RELATIONSHIPS BETWEEN GROWTH, MINERAL NUTRITION, AND SOILS IN YOUNG TEAK PLANTATIONS IN BENIN AND LIBERIA

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Abstract. Growth and vigor of trees show considerable variations in young teak plantations in Benin (Vertisols) as well as in Liberia (Ferralsols). Differences in growth are mainly related to topsoil acidity and the foliar Ca-status in Liberia. In Benin, waterlogging (followed by root decay) reduces the Mg-, K- and N-uptake. In addition, growth on the Vertisols is limited by a low K\text{ex}/CEC-ratio of usually < 17.

1. Introduction

The success of reforestations depends largely on a careful site evaluation and species selection. Where these were neglected yield-decrease and dieback due to mineral or water deficiency are frequent, especially during the first years after planting (Zech et al., 1989). Two examples will be described from young teak (Tectona grandis L.) plantations in Liberia and Benin.

Our purpose was to study the relationships between tree growth and tree nutrition (indicated by symptoms of deficiency) as well as between growth and soil properties. In another paper we discuss the relationships between the mineral supply of the trees and soil properties (Drechsel et al., 1989).

2. Materials and Methods

2.1 Locations

There are three sites located in Liberia (FDA/GFM). The Cavalla plantation is 25 km NNW of Zwedru (6°04'N/8°08'W); the Glaro plantation is a few km E of Glaro (5°18'N/7°30'W); and the Bomi Hills plantation is 55 km NNW of Monrovia (6°54'N/10°50'W). In Benin (ONAB/MFA), the Lama reforestation site 4/8 (7°05'N/2°13'W) is 70 km NNW of Cotonou.

2.2 Site descriptions

Listed below are pertinent characteristics of the two areas where sites are located. The features for Benin are shown in brackets.

- **Topography:** rolling landscape [large depression]
- **Geology:** Precambrian basement with granite, gneiss and diorite [Eocene clays and marls]
- **Mean annual precipitation:** 2223-3221 mm [1150 mm]
- **Mean monthly temperature:** 25-27°C [25-29°C]
Rainy seasons (> 100 mm/mo): March/April to October [March/April to July and September/October]
Soils: Ferralsols and Gleysols; pH 3.8-5.2 [Eutric and Calcic Vertisols; pH 5.5-8.0]

2.3 Methods
Leaf samples of (in each case) five trees of the same height and/or vigor were taken on seven plots in Benin and eight plots in Liberia in 1-1/2 and 5 yr old stands, respectively. In Liberia (provenance Bamaro/Ivory Coast), young (not completely developed) and the first mature leaves were collected separately from terminal shoots of the upper part of the crown. In Benin (provenance Kihuhwi/Tanzania) the first mature leaf of the young stem as well as different older leaves were sampled and washed twice with H₂Odist. After drying (65°C), samples were dissolved in conc. HNO₃ (pressure block, 8 h, 170°C; Benin) or ashed (550°C) and dissolved in 10% HCl (Liberia). Determination of K, Ca, Mg, Al, Fe, Mn, Zn and Cu was carried out using AAS. Phosphorus was analyzed photometrically using the molybdenum-blue-method and N by the Kjeldahl procedure. All data are means of a composite sample of five trees.

Soil samples for chemical analyses were taken from the main horizons of representative soil profiles (3 samples/horizon). Total nutrient stores (kg ha⁻¹ rooting depth⁻¹) of the fine earth (< 2 mm) were determined using HF/HClO₄-dissolution, followed by measurements of K, Ca, Mg, Al, Fe, Mn, Cu, and Zn by AAS, P photometrically. Exchangeable cations and CECeff. were analyzed using unbuffered 0.2 n BaCl₂ (Liberia) or 0.5 n NH₄Cl (Benin) for saturation and cation extraction and 0.2 n MgCl₂ (Liberia) as the replacing solution. Available Zn, Mn, Cu, and Fe were extracted with the double-acid method (Mehlich No. 1) and in Benin also with DTPA, Fe oxides with NH₄-oxalate (Feo) and dithionite-citrate (Fed), as well. Corg was determined by dry combustion (Carmhomat), "available" P by the Bray-1, double acid and Olsen methods and total N by the Kjeldahl procedure. Soil texture was analyzed by sieving and chain hydrometer after treatment with Na₄P₂O₇ and ultra sonic (3 min). All results are means of three samples.

Statistical operations were carried out with SPSS/PC+ (2-tailed signif.: *p < 0.05, **p < 0.01, ***p < 0.001).

3. Results
In Liberia and Benin growth and vigor of teak differ considerably according to soil conditions and (micro) relief.

3.1 Deficiency symptoms and growth in relation to site factors

3.1.1 Liberia. In the rolling landscapes under study the risk to fail with Tecotona grandis plantations is regarded to be very high (Woell, 1981). Teak shows:
(1) a mean annual growth rate of only < 0.6 m a⁻¹ on the tops of hills. Young leaves often are chlorotic, remaining older leaves are still green. The shoots are thin and partly show dieback. Several trees have died.