THE EFFECTS OF DEFOLIATION AND INORGANIC FERTILISERS ON THE GROWTH OF SOME TROPICAL TREE SEEDLINGS

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AGBOOLA, D. A. & KADIRI, M. 1999. **The effects of defoliation and inorganic fertilisers on the growth of some tropical tree seedlings.** The effects of defoliation and some inorganic fertilisers on the growth of 3-month-old seedlings of six tropical tree species, i.e. *Terminalia ivorensis, Terminalia superba, Ceiba pentandra, Gmelina arborea, Tectona grandis* and *Leucaena leucocephala,* were studied. The removal of two to three leaves significantly decreased root length and dry weights of root and shoot of seedlings of the six species. Seedling height was unaffected by defoliation. Removal of part of a previously intact leaf had no adverse effect on the total growth. There was increase in total leaf area and dry weight of seedlings treated with five inorganic fertilisers, that of $Mg(NO_3)_2$ being the most effective.

Key words: Defoliation - inorganic fertilisers - seedlings - tropical trees - growth - root - shoot

AGBOOLA, D. A. & KADIRI, M. 1999. **Kesan peranggasan dan baja tak organik terhadap pertumbuhan beberapa anak benih pokok tropika.** Kesan peranggasan dan beberapa baja tak organik terhadap pertumbuhan anak benih berumur 3 bulan bagi enam spesies pokok tropika iaitu *Terminalia ivorensis, Terminalia superba, Ceiba pentandra, Gmelina arborea, Tectona grandis* dan *Leucaena leucocephala* dikaji. Pembuangan dua hingga tiga daun mengurangkan dengan bererti panjang akar dan berat kering akar serta pucuk anak benih enam spesies tersebut. Ketinggian anak benih tidak dipengaruhi oleh peranggasan. Pembuangan sebahagian daripada daun yang masih berkeadaan baik tidak memberi kesan yang buruk terhadap jumlah pertumbuhan. Terdapat pertambahan dalam jumlah luas daun dan berat kering anak benih yang dirawat dengan lima baja tak organik, dan rawatan $Mg(NO_3)_2$ didapati paling berkesan.

Introduction

The tropical forest in its original state is exceptionally rich supporting more than a hundred different species per hectare compared to 10–15 in many temperate forests (Spore-CTA 1991). The natural vegetation has been faced with over-exploitation. Natural regeneration of forests in the tropics is threatened with many problems including poor seed germination, seedling establishment and survival (Onochie 1990).

Various nursery practices have been geared towards successful seedling establishment. However, successful seedling establishment of some species in plantation is still faced with some handicaps, mainly, loss of leaves by the young seedlings. Leaf can be lost through diseases, insect and animal feeding and infestation, and by physical means. For example, the heavy winds that accompany tropical rainstorms are a common source of leaf loss (Remison 1978). Leaf loss interferes with the metabolic processes of the plant in general and hence growth. This can be critical during the early vegetative phase especially when young seedlings have limited surfaces for photosynthesis (Devlin 1969).

The demand for nutrients by trees is very high and response to a lack of it, probably is the most common form of mineral deficiencies in trees. Nitrogen deficiency is readily manifested by chlorosis and wilting (Kozlowski 1971). Magnesium deficiency in trees is shown to form chlorosis, pigmentation which may later be followed by necrotic spotting (Devlin 1969). The easiest and fastest methods of correcting nutrient deficiencies are through the use of fertilisers which are mostly applied directly to the soil or indirectly to the plant foliage in liquid form (FDDP 1989).

This present study aims to verify the extent to which leaf removal and application of five inorganic fertilisers affect early vegetative growth of seedlings of six economically important tropical trees. *Terminalia ivorensis, Terminalia superba* and *Ceiba pentandra,* inhabitants of the tropical rain forest, are sources of high quality timber for furniture and construction in Nigeria. *Leucaena leucocephala, Tectona grandis* and *Gmelina arborea* are exotic species introduced into Nigeria from other tropical zones of the world, especially Southeast Asia. Of these *L. leucocephala* has been successfully used in various agroforestry practices (Kang & Wilson 1987, Beets 1989).

Materials and methods

Three-month-old seedlings of the six tree species were raised in nursery bags from seeds previously treated for dormancy release according to the methods of Agboola and Etejere (1991). The seedlings were divided into seven lots and then thinned to one plant per bag three weeks after germination.

