EFFECT OF WATERING REGIMES AND LEVELS OF UREA FERTILIZER APPLICATION ON ESTABLISHMENT OF TEAK SEEDLINGS IN AN ACIDIC SOIL

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Abstract

An investigation was carried out to assess the effects of different levels of urea fertilizers and different watering regimes on the growth and development of *Tectona grandis* seedlings at the Nursery stage. The study was carried out in the Nursery section of the Teaching and Research farm of the Department of forestry and wildlife, Delta State University, Asaba Campus, Nigeria. Three levels of urea fertilizer applied were as follows: 0.5g, 1.5g and 2.0g and per poly pot containing 10kg soil, while the different watering regimes applied were 1/7, 3/7 and 7/7 which were applied to the seedlings once per week, three times per week and seven times per week respectively. Parameters measured at two weeks interval were plant height, leaf number, leaf area and collar diameter. At the end of the experiment dry matter accumulation was determined for root, stem and leaf of the seedlings. The experimental design adopted was split plot design in a randomized complete block. The experiment was replicated three times. In general, there were significant differences ($P<0.05$) among the treatments. The seedlings treated with 2.0g and 1.5g of area fertilizer and watered 7 and 3 times per week gave the highest in all the parameters. Treatment effect of urea on leaf area was significant. Mean values ranged from 229.41cm^2. Interaction effect was also significant. Daily watering and 2.0g of urea elicited the maximum leaf area values of 643.95cm^2. Dry weight values ranged from 14.03g to 34.53g for root and leaf respectively. The successful establishment of teak in desertified environment will only be possible if there is sustainable source of water most especially at the initial stage.

Key words: Tectona grandis, urea fertilizer, seedling growth and development, Nursery.

Introduction

Teak has been highly appreciated as timber for centuries in this region. Wooden sculptures, doors and coffins made of teak over 1000 years old have been found in Persian temples. (Panday, 1996). Teak is considered virtually imperishable. It is preferred for naval construction because of its extreme resistance to decay and corrosive activity of water. It is suitable for variety of uses; luxury cabinet work, frames (doors and windows), furniture and joinery with solid wood, parquet floorings, star case carpentry, garden furniture, railway sleepers, bridges and other construction purposes (Etukudo, 2000).

Teak leaves are used for packing food products in the market, the root, bark and young leaves yield a yellowish brown, red or yellow dye, which is used

to colour paper and textile (Etukudo, 2000). The leaves are used by tradomedical practioners to treat anaemia, asthma fever and malaria. Teak is easily worked upon and has natural oils extracted from young shoot used as treatment for scabies.

The flowers are not left out; they are used to treat urinary complaints (Herbison, 2007). The seed oil applied as a hair tonic, it is resistant to termite attack (Kondas, 1995).

Botanical Characteristics

Tectona grandis belongs to the kingdom *Plantae*, order, *Lamiates*, family – *Verbenaceae*, *genus-Tectona*. There are three species of *Tectona* namely *grandis, Hamiltonians* and *philipinesis* (Bhat 2003, Herbison, 2007). The name teak is derived from the word THEKKU. Teak is a deciduous, medium-sized to large tree, that is up to 45-55m tall, bole is generally straight and branchlets are up to 20xm. It is up to 150-200cm in diameter at base and has fluted or low buttresses. Teak leaves are decussately opposite, simple, entire, and broadly ovate. Inflorescence consists of clymes arranged in a large terminal panicle up to 70cm long (Bekker, 2004).

Teak trees are well established in the south west but not very common in the north. It is pertinent to examine the survival of the species in such unfavourable condition, since there is presently, global warming due mainly to massive exploitation of forestry resources. *Tectona grandis* though has been studied by many authors (Nwoboshi; 1981, Iyamabo; 1990, Etukudo 2004), there has been no attempt to assess the performance in the presence of drought.

Teak has been chosen for this study because of its good quality as highlighted before now. It is readily available because of its high productivity which makes it attractive as energy source, especially in the area of wood shortage. Teak is also used as telecommunication and transmission poles in developing countries. Consequently, there is a need to ensure the sustainable production of this species whether the climatic conditions are favourable or not.

