

Research paper

An Evaluation of the Effects of Organic and Inorganic Fertilizers on the Growth Performance of Three Timber Species: *Cedrella odorata* L., *Entandrophragma angolensis* Welw. and *Terminalia superba* Diel., in Nursery.

Abstract

The continuous destruction of rainforest threatens many useful and multipurpose plant species such as *Cedrella odorata*, *Entandrophragma angolensis* and *Terminalia superba*. In this study we evaluated the effect of fertilization on the growth performance of these species in nursery. We used 10 nutrients treatments, nine of which were nutrient combinations and one, a negative control. Urea was added at 75 mg and 112.50 mg while super phosphate simple was added at 30 mg and 60 mg. A total of 120 uniformly growing seedlings were treated with fertilizers two weeks after transplanting. Information on height (cm), collar diameter (mm), leaf number, leaf area (cm²) and biomass production (g) was collected fortnightly for a 120 days period. *Cedrella odorata* produced maximum seedling height (13.55 cm), leaf number (9.99), leaf area (509.20 cm²) and total biomass (18.47g), *Terminalia superba* showed maximum collar diameter (4.78 mm) while *Entandrophragma angolensis* had the least growth performances.

Key words: Fertilizers, Growth characteristics, Nutrient combination, Performance,

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35 **Introduction**

36 Fertilization with organic and inorganic fertilizers during forest seedling culture is one of
 37 the most crucial factors with a positive effect on seedling quality, performance and
 38 establishment (Rafiqul *et al.*, 2004). Soil amendment, for forest nursery usually with
 39 organic matter, has also been reported to promote seedling quality (Focho *et al.*, 2011).
 40 Maintaining adequate fertility of forest nursery soils is of paramount importance to assure
 41 production of high quality planting stock (Hoque *et al.*, 2004). High quality planting
 42 stocks will have better adaptation, resistance to environmental stress and will have better
 43 field performance over long term (Davis and Jacob 2005).

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45 Tropical soils and forest are deficient in Nitrogen and Phosphorus nutrients and uptake of
 46 these limited quantities of nutrients by plant roots from litter is difficult (Lawrence, 2003;
 47 Jose, 2003). Therefore, inadequate management of nursery soil can result in depletion of
 48 soil fertility and a corresponding reduction in seedling growth (Ang *et al.*, 1995; Hoque *et*
 49 *al.*, 2004). However, a healthy seedling must be supplied with all the nutrients in the

proper proportion for efficient growth (Craven *et al.*, 2006; Gbadamosi, 2006) and development following outplanting.

Timber seedlings have varied needs for nutrients and the demand for a particular element or nutrient depends upon the growth requirements of the species in question (Ingested, 1979b). Environmental conditions also influence nutrient requirements for plant species in nursery and in the field (Ingested, 1979b). Information on the fertilizer needs of plants in nursery for tropical forest species are available (Nwoboshi, 1982), but more of such information would be necessary, since conditions change and also because species-specific records are very essential for producing quality seedlings for out planting (Rafiqul *et al.*, 2004).

Cedrella odorata, *Entandrophragma angolensis* and *Terminalia superba* are important tree species found in the dense forests of Equatorial Africa including Cameroon, these species are amongst the most exploited and exported species of the region (Laird, 1995; Shono *et al.*, 2007). Natural regeneration is reported to be poor and the distributions as well as the abundance of these species are decreasing (Nwoboshi, 1982; Laird, 1995). The wood from these species are light to moderately hard, exhibit characteristic strength and resistance to rot as compare to other softwood, durable and serve as timber. They are exploited commercially for local consumption, used for the making of doors and window panels, in house construction, scantling and other uses (FAO, 2000; Andre, 2001). Besides the timber, the leaves, barks and roots are used in traditional medicines for primary healthcare (Sofowora, 1993).