Seedlings were subjected to seven defoliation treatments 10 weeks after germination using a modified method of Remison (1978). Most tree seedlings are more susceptible to premature death due to loss of leaves at this age in their natural habitat in Nigeria. The seedlings at this stage had 5–7 leaves. The defoliation treatments were designated D_0 to D_6 as listed below:

D_0 - Control (no leaf removed)
D_1 - One whole leaf removed
D_2 - One half leaf removed
D_3 - Two whole leaves removed
D_4 - Two halves removed
D_5 - Three whole leaves removed
D_6 - Three leaf halves removed

In the defoliation treatment, a whole leaf blade was either detached (excluding the petiole) or cut into half with scissors. Leaves were carefully cut into half from the leaf apex to the base of the leaf along the side of the mid-rib. The experiment was carried in a greenhouse with minimum and maximum daily temperatures of 28 °C and 30 °C respectively. Trees were arranged in a randomised block design with five replicates. The root and shoot lengths, total plant height and dry weights of shoot and root were recorded 2 weeks after defoliation treatments were applied when seedlings would have been 12 weeks old. Means of replicate values were calculated while the analysis of variance (ANOVA) was used to interprete the data.

In a separate experiment, five inorganic fertilisers, NH_4NO_3, $Mg(NO_3)_2$, $NaNO_3$, $Al(NO_3)_3$, and NH_4Cl were used. Seedlings were raised in nutrient-free sandy loam in planting bags. Two grams of fertiliser per plant were applied when seedlings were two months old. Control seedlings received no fertiliser. Seedlings were watered with gentle mist spray every second day. A randomised block design of 6 species × 6 treatments × 5 replicates was used. Means of replicate values were also taken and the analysis of variance, ANOVA, used to interprete the data. Mean values were compared by the least significance difference, LSD at 0.05 probability level. Seedling growth was evaluated at the 3-month stage by measuring leaf area and total dry weights. Leaf area was measured using the electronic planemeter while the dry weights were determined after drying to constant weight by the method of Etejere and Osatimehin (1984).

Results

The values obtained for the growth parameters investigated under the effects of defoliation treatments D_3 and D_5 in all the species were significantly different from the control D_0 ($p = 0.05$) (Tables 1–4). It was observed that the removal of 2 and 3 leaves from the seedlings of the tree species significantly affected the total dry weights of root and shoot and root length as compared to the control in *Terminalia ivorensis, T. superba, Tectona grandis, C. pentandra* and *G. arborea* and *L. leucocephala* (Tables 1–3). For example, the total plant height of 3-month-old seedlings of *T. ivorensis* when no leaf was removed was 27.8 cm compared to 21.3 and 18.9 cm observed when 2 and 3 leaves were removed respectively (Tables 3 & 4). The dry weights of root and shoot in the same seedling in the control were 5 and 9 g respectively in comparison to 2.5 and 5.2 g in seedlings with 2 leaves removed, 2.0 and 4.3 g in *T. ivorensis* with 3 leaves removed (Tables 1 & 2). This trend was also observed in the other tree species.

The results showed that the shoot length of the seedlings of all the six species were mostly not affected by the defoliation treatment (Table 4). It was observed generally in all the species investigated that removal of part of an intact leaf had no adverse effect on the growth of the seedlings (Tables 1–4).

Tables 5 and 6 show the observed values for the effects of five fertilisers on the total leaf areas and dry weights of the 3-month-old seedlings of the six tree species investigated. There was an increase in the total leaf area and dry weight of seedlings treated with the five inorganic fertilisers (Tables 5 & 6). However, $Mg(NO_3)_2$ had the most significant effect in increasing the total leaf area (Table 5). None of the fertilisers tested, with the exception of $Mg(NO_3)_2$, had any significant effect on the total dry weight. Magnesium nitrate caused very high increase in total dry weight in all the seedlings, especially those of *C. pentandra* and *L. leucocephala* (Table 6), where 300 and 400% growth increases were observed respectively.

Table 1. Effect of defoliation on the root dry weight of 3-month-old seedlings of six tropical tree species. Data are mean values ± s.e. of five replicates.