This paper is to assess the performance of *Tectona grandis* when subjected to water stress with or without fertilizer application.

Materials and Methods

Study Area

The experiment was conducted at the Teaching and Research Farm of the Department of Forestry and Wildlife, Delta State University, Asaba campus, Asaba, Delta State. The University Campus is located between longitude $6^0$49'E and latitude $6^0$14'N. it is a region of moderate rainfall and soil fertility which falls in the rainforest zone of Nigeria. Rainy season is between April and October with a mean annual rainfally of 1,500mm – 1,847.3mm. The distribution is bimodal with peak in July and September and a period of low precipitation in August. The mean temperature is 23.8^0C with a maximum temperature of 37.3^0C.

The area has a mean monthly soil temperature of 100cm depth of 28^0C and monthly sunshine of 48 bars. The temperature is highest in the month of March through May (Meteorological Bulletin, 2004).

Seed and fertilizer Sources

Seeds of *Tectona grandis* were collected from Delta State University, Asaba Campus premises while the Urea fertilizer was purchased from the Delta State Agricultural Development Programme Office, Ibusa, Delta State.

Procedure

Seeds of *Tectona grandis* were initially planted on a bed of 2m x 1m until germination was observed. They were transplanted after two weeks into already prepared polythene pots. A total number of 540 seedlings of teak was used for this experiment. Three levels of urea fertilizer (0.5g. 1.0g and 1.5g) were applied to the seedlings in each polythene pot. This was followed by application of three different watering regimes to these seedlings according to the design. The experiment was a split plot design in a completely randomized design. The main plots were the levels of urea fertilizer while the sub plots were the three different watering regimes. The treatments are nine in all as follows:
W_1, UF_0, W_1UF_1, W_1UF_2, W_2UF_0, W_2UF_1, W_2UF_2, W_3UF_0, W_3UF_1, W_3UF_2.
Where;

W_1 = watering once per week
W_2 = watering three times per week
W_3 = watering every day of the week
UF_0 = 0.5g/10kg
UF_1 = 1.5g/10kg
UF_2 = 2.0g/10kg

The parameters measured were plant height, collar diameter, leaf number and leaf area. Dry matter accumulation was determined at the end of the experiment. The top soil samples were analyzed following the procedure of Jackson (1962).

Soil Analysis

Soil samples were randomly collected from a homogeneous land area within the premises of the Department of Forestry and Wildlife with the help of a soil auger. The soil samples were air-dried and were sieved with 2mm mesh. They were then analyzed for the following physiochemical soil characteristics.

i. Particle size distribution. This was determined by hydrometer method, which allow progressive sedimentation of the various particles within interval using hexameta phosphate as the dispersant.
ii. The soil pH was measured in a 1:1 soil water suspension using glass electrode pH meter.
iii. Organic carbon was determined by wet oxidation procedure.

iv. Total Nitrogen was determined by semi-micro Kjedhal digestion and distribution method.

v. The exchangeable cations was extracted with 1 No. ammonium acetate at pH 7 Na+ and K+ were measured by flame photometer, Mg++ and Ca++ were determined by EDTA titration.

vi. The leaching tube method was used to determine the cation exchange capacity.

vii. Available phosphorus was determined by Bray No. 1.

vii. The percentage base saturation of soil was calculated as % bs -= sum of all base forming cations x $\frac{100}{1}$

Dry Weight Determination

At the end of the experiment seedlings were carefully harvested, immersed in water and the soil was gently removed and the roots carefully rinsed with water to remove the soil particles. The seedlings were separated into roots, stems and leaf components. They were then dried in a Gallen Kamp oven at 80^{o}C for 48 hours. Weighing balance was used to determine the dry matter of the plants.

Results and Discussion

Plant Height

The effect of urea fertilizer on height of teak seedlings is presented in tables 1-3.

