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# COMPARATIVE EFFECTS OF SEASONALLY COLLECTED WATER SAMPLES FROM AWBA LAKE, IBADAN, ON THE AERIAL GROWTH OF *Ceiba pentandra, Linn F.*

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## ABSTRACT

Water samples were collected at the end of every quarter from Awba Lake, University of Ibadan, Southwest, Nigeria between December 2002 and December 2004 and chemically analysed for species which constitute plant nutrient. 200mls of each of these (treatments) was respectively added to nine polypots, each containing 1.4kg washed and sterilized river sand. To a tenth pot the control, was no water sample (treatment) but soil added. Each pot was replicated three times. A week old *Ceiba pentandra* seedlings was planted into each pot. The experiment was laid in a completely randomised design. Growth measurements were taken every two weeks for three months. The plants were then respectively transferred into larger poly pots on an open field and observed for the same period. Analysis of variance, followed by Duncan's Multiple Range Test at 95% probability showed (1) at the greenhouse stage (20 weeks after planting) there were no significant differences among the treatments for root collar diameter (RCD) but in the height, the control treatment was less than S04 (September 2004 ) and D03 (December 2003) water sample. For number of leaves, the control and S03 (September 2003) were lower than D03 but not different from other treatments (2) on the field (32 weeks after planting), for each of shoot length, RCD and leaf fresh weight, there were no differences. There were shoot dry weight, shoot fresh weight and leaf dry weight, respectively. For shoot dry weight: DO4, DO3 and control were not greater than other treatments except MO3 (March 2003). In the leaf dry weight, control was significantly greater than MO3 but not others. Finally, averages of most responses of *Ceiba pentandra* December was greater than June > September > March water samples, within the limits of the fertility of the soils used.

**Keywords:** Water samples, plant nutrients, treatments, greenhouse, river sand, field, field soil.

## INTRODUCTION

According to the law of conservation of matter, (Encyclopedia Britannica, 1975), plants grow better on soils that are richer in plant nutrients. Hence, many commercial nurseries apply plant nutrients to tree seedlings in form of fertilizers, manures or other materials containing any of these. Limitation to forestry and agricultural productivity of many developing nations like Nigeria can be traceable to problems of fertilizer cost, required variety and distribution (Sobulo, 2000).

Many water bodies have been known to be recipient of anthropogenic materials, especially water soluble ones, from our environment. Hence fertilizer elements have often been found as wastes and pollutants in surface waters (FAO, 1990, Brady and Weil, 1996; Aminuddin*et al.*, 2000). An attempt to use water containing hydro-chemicals as nutrient sources has not been common. However, Terry and Tate (1981) applied municipal waste water to crops. As trees meant for timber and pulp are not likely to be devalued by hydro-chemicals which may be toxic to humans, fear of unpredictable levels of such materials in irrigation waters or watering sources may not arise.

*Ceiba pentandra* is (fast growing) softwood which finds its use in construction and household works, hence, its use as test plant in this nutrient recycling study. Scanty information still exists on the composition and effect of our inland waters, in Nigeria, on planted crops. However, Agbola (1991) investigated the textural and mineralogical compositions of sediments along stream channels within the University of Ibadan. Oben (1999) observed the biotic and abiotic constituents of three lakes in Ibadan; she found significantly higher levels (at $p \geq 95\%$) of $CO_2$, Mn, and Fe in Awba lake (University of Ibadan) while Main Lake and the Golf Lake (both at the International Institute of Tropical Agriculture Moniya, Ibadan.) were higher in Mg and Cu. Temowo (2003), conducted a point assessment of hydro chemical properties such as pH, Electrical Conductivity (EC), N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn, B, Br, Ba, Pb, Ag, Cd, As, Co, Hg, Au, Mo, Sc, Se and U of Awba Lake, University of Ibadan, Ibadan. Similarly, Ajiboro (2006) observed the pH, Total Dissolved Solids (TDS), Electrical Conductivity, Ca, Na, K, Al, Fe, Mn, V, Sr, Ba, Cu, Zn, Co and V levels in the Main and Feeding Streams of Eleyele Lake, Ibadan, with a view to determining their health impacts on human consumption. The study was, therefore, investigated the effect of seasonally collected Awba Lake water samples on the growth of *Ceiba pentandra Linn F.*