Defoliation treatment	Dry weights of root ($x10^2g$)					
	Ts	Tv	Tg	Cb	Ga	Leu
D_0	7.9 ± 0.5	5.0 ± 1.2	130.0 ± 1.7	15.0 ± 1.3	33.4 ± 0	23.0 ± 0.2
D_1	9.7 ± 0.3	4.8 ± 1.2	127.3 ± 0.6	14.7 ± 0.2	33.6 ± 0.1	22.8 ± 1.6
D_2	7.2 ± 0.4	4.6 ± 1.0	128.4 ± 0.3	14.2 ± 0.5	33.7 ± 0	22.7 ± 1.2
D_3	5.1 ± 0.1	2.5 ± 0.61*	102.3 ± 0.2	9.3 ± 0.3*	26.3 ± 1.2*	15.2 ± 1*
D_4	7.3 ± 0.3	4.7 ± 0.1	126.8 ± 0.1	14.8 ± 1.5	34.0 ± 0.6	22.6 ± 0.3
D_5	4.6 ± 0.4*	2.0 ± 0.1*	94.2 ± 1.0	10.4 ± 2.4*	22.3 ± 0.1*	13.3 ± 1.1*
D_6	7.1 ± 0.4	4.4 ± 1.2	126.2 ± 0.7	14.6 ± 2.2	32.9 ± 0.1	22.8 ± 3.9

*Significantly different from control (p = 0.05).

D_0 = no leaf removed (control)
D_1 = one whole leaf removed
D_2 = one half leaf removed
D_3 = two whole leaves removed
D_4 = two leaf halves removed
D_5 = three whole leaves removed
D_6 = three leaf halves removed

Ts = *Terminalia superba*
Tv = *Terminalia ivorensis*
Tg = *Tectona grandis*
Cb = *Ceiba pentandra*
Ga = *Gmelina arborea*
Leu = *Leucaena leucocephala*

Table 2. Effect of defoliation on the shoot dry weight of 3-month-old seedlings of six tropical tree species. Data are mean values ± s.e. of five replicates.

Defoliation treatment	Dry weights of root ($x10^2g$)					
	Ts†	Tv	Tg	Cb	Ga	Leu
D_0†	12.6 ± 0.4	9.0 ± 0.4	60.0	99.0 ± 4.0	89.0 ± 0.3	48.0 ± 1.6
D_1	12.4 ± 0.7	8.8 ± 0.6	57.3 ± 0.1	94.0 ± 2.6	86.3 ± 0.2	47.3 ± 0.2
D_2	12.5 ± 0.2	8.7 ± 0.3	58.0	96.0 ± 6.3	87.2 ± 0.3	47.6 ± 1.2
D_3	8.4 ± 0.7	5.2 ± 0.1	46.4 ± 1.2	64.6 ± 2.4*	63.4 ± 1.7*	31.3 ± 1.1*
D_4	12.2 ± 1.3	8.6 ± 0.4	57.2 ± 1.3	96.2 ± 4.2	87.2 ± 0.5	47.7 ± 1.3
D_5	6.7 ± 0.1*	4.3*	39.6 ± 0.4	70.1 ± 1.6*	56.7 ± 1.3*	27.2 ± 1.4*
D_6	12.2 ± 0.1	8.2 ± 0.2	57.1 ± 0.3	97.3 ± 3.4	87.6 ± 0.3	47.3 ± 2.4

*Significantly different from control (p = 0.05).
†As in Table 1.

Table 3. Effect of defoliation on root length of 3-month-old seedlings of six tropical tree species. Data are mean values ± s.e. of five replicates.

Defoliation treatment	Root length (cm)					
	Ts†	Tv	Tg	Cb	Ga	Leu
D_0†	20.0 ± 0.3	16.4 ± 0.3	18.0 ± 2.0	20.4 ± 1.8	19.4 ± 1.3	18.2 ± 0.5
D_1	19.7 ± 0.2	16.2 ± 0.2	17.3 ± 0.1	18.9 ± 0.3	19.0 ± 0.1	16.4 ± 0.4
D_2	19.4 ± 0.3	16.0 ± 0.1	17.0 ± 0.1	18.8 ± 0.3	19.2 ± 0.2	18.0 ± 0.3
D_3	13.0 ± 0.1	10.0 ± 1.2*	12.3 ± 0.1	13.3 ± 0.6*	19.3 ± 1.2	13.9 ± 0.8*
D_4	19.8 ± 0.4	16.3 ± 0.4	17.4 ± 0.1	19.4 ± 0.7	18.8 ± 1.3	16.9 ± 1.3
D_5	12.3 ± 0.5*	8.0 ± 1.2*	9.6 ± 0.3	11.1 ± 0.3*	19.2 ± 0.7	12.0 ± 0.5*
D_6	18.3 ± 0.4	16.0 ± 0.2	17.0 ± 0.1	18.6 ± 0.4	18.7 ± 1.1	18.0 ± 0.5