The production of quality seedlings in nursery will better the chances of seedlings survival on the field, since such seedlings are expected to better resist or tolerate stress and diseases (Nwoboshi, 1982). The present study involved the combination of two inorganic fertilizers (Urea and Super phosphate simple) and organic fertilizer. The nutrients were added at four different levels in the potting mixture to observe the effects of added inorganic fertilizers (N and P) on seedlings of the four timber species in nursery. The aim of this study was therefore to determine nutrient combinations that will ensure good seedling performance for *Cedrella odorata*, *Entandrophragma angolensis* and *Terminalia superba*.

MATERIALS AND METHODS

Study site

This study was carried out in the screen house of the Department of Botany and Plant Physiology at the University of Buea campus, Cameroon. The Buea area has a humid tropical climate with an annual rainfall of about 2.800 mm, most of which is received between June and September (Ndam, 1996; Peguy *et al.*, 1999). The mean annual temperature is 28°C while the relative humidity was about 85 % and the annual sunshine is between 900 to 1200 hours per annum (Ndam, 1996). The topography of Buea is mountainous; soil type is basically volcanic making it suitable for agriculture (Cable and Cheek, 1998).

Preparation of potting mixture

Top soil used in this experiment was collected from fallow land at the University of Buea Campus. The soils were air dried and visible roots, leaves and other debris were removed

by sieving. Poultry droppings were collected from a poultry farm and allowed to decompose for 8 weeks. 9 × 6 inch polythene bags were used for the experiment. In addition to poultry droppings, nitrogen (N) was in the form of Urea and phosphorus (P) as Super Phosphate Simple (SPS). 120 seedlings with a mean height of 4.0 cm were transplanted into polythene bags and 12 seedlings per species were used for each treatment.

The amounts of nutrients added to each potting mix and the experimental combinations were as follows: Treatment 1: N0P0 (organic manure only), Treatment 2: N1P0 (75 mg urea, 0 mg SPS), Treatment 3: N2P0 (112.5 mg urea, 0 mg SPS), Treatment 4: N0P1 (0 mg urea, 30 mg SPS), Treatment 5: N1P1 (75 mg urea, 30 mg SPS), Treatment 6: N2P1 (112.5 mg urea, 30mg SPS), Treatment 7: N0P2 (0 mg urea, 60 mg SPS), Treatment 8: N1P2 (75 mg urea, 60 mg SPS), Treatment 9: N2P2 (112.5 mg urea, 60 mg SPS) and Treatment 10: (top soil only). Watering was done with deionised water three times a week. Data on height, collar diameter, leaf area, leaf number and biomass were recorded fortnightly.

Determination of soil nutrients

Soil samples were collected at different sites of the fallowed land and air-dried. The following parameters were determined: Soil pH in a 2:5 (w/v) soil water suspension; organic carbon by chromic acid digestion and spectrophotometer analysis (Hanes, 1984). Total nitrogen was determined from wet acid digest (Buondonno et al., 1993), exchangeable cations (calcium, magnesium, and potassium) were extracted using the Mehlich-3 procedure (Mehlich, 1984) and determined by atomic absorption

spectrophotometry. Available phosphorus was extracted by the Bray-1 procedure and analyzed using the molybdate blue procedure described by Murphy and Riley (1962).

Data Collection

After establishment of the experiment, data were collected fortnightly. The measurements of height were taken from the ground level to the tip of the seedlings using a meter rule. Collar diameter was determined with the use of an electronic caliper (G02022 165). The numbers of leaves produced by seedlings were counted. Leaf area measurements were done using a leaf area measuring system (Delta T devices. Model RS232). After 120 days of fertilisation of seedlings, seedlings were harvested and partitioned into leaf, stem and root components. The fresh and dry weights of the different seedling components were noted. Total biomass (total dry weights) was obtained by adding dry weights of leaves, stems and roots.

Data analysis

The effect of fertilization on the different growth parameters was evaluated by subjecting the collected data to one way and two way analysis of variance for within and between species interactions. The significance of the difference between means was tested using least significant differences (LSD). All statistical analyses were conducted using Minitab version 14.0 software (Minitab Inc., State College, PA, USA)

RESULTS

Soil analysis

The chemical properties of the soil used in this experiment are shown on table 1.

