited by woody plants and herbaceous plants can either be the same or not. In the most degraded soils, water does not infiltrate deeply and roots of the two components of savanna are limited to the upper

of a more or less stable mixture of grasses and woody plants is due to a

on this type of soil (Seghieri, 1990). Herbaceous cover is abundant (up to 90%).

'Hardé' has widespread surface overcrusting which greatly reduces its permeability. The upper layer (0–20 cm) texture is sandy-silt. It arises from the typical vertisol by anthropic degradation (Seiny-Boukar, 1990). Woody and herbaceous cover is sparse and patchy (5–7%). *Lannea humilis* is typically an indicator of the most degraded areas on the watershed.

Ferruginous soil has outcrops of underlying ironstone cuirass and scattered ferruginized gravel on the surface. The cuirass, which can be very thick, indicates that it is a very old soil formed under a wetter climate than at present (Seiny-Boukar, 1990). Indeed, in a wet enough tropical climate, ferruginous pedogenesis brings about a strong release of thermite or iron hydroxide. Accumulated in horizons, it can harden in cuirass which is very slowly destroyed, either in the surface layer by vegetation influence, or through all its thickness by mechanical action after water has taken off the underlying strata (Aubert & Boulaine, 1980). This soil is sandy in the first 40 cm (8–13% clay) and sandy-clayey deeper down (20–28% clay). The ligneous cover is the most important (40–50%) and the most diversified. Herbaceous cover is between 50% and 70% during the rainy season.

Methods

The study was conducted in 1986. Soil moisture was measured with a neutronic humidimeter (Solo 20 and one access per station) at 5–8 m from each shrub. Moisture contents exceeding $-1{\cdot}6$ MPa (pF 4.2) were considered to provide available water to the plants. The method of root extraction used here was limited to roots comprising the architectural system. Architectural root development results only from the depth and volume reached by infiltrated water during every rainy season in a given soil type. It does not depend on the seasonal variations of the soil water content. Therefore, only the tendency of the seasonal variation of soil water content (four dates) is used.

A root profile of one tree per station was carried out. The shrubs studied were adult individuals of *Acacia seyal* on vertisol, *Lannea humilis* on 'Hardé' and *Acacia hockii* on ferruginous soil. A pit of 2 m diameter was dug around each woody individual and roots were carefully extracted to a depth of 1·5 m and, for several lateral roots up layer in their entirety. A representative profile of each species has been drawn up to 1 m from the trunk (Fig. 1). Because of the limit of the scale on the figure, lateral roots have not been drawn.

Results

Wood and herbaceous root distribution and soil water profiles are presented in Figure 1. It was observed that, on the three stations, communities of annual grasses which constitute the herbaceous strata, have roots only in the upper soil layer (20–25 cm of depth). Differences are shown in the wood root distribution in relation to annual soil water distribution.

The vertisol had available water from June to November in the upper horizons. In August, water content was maximum at 20 cm depth and it was the highest of the three stations. Water was abundantly available for plants up to