## MATERIALS AND METHODS

### STUDY AREA

### Water Sample Source

Awba Lake is a freshwater habitat located at the south-western end of the University of Ibadan at an altitude of 209 meters above sea level. It has a surface area of about 6 hectares with a maximum depth of 5.5m (Oben 1999).

**Soil Sampling/Experimental Site**

Forestry Research Institute of Nigeria Jericho Hill, Ibadan is located on Longitude $3^0$ 51' E and Latitude $7^0$ 23'N. The area falls under the rainforest zone. The soil, according to USDA (1978) is regarded as an 'Alfisol'. The vegetation is dominated by forest species of trees such as shrubs like *Gliricida sepium, Leucaena leucocephala* and grasses *Chromolaena odorata, Panicum Spp, Andropogo Spp*, The rainfall is bimodal, usually with a break between August and September.

Water samples were collected using a plastic bottle from five points at approximately 7m apart along the southern bank of the Awba Lake (located at a southern axis of the University of Ibadan, Ibadan) for each of nine months: December 2002 (D02), March 2003 (M03), June 2003 (J03), September 2003 (S03), December 2003 (D03), March 2004 (M04), June 2004 (J04), September 2004 (S04) and December 2004 (D04). These were stored in the refrigerator before physico-chemical analysis (Table 1) at the Analytical Laboratory of the Institute of tropical Agriculture (IITA) Moniya, Ibadan. 200$cm^3$ of each sample was applied respectively to 9 poly pots. In the greenhouse, the estimated rate of growth (EGR) per week was calculated as one – eighth value of the difference in a parameter between growth at 20 weeks after planting and that at 12 weeks after planting while the growth rate on the field was one – twelfth value of the difference in a parameter between growth at 32 weeks after planting and that at 20 weeks after planting. The experiment was laid down in a Completely Randomized Design involving 10 treatments (quarterly water samples and a control) with three replicates.

A tenth poly pot was similarly prepared but with no water sample added, to serve as a control. Each pot was replicated three times. The pots were then transferred into the greenhouse and watered to field capacity and left overnight to equilibrate. The resulting 30 poly pots were randomly planted seedling of *Ceiba pentandra* L. which had been grown for about a week in germination trays using washed and sterilized river sand. Leaching was

**Table 1: Selected Physico-chemical Properties of Awba Lake, University of Ibadan water Samples (collected quarterly from December 2002 to December 2004).**

| Chemical Properties | WATER SAMPLE CODE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **D02** | **M03** | **J03** | **S03** | **D03** | **M04** | **J04** | **S04** | **D04** |
| Nitrate(mg/L) | 2.56 | 5.7 | 20.31 | 9.02 | 7.21 | 9.38 | 15.29 | 10.89 | 14.63 |
| Phosphate(mg/L) | 0.01 | 0.07 | 0.17 | 0.01 | 0.03 | 0.07 | 0.29 | 0.14 | 0.13 |
| Potassium(mg/L) | 6.33 | 8.38 | 7.51 | 8.38 | 8.38 | 9.51 | 19.8 | 10.7 | 10.7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Calcium(mg/L) | 18.06 | 19.63 | 21.01 | 19.83 | 19.83 | 23.56 | 32.62 | 20.13 | 21.72 |
| Magnesium(mg/L) | 4.67 | 5.39 | 5.63 | 4.67 | 4.67 | 6.19 | 6.94 | 6.07 | 6.31 |
| Sodium(mg/L) | 3.2 | 7.04 | 7.99 | 6.57 | 5.93 | 8.07 | 7.84 | 5.61 | 8.7 |
| Copper(mg/L) | 0.02 | 0.01 | 0 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 |
| Zinc(mg/L) | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.02 |
| Iron(mg/L) | 1.05 | 0.56 | 1.54 | 1.86 | 1.13 | 1.21 | 1.13 | 0.97 | 1.05 |
| Manganese(mg/L) | 0.02 | 0.08 | 0.08 | 0.03 | 0.03 | 0.08 | 0.08 | 0.16 | 0.08 |
| Lead(mg/L) | 0.16 | 0.16 | 0.26 | 0.16 | 0.16 | 0.26 | 0.16 | 0.16 | 0.26 |
| Conductivity(µs) | 0.22 | 0.26 | 0.24 | 0.24 | 0.23 | 0.32 | 0.35 | 0.29 | 0.31 |