*Significantly different from control (p = 0.05).
†As in Table 1.

Table 4. Effect of defoliation on the shoot length of 3-month-old seedlings of six tropical tree species. Data are mean values ± s.e. of five replicates.

Defoliation treatment	Shoot length (cm)					
	Ts†	Tv	Tg	Cb	Ga	Leu
D_0†	16.4 ± 0.1	11.4 ± 0.1	10.9 ± 0.4	16.4 ± 0.5	23.0 ± 0.1	20.0 ± 1.6
D_1	16.0 ± 1.3	11.4 ± 0.1	11.3 ± 0.1	17.5 ± 0.2	22.9 ± 0.3	18.9 ± 1.3
D_2	16.2 ± 0.9	11.2 ± 0.2	10.8 ± 0.1	16.8 ± 0.1	22.8 ± 0.1	19.4 ± 0.6
D_3	16.3 ± 0.6	11.3 ± 0.1	8.9 ± 0.2	16.0 ± 0.2	15.0 ± 1.2*	12.6 ± 0.5
D_4	16.2 ± 0.7	11.0 ± 0.1	10.2 ± 0.4	16.3 ± 0.1	22.9 ± 0.1	20.7 ± 1.2
D_5	15.9 ± 0.4	10.9 ± 0.3	7.8 ± 0.1	16.4 ± 0.2	13.3 ± 0.9*	12.5 ± 0.6*
D_6	15.6 ± 0.1	11.2 ± 0.4	10.4 ± 0.1	16.3 ± 0.4	21.5 ± 1.3	20.1 ± 0.2

*Significantly different from control (p = 0.05).
†As in Table 1.

Table 5. Effect of inorganic fertilisers on the leaf area of 3-month-old seedlings of six tropical tree species. Data are mean values ± s.e. of five replicates.

Fertiliser treatment	Leaf area of seedling (cm^2)					
	Ts†	Tv	Tg	Cb	Ga	Leu
Control	1435.0 ± 4.6	350.0 ± 2.7	6550.0 ± 7.3	1175.0 ± 9.1	4611.0 ± 18.1	788.0 ± 3.0
$NaNO_3$	1610.0 ± 11.3	412.0 ± 1.5	6730.0 ± 6.2	1360.0 ± 6.4	4764.0 ± 9.2	920.0 ± 7.4
$Mg(NO_3)_2$	1620.0 ± 11.2*	476.0 ± 2.5*	6947.0 ± 7.3*	1642.0 ± 3.5*	5102.0 ± 4.1*	1020.0 ± 8.1*
NH_4NO_3	1536.0 ± 9.7	436.0 ± 1.7	6714.0 ± 3.9	1260.0 ± 2.7	4821.0 ± 10.1	640.0 ± 4.1
$Al(NO_3)_3$	1497.0 ± 11.7	410.0 ± 6.4	6614.0 ± 11.2	1210.0 ± 4.2	4721.0 ± 8.7	360.0 ± 3.5
NH_4Cl	1560.0 ± 5.4	386.0 ± 5.1	6783.0 ± 8.4	1320.0 ± 6.1	4801.0 ± 7.2	802.0 ± 5.6

*Significantly different from control (p = 0.05).
†As in Table 1.

Table 6. Effect of inorganic fertilisers on the total dry weights of 3-month-old seedlings of six tropical tree species. Data are mean values ± s.e. of five replicates.