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147 **Seedling heights**

148 Generally, the addition of fertilizer led to a significant ($P<0.05$) increase in height for *C.*
149 *odorata* (table 2). The greatest height of 13.55 cm for this species was observed
150 following the addition of urea (112.5 mg) and super phosphate simple (60 mg).
151 Fertilization of *T. superba* also resulted in height increments but the difference was not
152 significant for all nutrient additions. Exogenous addition of 30mg of SPS produced the
153 best height of 9.57 cm for this species (table 2). This observation was similar for *E.*
154 *angolensis* where the addition of Urea and SPS at 112.5 mg and 60 mg respectively
155 produced the best height of 10.79 cm. The least heights were observed in situations where
156 there were no nutrient additions except for *E. angolensis* in which the least height of 8.57
157 cm was observed with the addition of poultry manure (table 2).

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159 **Number of leaves**

160 Fertilizer applications significantly ($P<0.05$) increased leaf numbers for the species except
161 for *E. angolensis*. *C. odorata* produced a maximum of 10 leaves following the addition of
162 urea at 112.5mg. *T. superba* responded to nutrient addition by the significant production
163 of more leaves. The addition of poultry manure led to the maximum of 9 leaves for this
164 species (table 2). Fertilization had no significant effect on leaf numbers for *E. angolensis*
165 nonetheless; the highest leaf number of 4 was recorded with the addition of super
166 phosphate simple at 30 mg. All nutrient treatments resulted in the production of more
167 leaves as compared to the control (table 2).

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169 **Collar diameter**

Nutrient additions at all concentrations significantly ($P < 0.05$) increased collar diameter for *C. odorata*, with P additions at 30 mg producing the highest value of 4.33 mm (table 2). *T. superba* did not show any significant increase in collar diameter following the addition of P and N; however, the addition of poultry manure caused a significant increase in collar diameter (4.78 mm). *E. angolensis* did not show any significant gain in collar diameter following addition of nutrients at all concentrations (table 2).

Total leaf area

C. odorata and *T. superba* showed a similar response to P addition at 30 mg by producing significantly larger leaves. Their maximum leaf areas were 509.2 cm² and 98.8 cm² respectively (table 2). *E. angolensis* did not show any significant increase in leaf area with nutrient additions. Nonetheless, the addition of N (urea 75 mg) resulted in the highest leaf area (92.3 cm²) for this species.

Total Biomass

C. odorata and *T. superba* showed marked increase in total biomass with the addition of nutrients (Table 3). Generally, the total biomass of *C. odorata* seedlings increased the most with Nitrogen (N) than with combinations of Nitrogen (N) and Phosphorus (P) while the biomass of *T. superba* was highest (18.46 g) with phosphorus only (N0P1) than in combination. The maximum total biomass was 18.47 g recorded for *C. odorata* with treatment combination (N1P0). *E. angolensis* also demonstrated an increase in biomass

(4.33 mg) following nutrient addition, but the values were inferior to those observed for the other two species (table 3)

Discussion

The main morphological parameters used to evaluate seedling quality included seedling height, number of leaves, collar diameter and leaf area (Focho *et al.*, 2011). These morphological attributes are vital structures to assess quality of seedlings in nursery (Focho *et al.*, 2011). The results of this fertilizer application study supports the general expected response that seedlings treated with appropriate combination of fertilizers will yield better growth performance than seedlings with no nutrient applications. This is also in conformity with earlier works on other plantation species such as *Anthocephalus chinensis* and *Dalium guineense* (Okeke and Omaliko 1997; Hoque, 2004). Positive results of fertilization were also reported on *Xizyphus spinachristtii* and *Zizypus maldritania*.