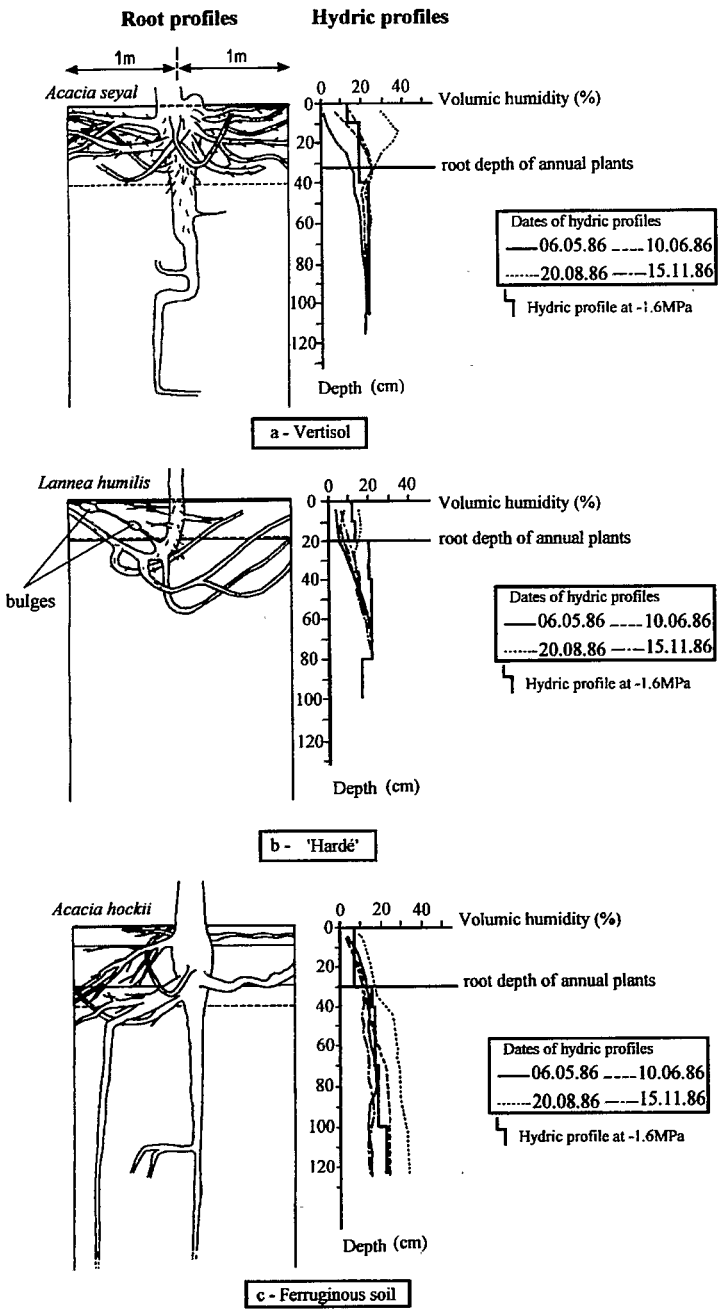

Fig. 1. Root profiles of three woody species in relation to some soil water profiles during the rainy season 1986 in three types of soil in the North-Cameroon; (a) vertisol, (b) 'hardé', (c) ferruginous soil.

40 cm deep during the entire rainy season. 'Hardé' contained very little available water: only in the top 20 cm and only in August. Ferruginous soil also had little available water in the 30 cm depth. Much more water was available for plants in the subsoil than in surface layers during the rainy season, as water did not stay

available in the soil outside of the cracks, and, subsequently, as the cracks close, grasses could use this resource for growth and fast development of their root system in this fertile (high organic matter and nutrient rates) and humid substrate (Seiny-Boukar, 1990). From this moment, herbaceous plants and woody plants like *Acacia seyal* do exploit the same surface soil layers up to 20–25 cm, the depth of grass roots, after annual vegetation has been installed. Trees were favoured only by their durability at the beginning of the rainy season. Since annual species were installed in dense stands, their development was favoured by their dense and compact roots in this type of soil (cover up to 90%).

depth. Annual communities had to complete their development every rainy season before becoming able to extract available water. Moreover, woody roots access deep layers while annual plants do not. Thus, according to their life form, woody species exploit soil water for a longer period of time during the rainy season than annual species. That should contribute to an increase in their period of photosynthetic activity compared to annual species on non degraded soils (Seghieri, 1990; Seghieri *et al.*, 1995).

The results presented here show that trees and grasses are both abundant in the first surface layers (up to 20–25 cm depth). Lawson *et al.* (1968) showed that thick horizontal laterals roots of woody species from guinea savanna (Ghana) seem to be produced more frequently just under the zone of main concentration of grass roots, i.e. between 20 cm and 30 cm. It is difficult to assess whether root competition or direct environment is responsible for root behaviour. Much more

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