Treatment effect of urea fertilizer on plant height was significant ($P<0.05$) from two weeks after transplanting (WAT) to 12WAT. Similar result was also obtained for watering regimes. However, 2.0g of urea fertilizer and daily watering regimes (7/7) influenced plant height more than the rest treatments. The interaction effect was very significant 2.0g of urea fertilizer and daily watering regime elicited the tallest height of 39.81cm at 12 WAT. The lowest height of 14.98cm was given by 0.5g urea and once per week (1/7) watering regime.

Leaf Number

The effect of urea fertilizer on leaf number of teak seedlings is presented in Tables 4-6. Treatment effect of urea fertilizer on leaf number was very negligible ($P>0.05$). At this particular period some of them were turning yellow or experiencing wilting. It was only at 10 WAT that there was a pronounced effect of urea on leaf number. The highest leaf number was 14.67 still produced by 2.0g of urea. The minimum at this time was 12.67 given by 0.5g of urea fertilizer. Effect of watering regimes on leaf number was significantly different ($P<0.05$) as from 2WAT. Seedlings subjected to (7/7) watering regime exhibited greater leaf number than the rest (16.89). similarly urea fertilizer watering

regimes interaction was significant. As expected, seedlings subjected to 2.0g of urea and 7/7 watering regimes produced the highest leaf number (18.00).

Leaf Area

Urea and watering regimes main effects were also significant for leaf area of teak seedlings ($P<0.05$) (Table 9-10) Similar trend was also observed on interaction effect of fertilizer and watering regime on leaf area of teak seedlings. Surprisingly, seedlings subjected to 0.5g of urea fertilizer and daily watering regime exhibited the highest leaf area value of 889.92cm^2 which was far higher the those of 2g and 1.5g of urea fertilizer. At 6-12WAT clogging was observed in some treatments that contained 2g of urea fertilizer.

Collar diameter

The effect of urea fertilizer on collar diameter of teak seedling is as presented in tables 11-13. Treatment effect of urea fertilizer on collar diameter of teak seedlings was not pronounced from 2WAT – 8 WAT. However, significant differences occurred at the last two weeks 2g of urea fertilizer proved superior to the rest treatment by having 1.64mm mean maximum collar diameter. Watering regimes treatment effect was significant ($P<0.05$) throughout the duration of the study, except at 4WAT. Seedlings subjected to daily watering produced higher collar diameter values than the rest (1.91mm). The lowest was given by seedling subjected to once per week watering regime. The interaction effect was also significant except at 4WAT. Seedlings treated with 2.0g of urea fertilizer subjected to daily watering exhibited the greatest collar diameter value (2.32mm).

Similarly, dry weight values were higher for seedlings subjected to daily watering regime and 2.0g of urea fertilizer (Table 14).

Discussion

The results of these experiments indicate that teak can be successfully established in the presence of moisture and nitrogen fertilizer. Maximum seedlings height was recorded when they were subjected to 2.0g of urea fertilizer and daily watering which suggests that introduction of this species to a drought prone area may face serious challenges at the initial stage. However, the treatment effect of the fertilizer on leaf number was very negligible this could be attributable to water stress rather than the ineffectiveness of the fertilizer as also confirmed by Anderson (2000). According to him, Nitrogen is taken up by the plant mainly through its roots as ammonium ion (NH_4+) or as nitrate ions ($N0_5$). In the plant the nitrate is rapidly converted to ammonium which combines with carbohydrates formed during photosynthesis to form aminoacids, and eventually protein. The protein formed causes the leaves to grow and increase their green surface area. The findings in this study with respect to leaf area agreed with the above assertion.

Furthermore, seedlings treated with different rates of urea fertilizer and subjected to watering once per week shows that tallness is not always positively correlated with leaf number production because there were some shorter seedlings which produced more number of leaves than the taller once. This observation is in line with Etukudo *et al* (2004).

There was a gradual increase in collar diameter for all treated seedlings. It was observed that collar diameter increased as height increased. Rapid growth in the height of teak seedlings was accompanied by higher diameter growth. These favourable results can be attributed to the presence of fertilizers as also reported by Simpson (2007), Pritchell (1990), Anderson and Gessel (2008). It is equally true that the seedling growth would have been inhibited if sufficient water was not available. The initial insignificant difference recorded for treatment effect of fertilizer on collar diameter was probably due to inadequate moisture supply to the plants.

