ROOT GROWTH CHARACTERISTICS OF SOME EXOTIC AND INDIGENOUS TREE SPECIES IN THE NIGERIAN SAVANNA

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Summary

Roots of exotic and native tree species were exposed by digging trenches adjacent to tree stands in plantations at four vegetative zones of varying dryness and soil types (Afaka, Miango and Nimbia) in Nigeria. Root size and distribution were measured and compared at three determined depths along the soil profiles. Although all the soil types have a layer of hard iron crust (plinthite layer) within a depth of 40–60 cm in the soil, the roots of the exotics were able to penetrate beyond the plinths while most of the native woodland species had their roots spread on top of the plinths. Among the exotics, Eucalypts proved best at penetrating the plinths, having comparatively larger sized and more numerous roots that were well distributed along the soil profile. Closely following the eucalypts were the pines. Roots of all trees studied at Nimbia grew better than those at other locations. This was attributed to the pisolitic nature of the Nimbia plinths which can go soft when wet but hard when dry as opposed to the continuously hard plinth types at the other localities. The relationships between root penetration, tree growths, and the tree abilities to harness soil water during the dry season at different localities are discussed.

Introduction

The savanna areas have been mapped out into different zones, each with its own soil types and weather condition variant. On the major soil types in these zones, trial plots were established around the early sixties with different fast growing exotic tree species of known end uses. This was aimed at determining growth performances, species adapted to each soil type and the effect of several aspects of site on growth. The exotic species were favoured since the native woodland species are rather slow growing and when mature, range between shrubs to averagely tall trees (Keay, 1959).

Growth and yield assessments have been appraised ever since. Results show that certain species like *Acrocarpus fraxinifolius* planted in the same year at two closely related localities, gave stunted growth in one location, but excellent yield in the other. After more than ten years of growth, it was also shown that species like eucalypts and pines which started off well in all localities later had some of the trees suffering shoot die-back. Pathological, physiological, entomological and soil chemical studies revealed little to no related casualty.

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Literature

(Keay, 1959 and Tomlinson, 1965) show that savanna soils have a layer of hard iron crust commonly called the plinthite layer. This may form a barrier to root penetration and when they are found a few centimeters below the soil, deeply stored water may become inaccessible to such roots especially during the dry season. Such plants may die. Given the presence of the plinthite layer, this paper reports on a project undertaken to find whether there are any variations in root growth and distribution that may be contributory to any growth anomalies observed in tree growths in some of these localities.

Material and Methods

(1) The study area :—The study area lies within latitude 9^{O}S and 11^{O}N and longitude 7^{O}W and 10^{O}E. The localities chosen were Afaka, Miango and Nimbia. The soil properties in these localities have been described by Tomlinson (1965) as follows:

(a) Afaka (Northern guinea savanna). Occupied by loamy soil that show little variation in texture. Plinthite layer is very compact. Drainage is mosly imperfect and underlying rocks are of precambrian age composed of crystalline gneisses with associated schists. Mean annual rainfall is about 1143 mm. In the dry season, relative humidity is between 14–21% and may be lower, but in the rainy season may go up to 32%.

(b) Miango (at the Plateau). Lies about 1200 m above sea level. They soil has not recieved any detailed description yet, but is of deep and well drained fertile brown loam derived from basalt. The plinthite layer is not as undurated as that at Afaka. There are presence of mottles below the plinthite layer. Topography varies from flat to a gentle slope. The rainfall is about 1,397 mm per annum.

(c) Nimbia (derived Savanna). This is of the GIMI series which is essentially of brown sandy clay loam. Soils are not well drained and generally have redish mottles within a depth of about 1m. The plinthite layer is of the pisolitic type that can go hard when dry but dissociates into fragments when wet. The plinthite layer is generally thicher than those of Afaka and Miango: Topography is generally undulating. Annual rainfall is about 1,525mm.