Fertilizer requirement of species differ, reasons why efforts must be made to identify the appropriate fertilizer preference for all species. According to Offiong *et al.*, (2010), the inherent characteristics of species and intraspecific genotypes play an important role in restricting or enhancing efficiency of plants in the uptake, use and tolerance to mineral elements. The different combinations of nitrogen, phosphorus and organic fertilizers significantly ($p < 0.05$) affected some important morphological traits and biomass production of *C. odorata*, *E. angolensis* and *T. superba* examined in this study. This could be attributed to the two essential minerals (N and P) required for optimum plant

growth and development. Offiong *et al.*, (2010) reported that nitrogen, phosphorus and potassium are essential for plant growth, particularly at the nursery state.

The best mean height of *C. odorata* and *E. angolensis* was recorded with the addition of N (112.5 mg) and P (60 mg). This observed increase in growth in response to N and P application is not unusual. Abod and Siddiqui (2002) had demonstrated that plants which received adequate N showed vigorous elongation of stem thus, N promoted vegetative growth of stems and leaves. Phosphorus is intimately associated with all life processes and is a vital constituent of every living cell. It is also important because a high concentration of P is found in plant parts that are growing rapidly (Abod and Siddiqui 2002). Similar findings had been reported by Okeke and Omaliko (1997) and Hoque, (2004) in their studies on fertilizer treatments on plantation seedlings of *Anthocephalus chinensis* and *Dalium guineense* in nursery. The maximum leaf number in this study was obtained with treatment combination N2P0. Basically, N has been called the growth element because it is a vital part of plant protoplasm. Protoplasm is the seat of cell division and, therefore, plant growth (Abod and Siddiqui 2002). It is also one of the fundamental units in proteins, nucleic acid and chlorophyll; it controls the formation of seedlings foliage (Offiong *et al.*, 2010). The maximum collar diameter in this study was recorded with treatment combination N0P0 (decomposed poultry manure). The slow release of nutrients from organic origin gives rooms for maximum utilization of nutrients for cell division, enlargement and building of stem biomass of seedlings. The gradual release of nutrient prevented leaching of nutrients and allows ample time for fine roots to take up nutrients for biomass increment (Offiong *et al.*, 2010). Poultry manure is very

rich in nitrogen, a probable reason for the observed diameter increment (Abod and Siddiqui 2002)

Leaf area production was optimal with treatment combination of N0P1. Subsequent release of Phosphorus which was applied in a rock form as Super Phosphate Simple increased the leaf area of seedlings. Phosphorus may have contributed in increasing the leaf area by promoting photosynthesis, thus enhancing energy formation for cell division and expansion. A similar observation was reported by Mariswamy *et al.*, (2011) on influence of nutrients on seedlings of *Terminalia bellirica* in nursery.

Total biomass was generally influenced by the addition of nitrogen and phosphorus solely and in combination. The increased availability of N in the root zone might have encouraged uptake by seedlings resulting in higher growth and eventual accumulation of biomass. Similar results of increased biomass of seedlings due to nitrification inhibition were reported by Rastovski (1997) in *Picea abies*, *Pinus sylvestris* and *Abies alba* seedlings and Jacobs *et al.* (2003) in *Pseudotsuga menziesii* (Douglas fir) seedlings.

The fact that nitrogen is essential for the formation of proteins in addition to its role in photosynthesis, the high uptake of nitrogen resulted in higher production and partitioning of photosynthates to the different plant parts resulting to high biomass production (Mariswamy *et al.*, (2011). Phosphorus may also have contributed in enhancing biomass production by increasing photosynthesis, cell division and cell enlargement, in which phosphorus play a paramount role in the anabolic processes.

Conclusion

From all aspects, it was observed that, nitrogen and phosphorus fertilizers obviously had beneficial effects, thus the increase in heights, leaf numbers, collar diameter, leaf area and total biomass production of these timber seedlings in nursery. It was also observed that generally, all the fertilizer combinations influenced the growth of seedlings in nursery as the values were better than those observed with the control treatment. The results of the present study indicated that *C. odorata* and *T. superba* had better performances with treatment applications than *E. angolensis*. This pot experiment provides a basis for fertilizer trials in the field. There is need for many of such studies so that nursery quality of endangered species could be improved and thus guaranteeing their survival following out planting in regeneration programs.