Conclusion

It is inferred from this study that *Tectona grandis* require sufficient moisture and fertilizer application for good growth and development. The insignificant differences recorded in collar diameter, leaf number and leaf area with regards to treatment effect could be a source of encouragement. The implication is that teak seedling, establishment in water stressed is a possibility; however, the seedling growth may be stunted, defoliation may be prevalent and if the selection continues indefinitely, it will lead to mortality. Nevertheless, the important lessons to be learned here in view of the urgent need to promote tree planting which will eventually mitigate the effect of desertification and global warning is that provision must be made for irrigation if proper establishment of teak is to be guaranteed.

Overall, from a practical stand point, effort should be concentrated on identifying species that are capable of withstanding water-stress for reforestation purposes in the drier climate of Nigeria.

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Table 1: Effect of urea fertilizer on plant height (cm) of teak seedlings

Treatment	Weeks after transplanting (WAT)					
fertilizer level	2	4	6	8	10	12
2g	11.74[a]	14.70[a]	20.41[a]	24.31[a]	27.36[a]	30.41[a]
1.5g	11.23[b]	13.60[b]	17.58[b]	25.91[b]	25.06[b]	27.23[b]
0.5g	9.86[c]	12.02[c]	15.17[c]	17.29[c]	21.61[c]	23.17[c]
LSD	0.19	0.81	1.13	0.44	0.70	0.96

Mean of the same column with different letters are significantly different at ($P<0.05$) using LSD.

Table 2: Effect of watering regimes on plant height (cm) of teak seedlings

watering regimes days of weekly watering	Weeks after transplanting (WAT)					
	2	4	6	8	10	12
A	10.64	11.43^{c}	13.01^{c}	13.73^{c}	14.50^{c}	14.98^{c}
B	10.93	13.61^{b}	19.03^{b}	22.66^{b}	29.11^{b}	33.51^{b}
C	11.26	15.08^{a}	21.11^{a}	26.12^{a}	30.41^{a}	34.61
LSD	0.16	0.32	0.38	0.38	0.34	0.36

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 3: Interaction effect of urea application rate and watering regimes

Treatment fertilizer levels/watering regimes	**Weeks after transplanting (WAT)**					
	2	**4**	**6**	**8**	**10**	**12**
2g + A	11.50^{bc}	12.33^{d}	13.20^{g}	14.17^{g}	14.83^{e}	15.03^{c}
2g + B	11.70^{b}	14.76^{bc}	23.03^{b}	27.63^{b}	32.33^{a}	37.02^{b}
2g + C	12.03^{a}	17.10^{a}	25.00^{a}	31.13^{a}	14.90^{e}	39.81^{a}
1.5g + A	10.90^{b}	11.23^{e}	12.67^{g}	13.33^{g}	14.50^{e}	15.00^{e}
1.5g + B	11.33^{c}	14.10^{c}	19.23^{d}	23.17^{d}	30.00^{c}	31.82^{c}
1.5g + C	11.47^{bc}	15.47^{b}	20.8^{bc}	26.23^{c}	30.67^{c}	34.62^{c}
0.5g + A	9.53^{f}	11.33^{e}	13.17^{g}	14.17^{e}	14.17^{e}	14.98^{e}
0.5g + B	9.y77^{f}	12.07^{de}	14.83^{f}	17.17^{f}	25.00^{d}	26.81^{d}
0.5g + C	10.27^{e}	12.67^{d}	17.50^{e}	21.00^{e}	25.67^{d}	27.10^{d}
LSD	0.26	0.82	1.11	0.62	0.74	0.80

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 4: Effect of urea fertilizer on leaf number of teak seedlings

Fertilizer levels	**Weeks after transplanting (WAT)**					
	4	**6**	**8**	**10**	**12**	
2g	7.33^{a}	10.44^{a}	13.78^{a}	13.78^{a}	14.67^{a}	13.06^{a}
1.5g	6.44^{a}	9.56^{a}	12.78^{a}	12.67^{a}	13.11^{a}	13.56^{a}
0.5g	6.89^{a}	10.00	12.44^{a}	12.03^{a}	12.67^{a}	12.89^{a}
LSD	ns	ns	ns	ns	1.82	ns