(ii) Procedure: Three trees of *Eucalyptus camaldulensis, E. citriodora, E. cloeziana, E. propinqua, Pinus caribaea, P. oocarpa, Calistris robusta, Acrocarpus fraxinifolius, Tectona grandis* and *Gmelina arborea* were selected from plots in these localities. Three of each native woodland species were also chosen but from forest reserves close to the plantation. The native species studied were *Albizia zygia, Parkia clypertoniana, Daniela oliveri, Vitex doniana, Lannea schmiperi, Isoberlinia doka* and *Uapaca togoensis*. The native species are not necessarily of universal distribution within the savanna areas, hence the species chosen in each location were those native to the area only. Similarly, the exotics are not equally represented in all the localities. Between localities, in each species, attempts were made to select exotics of same age whereever possible. For the native species, trees of similar heights and girths that were judged to be more than ten years old were selected.

Roots of these trees were exposed by carefully digging tranches adjacent to the tree stands. Roofs were further exposed with the garden fork. Root number and distribution within two size classes (about or below 2.5cm. in diameter) at 0–30cm, 30–60cm, and 60–90cm and 90cm and beyond in the soil profile were determined and the means compared between species in a locality and with those at other localities using the student's "T" test (Zar, 1974).

Results and Discussion

Though all the soils in the tree localities studied have plinths, the roots of some species were better distributed within the soil profile than others (Tables 1, 2 and 3). Generally, plinths were found within the first 50cm in the soil in all the localities studied and varied between 15 – 20cm in thickness. At Afaka, roots of *Acrocarpus fraxinifolius* were concentrated on top of the plinthite layer, but at Nimbia, they developed twice as much roots as at Afaka (p=0.05) which penetrated through the plinth beyond 90cm. (Tables 1 and 3). The above observations may be linked with the nature of the plinths. At afaka, the plinthite layer is the continuously compact type, but at Nimbia, is the pisolitic type which can go hard when dry, but dissociates only when wet (Tomlinson, 1965). Hence, during the rainy season, the roots of trees at Nimbia will be able to grow through the plinth with greater ease while those of trees at Afaka may not.

Except *Eucalyptus citroidora,* eucalypts proved best at penetrating plinths, for in the localities studied, they had comparatively larger sized and more numerous roots (p=0.05) distributed almost evenly down the first 90 cm of the soil and beyond (Tables 1 and 2). At Miango, despite and combined banners of the plinth and close aggregation of rocks below the plinth in the *E. camaldulensis* plot, it distributed larger roots down the profile than other species growing under the impedence of the plinth alone (Table 2, p=0.05). Closely following the eucalypts in root size, distribution and number in all localities are the pines (Table 1, 2 and 3).

Most of the native woodland species studied exhibited poorer root growth than the exotics (Tables 1, 2 and 3). The *Lannea schmiperi, Isoberlinia doka* and Uapaca togensis roots were concentrated above the plinth at Afaka where some of those of the exotics were able to penetrate (Table 1). At Miango, the roots of *Vitex doniana* spared horizontally on top of the plinth, but those of the exotics were able to penetrate it and were also more numerous than the *V. doniana* roots (Table 2, p = 0.05). However, at Nimbia, *Daniella oliveri, Parkia clypertoniana* and *Albizia zygia* roots performed a well as those of the exotics (Table 3). This may have resulted from the nature of the plinth at Nimbia as already discussed. The above findings may explain at least in part the general poor growth of most native trees observed in the Nigerian savanna (Kemp, 1969). Those species whose roots are concentrated on top of the plinth would have access to ample soil water only during the rainy season, but during the dry months, only those species whose roots were able to penetrate the plinths and beyond will be able to make use of the deeply stored water. Since water is one of the critical factors limiting plant growth in the Nigerian savanna, the deep rooted species will be able to grow round the year while the shallow rooted ones cannot.