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371 **Table: 1. Chemical properties of soil used in the screen house experiment. Soil**
372 **collected 0 to 20cm from fallowed land at the University of Buea campus**

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375	Parameter	Chemical Properties
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378	p ^H	5.17
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380	Ca Meq/100g	2.13
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382	Mg Meq/100g	0.75
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384	K Meq/100g	0.18
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386	P ppm	3.20

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Org C % 9.57

Species	Treatment	Height (cm)	Leaf number	Collar diameter (mm)	Leaf area(cm ²)
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Tot N % 0.61

Table 2. Growth parameters (height, leaf number, collar diameter and leaf area) of different seedling species.(Values in the same column of seedlings species followed by the same letters are not significantly different)

<i>C. odorata</i>	T1:N0P0	11.83 ^b	9.33 ^a	4.31b ^c	372.8 ^b
	T2:N1P0	12.83 ^{bc}	9.58 ^a	4.26b ^c	493.2 ^{b-d}
	T3: N2P0	12.88 ^{bc}	9.99 ^{ab}	4.21b ^c	500.8 ^{b-d}
	T4: N0P1	13.23 ^{bc}	9.38 ^a	4.33b ^c	509.2 ^{b-d}
	T5: N1P1	12.65 ^{bc}	9.13 ^a	4.30bc	465.8 ^{b-d}
	T6: N2P1	11.84 ^b	9.38 ^a	4.06 ^b	426.7 ^{bc}
	T7: N0P2	11.68 ^b	9.55 ^a	3.67 ^b	395.1 ^b
	T8: N1P2	11.21 ^b	9.46 ^a	4.05 ^b	399.9 ^b
	T9: N2P2	13.55 ^{bc}	9.46 ^a	4.07 ^b	503.9 ^{b-d}
	T10 :Control	9.06 ^a	7.91 ^b	3.06 ^a	216.4 ^a
<i>E. angolensis</i>	T1:N0P0	8.57 ^{ac}	3.71 ^a	2.88 ^a	90.8 ^{a-c}
	T2:N1P0	9.01 ^{ac}	3.91 ^a	2.90 ^a	92.3 ^{a-c}
	T3: N2P0	9.05 ^{ac}	3.94 ^a	2.64 ^a	59.3 ^d
	T4: N0P1	8.88 ^{ac}	4.10 ^a	2.66 ^a	75.0 ^a
	T5: N1P1	8.96 ^{ac}	3.49 ^a	2.73 ^a	85.5 ^{ac}
	T6: N2P1	9.56 ^{bc}	4.08 ^a	2.59 ^a	85.3 ^{ac}
	T7: N0P2	10.6 ^b	4.08 ^a	2.83 ^a	91.4 ^{a-c}
	T8: N1P2	10.5 ^b	3.91 ^a	2.89 ^a	90.6 ^{a-c}
	T9: N2P2	10.7 ^b	3.57 ^a	2.59 ^a	86.7 ^{ac}
	T10 :Control	9.14 ^{bc}	3.48 ^a	2.73 ^a	57.4 ^{bd}
<i>T. superba</i>	T1:N0P0	9.49 ^a	9.21 ^a	4.78 ^a	97.5 ^a
	T2:N1P0	9.01 ^{ab}	8.49 ^{ac}	2.84 ^b	97.6 ^a
	T3: N2P0	9.22 ^{ab}	8.69 ^{ac}	2.94 ^b	90.3 ^{ac}
	T4: N0P1	9.57 ^a	8.33 ^{ac}	3.27 ^b	98.8 ^a
	T5: N1P1	9.47 ^a	8.52 ^{ac}	2.82 ^b	86.3 ^{ac}
	T6: N2P1	9.12 ^{ab}	8.19 ^{ac}	2.64 ^b	77.0 ^b
	T7: N0P2	8.98 ^{ab}	8.46 ^{ac}	2.74 ^b	87.4 ^{ac}
	T8: N1P2	8.63 ^b	8.35 ^{ac}	2.67 ^b	79.6 ^b
	T9: N2P2	8.65 ^{ab}	7.94 ^{ac}	2.59 ^b	88.6 ^{ac}
	T10 :Control	8.24 ^b	7.02 ^b	2.45 ^b	72.4 ^d