Fertiliser treatment	Total dry weight of seedling (g)					
	Ts[†]	Tv	Tg	Cb	Ga	Leu
Control	1.62 ± 0.01	1.65 ± 0.02	8.84 ± 0.14	12.65 ± 0.09	18.46 ± 0.19	7.47 ± 0.18
$NaNO_3$	3.01 ± 0.02	1.97 ± 0.03	8.77 ± 0.14	12.94 ± 0.14	18.76 ± 0.87	7.86 ± 0.18
$Mg(NO_3)_2$	5.24 ± 0.04**	4.87 ± 0.06**	16.29 ± 0.17**	34.64 ± 0.11**	30.0 ± 0.76**	28.92 ± 0.14**
NH_4NO_3	4.6 ± 0.06	3.70 ± 0.22	8.93 ± 0.03	13.01 ± 0.46	18.6 ± 1.24	8.01 ± 0.26
$Al(NO_3)_3$	1.72 ± 0.04	1.75 ± 0.01	8.19 ± 0.39	12.12 ± 0.01	18.77 ± 1.26	7.48 ± 0.27
NH_4Cl	2.46 ± 0.03	1.74 ± 0.01	8.74 ± 0.01	13.53 ± 0.4	18.73 ± 0.06	7.95 ± 0.36

**Highly significantly different from control (p = 0.05).
[†]As in Table 1.

Discussion

The removal of 2 or 3 leaves in the 3-month-old seedlings of all three species in this study significantly affected dry weights of root and shoot compared to the control trees. Root length was the most adversely affected by defoliation especially in *T. ivorensis, T. superba, C. pentandra* and *T. grandis* (Table 3).

Removal of half a leaf from the seedlings had no effect (Tables 1-4). The result of the present study compared favourably with that of Remison (1978) on the effect of defoliation on growth of maize. He found that in the field, defoliation of all leaves from the plant at 50% silking reduced the dry matter accumulation severely. Removing half of the leaves above or below the ear did not affect cob and grain weight to the same extent as removing all leaves above and below the ear. Leaves are essential for photosynthetic and respiratory activities and their loss by any means can retard or inhibit growth processes.

This study has shown that defoliation of young seedlings of tree species in the early vegetative phase impaired root growth and consequently may affect the uptake and distribution of nutrients (Tables 1–4). In turn, this may result in reduced growth rate of defoliated plants. A number of workers (Davidson & Milthorpe 1965, Evans 1973) have shown that defoliation has deleterious effects on plant growth. Dry matter accumulation was most affected when a greater number of leaves (2–3) were defoliated at especially at 2- to 3-month stage (Tables 1 & 2).

Presumably with 2–3 leaves removed the tender plants depended in part on the green stems for their photosynthetic activities and less leaf material for growth was deposited. Martin and Leonard (1967) reported that stripping corn leaves at an early stage of growth checked grain development and reduced yield. When half the leaves were removed, there was no effect on growth. This showed that the undefoliated halves, other green parts of shoot and the intact leaves provided enough photosynthates needed for growth at this stage.

Removal of leaves in this investigation is perhaps a semblance of conditions where leaf-eating insects or diseases and physical removal by wind or heavy rain remove leaf area. Insects, according to Martin and Leonard (1967), may not remove all leaves on plants although some insects such as locusts and army worms can devour large parts leaving only bare stalks or sometimes only stubs in the field. Occurence of greater damage on shoot of young seedlings of *Chlorophora excelsa (Milicia excelsa)* by leaf gall-forming aphids has been clearly documented by Fasidi and Olofinboba (1975).

The present results of the effect of inorganic fertiliser on growth compare well with those of Etejere and Osatimehin (1984). Magnesium nitrate, NH_4NO_3 and KNO_3 significantly increased the dry weight of above-ground tissue of seedlings of baobab, *Adansonia digitata* , with KNO_3 being the most effective. Ammonium nitrate and KNO_3 enhanced the plant root length and shoot height. Ekwebelam and Reid (1984) found that application of three levels of ammonium nitrate led to significantly larger biomass in 16-week-old seedlings of *Pinus contata.*

If a plant is supplied with high concentrations of fertiliser, especially that containing nitrogen, there is a tendency for the plant to have increased leaf cell number and cell size with an overall increase in leaf production (Njoku 1957). This explains the observed enhancement of leaf area of the tree seedlings by the five fertilisers (Table 5). Magnesium nitrate apart from enhancing leaf area also caused increased total dry weight. Magnesium is a constituent of chlorophyl and hence plays a prominent role in the production of photosynthates and assimilable materials (Nanson & Mcleroy 1963).

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