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 5: Effect of watering regimes on leaf number of teak seedlings

watering regimes day of weekly watering	Weeks after transplanting (WAT 2	4	6	8	10 12
A	6.00[b]	8.89[c]	11.00[c]	10.89[c]	9.33[c]	7.78[c]
B	7.11[a]	10.00[b]	13.22[b]	13.11[b]	[14.89]b	15.33[b]
C	7.56[a]	11.11[a]	14.78[a]	14.44[a]	16.22[a]	16.89[a]
LSD	0.56	1.01	0.94	0.79	1.05	0.97

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 6: Effect of urea fertilizer and watering regimes on leaf number of teak seedlings (Interaction)

Treatment urea fertilizer regimes	Weeks after transplanting (WAT) 2	4	6	8	10	12
2g + A	6.00[b]	9.33[c]	11.67[b]	11.33[c]	10.00[c]	8.00[d]
2g + B	8.00[a]	10.00[bc]	14.00[ab]	14.00[ab]	16.00[ab]	16.00[b]
2g + C	8.00[a]	12.00[a]	15.67[a]	16.00[a]	18.00[a]	18.00[a]
1.5g + A	6.00[b]	8.67[c]	10.67[b]	10.67[c]	8.67[c]	8.00[d]
1.5g + B	6.00[b]	10.00[bc]	13.00[b]	13.33[b]	14.67[b]	16.00[b]
1.5g + C	7.33[ab]	10.00[bc]	14.67[ab]	14.00[ab]	16.00[ab]	16.67[ab]
0.5g + A	6.00[b]	8.67[c]	10.67[b]	10.67[c]	9.33[c]	8.67[d]
0.5g + B	7.33[ab]	10.00[bc]	12.67[b]	12.00[bc]	14.00[b]	14.00[c]
0.5g + C	7.33[ab]	11.33[ab]	14.00[ab]	13.33[b]	14.67[b]	16.00[b]
LSD	1.62	7.90	2.30	1.79	2.05	1.50

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 7: Effect of urea fertilizer on leaf area of teak seedlings

Treatment fertilizer levels	Weeks after transplanting (WAT) 2	4	6	8	10	12
2g	32.29[a]	63.39[a]	112.33[b]	109.24[c]	133.26[c]	229.42[c]
1.5g	31.64[a]	63.21[a]	100.53[c]	167.85[b]	223.36[b]	345.4[b]
0.5g	30.78[b]	61.55[b]	123.20[a]	246.28[a]	360.27[a]	533.68[a]
LSD	0.66	1.00	1.00	7.39	22.54	39.54

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 8: Effect of watering regimes on leaf area of teak seedlings

watering regimes days weekly watering	Weeks after transplanting (WAT) 2	4	6	8	10	12
A	30.40[c]	59.91[c]	105.56[c]	142.00[c]	101.77[c]	87.75[c]
B	31.17[b]	62.06[b]	109.59[b]	184.74[b]	252.88[b]	376.83[b]
C	33.14[a]	66.28[a]	120.91[a]	196.63[a]	362.29[a]	643.95[a]
LSD	0.73	1.24	0.38	3.99	17.44	32.67

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 9: Effect of fertilizer and watering regimes on leaf area of teak seedlings (Interaction)

Treatment fertilizer levels/ watering regimes	Weeks after transplanting (WAT) 2	4	6	8	10	12
2g +A	29.50[c]	56.33[e]	101.28[f]	95.62[e]	96.83[g]	81.40[g]
2g + B	31.34[b]	61.75[cd]	105.26[e]	107.45[d]	146.23[e]	292.47[e]
2g + C	36.04[a]	72.08[a]	130.43[c]	124.65[c]	156.73[d]	313.45[d]
1.5g + A	31.13[b]	62.27[c]	93.06[g]	85.64[f]	85.97[h]	81.40[g]
1.5g + B	31.50[b]	63.10[c]	100.69[f]	201.49[c]	151.25[d]	226.28[f]
1.5g + C	32.38[b]	64.55[b]	107.85[d]	216.43[c]	432.87[c]	728.67[b]
0.5g + A	30.57[b]	61.13[d]	122.35[b]	244.73[a]	122.37[f]	99.55[g]
0.5g + B	30.66[b]	61.32[cd]	122.81[b]	245.28[a]	461.15[b]	611.76[c]
0.5g + C	31.10[b]	62.20[c]	124.43[a]	248.82[a]	497.29[a]	889.92[a]
LSD	1.13	1.88	0.97	8.09	29.64	65.20

