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Bradyrhizobium Populations Occur in Deep Soil under the Leguminous Tree *Acacia albida*

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Soil cores were drilled under the leguminous tree *Acacia albida* growing in two different ecoclimatic zones of West Africa: the Sahelian area (100 to 500 mm of annual rainfall) and the Sudano-Guinean area (1,000 to 1,500 mm of annual rainfall). Soil samples were collected at different depths from the surface down to the water table level and analyzed for the presence of rhizobia able to nodulate *A. albida*. In both areas, population densities of rhizobia were substantially greater near the water table than near the surface. In the Sahelian area, rhizobia were present as deep as 34 m at a concentration of 1.3×10^3/g of soil. In the Sudano-Guinean area, population densities at 0.5 to 4.5 m depth were higher than in the Sahelian area and, at several depths, comparable to that of temperate soils supporting legume crops (10^4 rhizobia per g of soil). Surface and deep soil isolates from all four sites were found to be slow-growing rhizobia (*Bradyrhizobium* sp.). The proportion of effective isolates was almost the same within surface and deep soils.

The leguminous tree *Acacia albida* plays a major role in the agro-sylvo-pastoral balance of the Sahelian regions of Africa. In contrast with other Sahelian trees, *A. albida* has the unique phenology of bearing leaves in the dry season and shedding them at the beginning of the wet season. Taking advantage of this inverted phenological cycle, farmers grow crops under the leafless trees during the rainy season and nomads can use the aerial forage for their cattle during the

regions characterized by a variation of the annual rainfall from 100 to 1,500 mm and by a large difference in the water table depth (35 to 1.5 m, respectively) provides a good model to examine the distribution and effectiveness of bradyrhizobial populations associated with surface and deep roots of this important tree.

The objectives of the present study were (i) to investigate nodule occurrence on the whole root system of *A. albida* in

TABLE 1. Distribution of *Bradyrhizobium* populations in four cores drilled under the canopy of *A. albida* trees from the surface to the water table

Sahelian ecoclimatic zone (100 to 500 mm of annual rainfall)		Sudano-Guinean ecoclimatic zone (1,000 to 1,500 mm of annual rainfall)	
Louga	Diokoul	Djinaki	Kabrousse

TABLE 2. Symbiotic effectiveness of *Bradyrhizobium* isolates from the two Sahelian cores from Louga and Diokoul and from various surface Sahelian soils

Origin and depth (m) of sample	Effectiveness[a]			
	Highly effective	Effective	Partially effective	Ineffective
Louga				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

In contrast, at the more humid sites of Djinaki and Kabrousse (Table 3), most of the isolates from the coring were highly effective or effective. For the surface isolates from various sites (n = 18), 83% were effective and partially effective and 17% were ineffective.

DISCUSSION

Up to now, it has been generally observed that populations of rhizobia were restricted to the upper soil horizons, mostly because studies were focused on annual crops with relatively shallow root systems. When dealing with deeply rooting trees, rhizosphere microorganisms, including *Rhizobium* and *Bradyrhizobium* species, may occur in the deep soil. In fact, Virginia et al. (14) studied the distribution of rhizobia under *Prosopis glandulosa* in the California Sonoran Desert and reported that population densities as high as 6.1×10^3 cells per g of soil occurred at 4 to 6 m below the ground near the water table. Our results clearly demon- [redacted]

isolates with similar effectiveness could have very different physiological tolerances related to free-living survival in the soil at different depths (15).

Deep soil samples (34 m) from Louga showed very low total nitrogen (0.05%) and organic carbon (0.15%) concentrations. This low N and C availability in deep soils could be expected to limit microbial activity, but the presence of the active root system of *A. albida* could greatly improve the deep soil environment for bradyrhizobia in the vicinity of roots. It is also interesting that in the Sahelian area, the largest populations of bradyrhizobia were found at the depth where small *A. albida* root fragments were present in soil samples recovered from the coring. In the Sudano-Guinean area, the presence of a high density of roots from the surface to the water table could also explain the large populations of bradyrhizobia present in the paddy fields of Casamance. We recently found in Kabrousse that population densities of bradyrhizobia were negligible (<1/g of soil) in the soils outside the tree canopy (3a). This suggests that the presence [redacted]

ogy, vol. 1. The Williams & Wilkins, Co., Baltimore.
9. **Jung, G.** 1970. Variations saisonnières des caractéristiques microbiologiques d'un sol ferrugineux tropical peu lessivé (Dior), soumis ou non à l'influence d'*Acacia albida* (Del.). Oecol. Plant. **V**:113–136.
10. **Le Houérou, H. N.** 1989. The grazing land ecosystems of the African Sahel, p. 1–282. *In* W. D. Billings, F. Golley, O. L. Lange, J. S. Olson, and H. Remmert (ed.), Ecological studies series, vol. 75. Springer-Verlag, New York.
11. **Schulze, E. D., G. Gebauer, H. Ziegler, and O. L. Lange.** 1991.

no. 15. Blackwell Scientific Publications Ltd., Oxford.
13. **Virginia, R. A., W. M. Jarrell, P. W. Rundel, D. H. Kohl, and G. Shearer.** 1989. The use of variation in the natural abundance of ^{15}N to assess symbiotic nitrogen fixation by woody plants, p. 375–394. *In* P. W. Rundel, J. R. Ehleringer, and K. A. Nagy (ed.), Stable isotopes in ecological research. Ecological Studies Series, vol. 68. Springer-Verlag, New York.
14. **Virginia, R. A., M. B. Jenkins, and W. M. Jarrell.** 1986. Depth of root symbiont occurrence in soil. Biol. Fertil. Soils **2**:127–130.