**D02 = December 2002, M03 = March 2003, J03 = June 2003, S03 = September 2003, D03 = December 2003, M04 = March 2004, J04 = June 2004, S04 = September 2004, D04 = December 2004.**

prevented by supporting each pot (being made up of polythene with small perforations on it) at the bottom with a plastic dish of height 4cm and mean cross-sectional area 162.8cm$^2$ (top, 254.6 and bottom, 70.9cm$^2$). Growth parameters of plant height, root collar diameter and number of leaves were assessed fortnightly from 10 to 20 weeks after planting.

The *Ceiba petandra* were transferred to the field within bigger pots (black polybags of approximate height 25cm and mean cross-sectional area 201cm$^2$ each containing approximately 9kg of soil (*Alfisol* from FRIN) whose selected physico-chemical characteristics are shown in Table 2. These were placed on a field of 30m x 30m in the FRIN arboretum (open forest field) at 3m x 3m spacing and arranged in a completely randomized design (CRD) with 3 replicates.

**Table 2: Selected hydrochemical characteristics of soils used in the study.**

| **Property** | **Value** | |
|---|---|---|
| | **Washed and Sterilized River sand** | **Alfisol from FRIN Arboratum** |
| pH | 6.5 | 6.80 |
| Organic carbon (%) | 0.28 | 1.39 |
| Nitrogen (%) | 0.008 | 0.14 |

| | | |
|---|---|---|
| Available P(mehlic)(mg/kg soil) | 11.88 | 13.84 |
| Exchangeable k (cmol/kg soil) | 0.09 | 0.54 |
| Exchangeable Ca (cmol/kg soil) | 1.24 | 4.36 |
| Exchangeable Mg (cmol/kg soil) | 0.19 | 1.39 |
| Exchangeable acidic (cmol/kg soil) | - | 0.00 |
| ECEC | - | 6.55 |
| Micronutrient Zn (mg/kg soil) | - | 3.61 |
| Micronutrient Cu (mg/kg Soil) | - | 4.88 |
| Micronutrient Mn (mg/kg Soil) | - | 101.50 |
| Micronutrient Fe (mg/kg Soil) | | 13.72 |