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 10: Effect of urea fertilizer on collar diameter (cm) of teak seedlings

Treatment fertilizer levels	Weeks after transplanting (WAT) 2	4	6	8	10	12
2g	0.33[a]	3.93[a]	0.57[a]	0.74[a]	1.47[a]	1.64[a]
1.5g	0.32[a]	0.37[a]	0.59[a]	0.71[a]	1.32[b]	1,51[b]
0.5g	0.25[b]	0.37[a]	0.52[a]	0.70[a]	0.78[c]	0.98[c]
LSD	0.032	ns	ns	ns	0.057	0.234

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 11: Effect of watering regimes on collar diameter of teak seedlings

watering regimes days of watering weekly	Weeks after transplanting (WAT) 2	4	6	8	10	12
A	0.24[c]	3.82[a]	0.42[c]	0.57[b]	0.61[c]	
B	0.30[b]	0.37[a]	0.61[b]	0.78[a]	1.41[b]	
C	0.36[a]	0.49[a]	0.66[a]	0.8[a]	1.56[a]	
LSD	0.029	ns	0.049	0.06	0.037	

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 12: Effect of urea fertilizer and watering regimes on collar diameter of teak seedlings

Treatment Urea fertilizer watering regimes	Weeks after transplanting (WAT) 2	4	6	8	10	12
2g +A	0.24[c]	0.087[a]	0.40[c]	0.52[c]	0.58[c]	0.63[c]
2g + B	0.35[b]	0.40[a]	0.60[ab]	0.85[a]	1.90[a]	1.97[b]
2g + C	0.40[a]	0.54[a]	0.70[a]	0.86[a]	1.93[a]	2.32[a]
1.5g + A	0.26[c]	0.29[a]	0.42[c]	0.52[c]	0.57[c]	0.61[c]
1.5g + B	0.32[b]	0.36[a]	0.66[ab]	0.77[ab]	1.50[b]	1.63[c]
1.5g + C	0.37[ab]	0.46[a]	0.71[a]	0.84[a]	1.90[a]	2.28[b]
0.5g + A	0.22[c]	0.29[a]	0.43[c]	0.68[b]	0.67[d]	0.72[c]
0.5g + B	0.22[c]	0.36[a]	0.56[b]	0.71[b]	0.83[c]	1.09[d]
0.5g + C	0.31[b]	0.40[a]	0.57[b]	0.71[b]	0.84[c]	1.13[d]
LSD	0.044	ns	0.122	0.099	0.068	0.37

Mean of the same column with different letters are significantly different at (P<0.05) using LSD.

Table 13: Result of initial pre-planting soil analysis

Soil characteristics determined	Value obtained
Particle size distribution (%)	
Sand	76
Silt	15
Clay	9
Textural class	**Loam sand**
Soil pH (H_2O)	5.78
Organic matter (gkg^{-1})	24
Total N (gkg^{-1})	1.80
Available P ($mgkg^{-1}$)	7.70
Exchangeable cation ($cmol/kg^{-1}$)	

Ca^{+}	5.30
Mg^{++}	1.70
K^{+}	0.10
Na^{+}	0.04
CEC ($cmol/kg^{-1}$)	12.76
%BS	56.20

Table 14: Mean dry weights of teak seedlings as influenced by Urea fertilizer

Sample	Mean value (g)
Leaves	34.53a
Stem	24.12b
Root	14.03c
LSD	1.00

Means of the same letters are not significantly different at P=0.05