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ORIGINAL ARTICLE

Yields and nutrient pools in soils cultivated with *Tectona grandis* and *Gmelina arborea* in Nigerian rainforest ecosystem

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Abstract This study examined the yield of the two most prominent exotic species in southwest Nigeria and the nutrient status of soils cultivated with these species. The impacts of plantation development on soil nutrients were also examined. The plantations species are *Gmelina arborea* (Gmelina) stands established in 1984, 1988, 1990 and 1994 and *Tectona grandis* (Teak) established in 1990, 1992, 1994, 1996 and 1997. Growth data and composite soil samples from 3 depths (0–15, 15–30 and 30–60 cm) were collected from five equal sized plots (20×20 m^2) randomly located in the plantation of the two species. Also, soil samples were collected from the adjacent natural forest for comparison. The results for both species show that tree growth variables increased substantially with increase in tree age. There was significant difference in number of trees per hectare, dominant diameter, volume/ha and MAI for the Gmelina stands. In the Teak stand, there was significant difference in most of the tree growth variables also. Nutrients required by plants to survive were present in the soil samples from the plantations and the natural forest in different proportions. There was high correlation between percentage sand and most of the tree growth variables for both species. The pH value obtained for the Gmelina stands ranged between 6.47 and 7.47 while that of Teak stands ranged between 5.57 and 8.33. There was also a high and positive relationship between

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some soil chemical properties and tree growth variables. The highest significant correlation coefficient existed between phosphorus concentration and basal area for stands of both species. The *r*-values are 0.98 and 0.96 for Gmelina and Teak, respectively. While a high, negative and significant *r*-value (−0.88) was also obtained between potassium and volume/ha for the Gmelina stands, a high positive *r*-value was obtained between the potassium and basal area for the Teak stands. Comparison of soil nutrients in the plantations with the nutrients in the natural forest revealed the adverse impacts of plantation establishment on soil nutrient status. Recommendations on land policy issues and forest conservation were made.

1. Introduction

Forest plantations are forest stands established by planting or/and seeding in the process of afforestation or reforestation. They are either of introduced species or intensively managed indigenous species that are of even aged class and regular spacing (FAO, 2004). It is a forest stand in which trees are predominantly established by planting, deliberate seeding or coppicing, where the coppicing is of previously planted trees. It includes all stands established by planting or seeding of both native and non-native species.

As the rate of logging in natural forest ecosystem and consumption of wood continue to increase, the need for averting the imminent wood famine become obvious. Nigeria may run out of wood very soon and this will subsequently render several labor forces in the nation's forest based industries jobless. Over exploitation of forest woods as fuelwood and charcoal rendered Nigeria poorer in forest resources. In view of this imminent wood deficit, production from forest reserves was augmented with artificial plantations through tree planting. The Federal and State Governments decided to embark on tree planting through mass mobilization of rural farmers, civil servants and the private sectors. As a result, the annual national tree planting campaign came into existence. This was also followed by various afforestation projects funded by foreign agents and Nigerian Government. Today, some plantations of exotic and indigenous species have been established. Prominent among the exotic species are *Tectona grandis*, *Gmelina arborea*, *Eucalyptus* spp., *Ciderella odoranta* and *Pinus* spp. while the indigenous ones include *Nauclea didderichii*, *Triplochiton scleroxylon*, *Terminalia ivorensis* and *Terminalia superba*.

The impacts of plantation development on alfisols cannot be overemphasized. Plantation trees grow rapidly and therefore nutrients demand is high especially at the early stage of development. The nutrient demand also varies with the age of the stand as reported by Farley and Kelly (2004). There is generally organic matter build up and surface hardness in plantations. Evans (1999) reported that exposure of some tropical soils during land preparation with heavy machines can lead to formation of hard pans. The rate of change in edaphic properties in relation to tree age is yet to be ascertained especially with Teak and Gmelina that are the two most cultivated exotic species in Nigeria. This could assist to determine the ability of the soil to support plantation rotation since the number of rotations in coppice management depends on the soil nutrient pools. The findings of Turner and Kelly (1985) indicated that the most significant changes in the nutrient status of the soil are likely to occur in plantations that are 10–20 years old. In addition, the comparisons of stands of various ages to adjacent natural forest are very useful for understanding how nutrient status changes as plantation matures (Davis and Lang, 1991; Farley and Kelly, 2004).

Gmelina and Teak are deciduous tree species belonging to the verbenaceae family. Both are grown in plantations as exotic species in Nigeria, Ghana and Sierra-Leone. While Gmelina is grown principally to provide raw materials for the pulp/paper industries, Teak is to provide high quality sawn timber and poles. They are regarded as very suitable species for rapid production of large volumes of timber, fuelwood and poles of uniform and desirable quality (Akindele, 1989). *Gmelina* is native of India and Burma where it reaches its best development. But natural distribution extends from Himalayan in Pakistan to Nepal, Cambodia, Vietnam and southern provinces of China (Lamb, 1968; Onyekwelu and Stimm, 2002). It tolerates a wide range of conditions with annual rainfall from 750 to 500 mm, mean annual temperature of 21–28 °C and deep, well drained, based-rich soil with pH between 5.0 and 8.0 (Onyekwelu, 2002). Gmelina is short-lived with a life span of 30–50 years but grows fast during the first 5–6 years and achieves a high biomass at an early age (Nwoboshi, 1985).

Teak is one of the world's premier hardwood timbers. It is indigenous only to India, Lao, Thailand and Myanmar (Pandey and Brown, 2000). Teak can be produced under diverse conditions, but high productivity can only be expected on good and accessible sites and in many countries, Teak is planted on degraded lands (Enters, 2000). Teak is a large deciduous tree with a rounded crown and, under favorable conditions; it can develop into a tall clean cylindrical bole of more than 25 m in height. Leaves are broadly elliptical or obovate and usually 30–60 cm long. It grows in well-drained deep alluvium soil, below 1000 m elevation, with annual rainfall of 1250–3750 mm, minimum temperature of 13–17 °C and maximum temperature of 39–43 °C, it is light demanding and coppices and pollards vigorously. Teak begins flowering and seeding at a young age, and produces abundant seeds almost every year. The hard thick pericarp of the seed prevents easy germination and a considerable portion of fresh seeds remains dormant in the first year. Teak seeds remain viable for many years. Jadeja and Nakar (2010) described the phonology of Teak in his study. Teak grows a little slower than Gmelina but it has longer life span (Adekunle, 2000).

The objectives of this study therefore were to assess the yield of the two most prominent afforestation species in Nigeria and the present status of the soils used to cultivate them. The study was also to examine the impacts of plantation development on soil properties in tropical rainforest ecosystem of southwest Nigeria and to determine the relationship between soil physical and chemical properties and plant growth. These were achieved through field inventory and soil sample collection and laboratory analyses.