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Table 1

Mean root number and distribution along soil profiles at Afaka ($S.E_{xt\ at\ p\ =\ 5\%}$)

	Horison (cm)	0 – 30	30 – 60	60 – 90	90 +
E. citriodora	> 2.5cm < 2.5cm	8 ± 1 196 ± 9	3 ± 0.01 132 ± 4	1 ± 0.02 17 ± 2	0 0
E. cloeziana	> 2.5cm < 2.5cm	10 ± 1 117 ± 6	12 ± 0.4 77 ± 5	7 ± 0.4 27 ± 2	3 ± 0.02 11 ± 2
E. propinqua	> 2.5cm < 2.5cm	7 ± 1 105 + 3	6 ± 0.5 35 + 3	4 ± 0.1 14 + 2	2 ± 0.2 8 + 1
C. robusta	> 2.5cm < 2.5cm	5 ± 0.04 107 ± 7	2 ± 0.03 15 ± 3	0 3 ± 0.4	0 1 ± 0.03
A. fraxiniforlius	> 2.5cm < 2.5cm	1. ± 1 158 ± 5	3 ± 0.02 135 ± 5	0 3 ± 0.4	0 0
P. caribaea	> 2.5cm < 2.5cm	6 ± 0.1 118 ± 5	2 ± 0.03 37 ± 2	1 ± 0.4 11 ± 3	0 3 ± 0.4
I. doka	> 2.5cm < 2.5cm	2 ± 0.04 23 ± 2	2 ± 0.01 18 ± 3	0 0	0 0
L. schmiperi	> 2.5cm < 2.5cm	3 ± 0.02 21 ± 3	1 ± 0.04 3 ± 1	1 ± 0.01 1 ± 0.02	0 0
U. togoensis	> 2.5cm < 2.5 cm	5 + 1 37 + 3	1 + 0.01 4 + 0.2	1 + 0.02 1 + 0.03	0 0

Table 2

Mean root number and distribution along soil profiles at Miango (S. E_{xt} at p = 5%)

Horison (cm)	*E. camaldulensis*		*P. caribaea*		*P. oocarpa*		*V. doniana*	
	> 2.5cm	< 2.5cm	> 2.5cm	< 2.5cm	> 2.5cm	< 2.5cm	> 2.5cm	< 2.5cm
0 – 30	12 ± 2	246 ± 11	4 ± 0.4	143 ± 5	6 ± 1	120 ± 4	23 ± 0.4	19 ± 3
30 – 60	0	92 ± 3	0	57 ± 2	0	31 ± 3	0	0
60 – 90	0	35 ± 4	0	28 ± 2	0	30 ± 2	0	0
90 –	4 ± 0.3	7 ± 1	0	16 ± 3	0	7 ± 0.4	0	0

Table 3

Mean root number and distribution along soil profiles at Nimbia ($S.E_{xt\ at\ p = 5\%}$)

	Horison (cm)	0 – 30	30 – 60	60 – 90	90 +
P. oocarpa	>2.5cm <2.5cm	15 ± 2 175 ± 7	0 46 ± 4	0 34 ± 3	0 33 ± 4
P. caribaea	>2.5cm <2.5cm	11 ± 2 154 ± 5	0 45 ± 3	0 40 ± 4	0 11 ± 2
G. arborea	>2.5cm <2.5cm	11 ± 2 172 ± 9	3 ± 0.4 22 ± 2	1 ± 0.2 19 ± 2	0 16 ± 3
T. grandis	>2.5cm <2.5cm	12 ± 1 277 ± 5	3 ± 0.2 52 ± 4	1 ± 0.05 30 ± 2	0 15 ± 2
A. fraxinifolius	>2.5cm <2.5cm	11 ± 0.6 217 ± 5	9 ± 2 104 ± 2	0 96 ± 3	0 26 ± 2
D. oliveri	>2.5cm <2.5cm	2 ± 0.1 9 ± 2	3 ± 0.3 19 ± 3	3 ± 0.2 9 ± 1	1 ± 0.04 3 ± 0.04
P. clypertoniana	>2.5cm <2.5cm	6 ± 1 17 ± 2	3 ± 0.3 23 ± 2	3 ± 0.4 44 ± 5	0 6 ± 1
A. zygia	>2.5cm <2.5cm	3 ± 0.4 14 ± 2	1 ± 0.3 24 ± 3	0 25 ± 3	4 ± 0.2 31 ± 4