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426 Table 3. Growth parameters (Dry weights of leaf, stem and roots as well as total biomass) of
different seedling species. (Values in the same column of seedlings species followed by the
same letters are not significantly different)

Species	Treatment	Dry Wt. of leaf(g)	Dry Wt. of stem (g)	Dry Wt. of root (g)	Total biomass (g)
<i>C. odorata</i>	T1:N0P0	7.90 ^{bc}	3.70 ^b	3.86 ^a	15.46 ^b
	T2:N1P0	11.80 ^b	3.30 ^{bc}	3.37 ^c	18.47 ^a
	T3: N2P0	11.57 ^b	3.13 ^{bc}	3.40 ^c	18.10 ^b
	T4: N0P1	8.70 ^{bc}	3.50 ^{bc}	2.70 ^b	14.90 ^b
	T5: N1P1	9.07 ^{bc}	2.56 ^d	4.20 ^a	15.83 ^b
	T6: N2P1	4.73 ^d	2.80 ^d	2.60 ^b	10.13 ^c
	T7: N0P2	9.70 ^{bc}	3.20 ^{bc}	2.53 ^b	15.43 ^b
	T8: N1P2	8.50 ^{bc}	3.30 ^{bc}	5.87 ^d	17.67 ^a
	T9: N2P2	7.90 ^{bc}	3.30 ^{bc}	4.57 ^a	15.77 ^b
	T10 :Control	2.40 ^a	1.33 ^a	2.30 ^b	6.03 ^d
<i>E. angolensis</i>	T1:N0P0	1.33 ^b	0.86 ^{bc}	1.20 ^{ab}	3.40 ^{ac}
	T2:N1P0	2.90 ^a	0.63 ^{bc}	0.80 ^{ab}	4.33 ^b
	T3: N2P0	0.68 ^c	1.26 ^a	1.63 ^b	3.57 ^{a-c}
	T4: N0P1	1.43 ^b	0.53 ^{bc}	0.53 ^a	2.50 ^{ac}
	T5: N1P1	1.233 ^b	0.60 ^{bc}	0.73 ^a	2.57 ^{ac}
	T6: N2P1	1.167 ^b	0.56 ^{bc}	0.77 ^{ab}	2.50 ^{ac}
	T7: N0P2	1.467 ^b	0.70 ^{bc}	1.10 ^{ab}	3.27 ^{ac}
	T8: N1P2	1.50 ^b	0.86 ^{bc}	0.97 ^{ab}	3.33 ^{a-c}
	T9: N2P2	0.733 ^c	0.56 ^{bc}	0.50 ^a	1.80 ^a
	T10 :Control	0.66 ^c	0.43 ^{bc}	0.67 ^{ab}	2.97 ^{ac}
<i>T. superba</i>	T1:N0P0	9.40 ^d	2.43 ^c	1.90 ^{bc}	13.73 ^{ab}
	T2:N1P0	6.00 ^c	1.33 ^b	3.50 ^b	10.83 ^{bc}
	T3: N2P0	9.27 ^d	1.46 ^b	2.07 ^c	12.80 ^d
	T4: N0P1	11.43 ^b	3.70 ^a	3.33 ^b	18.46 ^a
	T5: N1P1	8.07 ^{dc}	1.46 ^d	2.23 ^c	11.77 ^{cd}
	T6: N2P1	6.40 ^c	1.63 ^d	1.07 ^a	9.10 ^c
	T7: N0P2	9.033 ^d	1.50 ^d	2.17 ^c	12.70 ^d
	T8: N1P2	10.07 ^{bc}	2.30 ^c	1.67 ^{bc}	14.03 ^{ab}
	T9: N2P2	7.13 ^{ab}	1.23 ^b	1.07 ^a	9.43 ^c
	T10 :Control	3.10 ^a	1.13 ^b	1.07 ^a	5.30 ^b