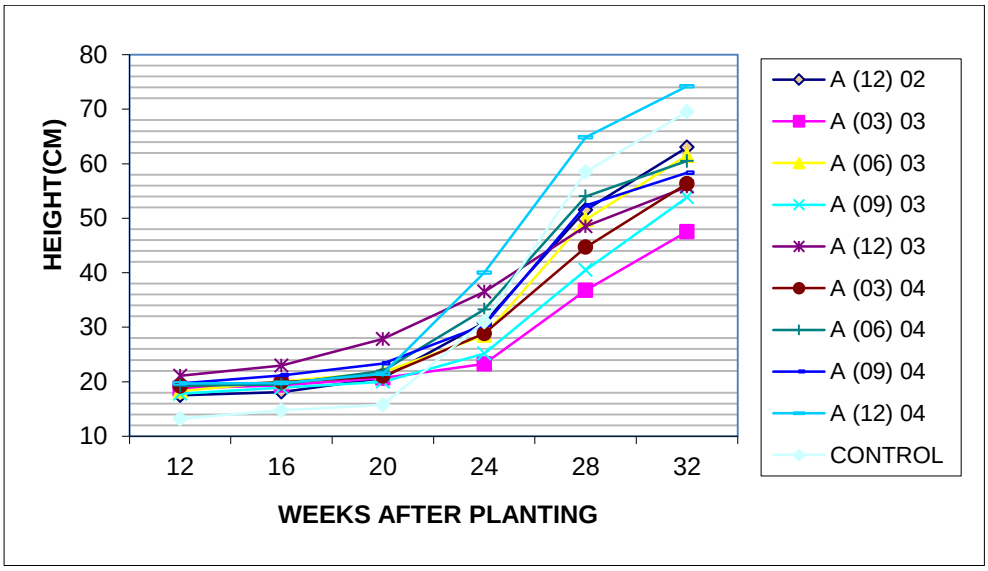
The plants were watered from a nearby stream whose selected chemical properties are stated in Table 3. As in the greenhouse, fortnightly growth characteristics of plant height, root collar diameter and number of leaves were taken six times; the Fresh Bole Volume Factor (FBVF = Height x square of diameter) were subsequently calculated for each plant. The plants were harvested after 12 weeks of growth. The fresh weight of stem and leaves were taken. Oven drying at $75^0$c for about 48 hours was carried out in the first week of harvesting, after which shoot and leaf dry weights measurements were carried out.

**Table 3: Selected chemical properties of stream water obtained from Forestry Research Institute of Nigeria, Ibadan.**

| ***Property*** | **Value** |
|---|---|
| pH | 6.8 |
| N03(mg/L) | 32.44 |
| P04(mg/L) | 0 |
| K(mg/L) | 6.95 |

## RESULT AND DISCUSSION

The observed variation in plant height, root collar diameter and number of leaves in the greenhouse (10 to 20 weeks) and on the field (20 to 32 weeks after planting) are summarized in Figures 1 – 3.



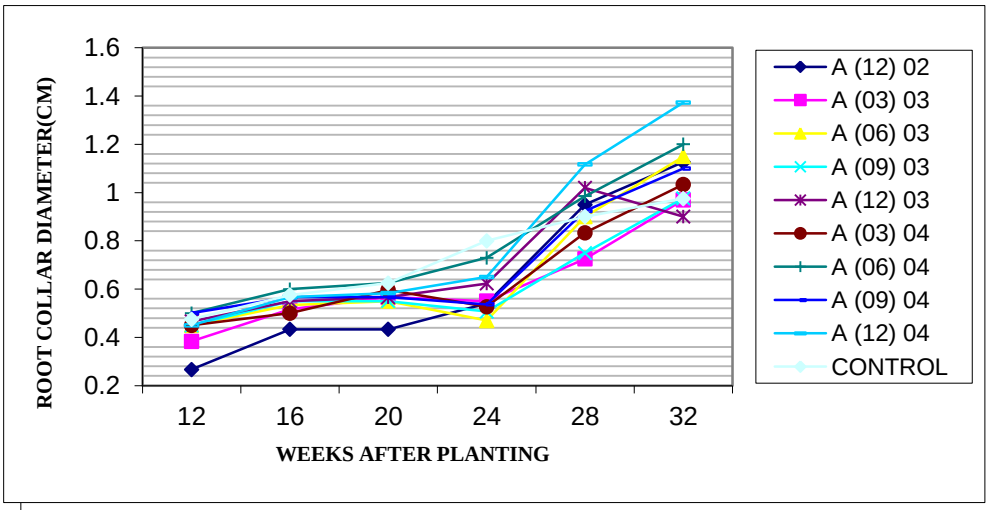

**A(12)02 = D02 , A(03)03 = M03, A(06)03 = J03, A(09)03 = S03, A(12)03 = D03, A(03)04 = M04, A(06)04 = J04, A(09)04 = S04, A(12)04 = D04.**

**Fig 1: Effects of different water samples on the Height of *C pentandra*.**

### Plant Height

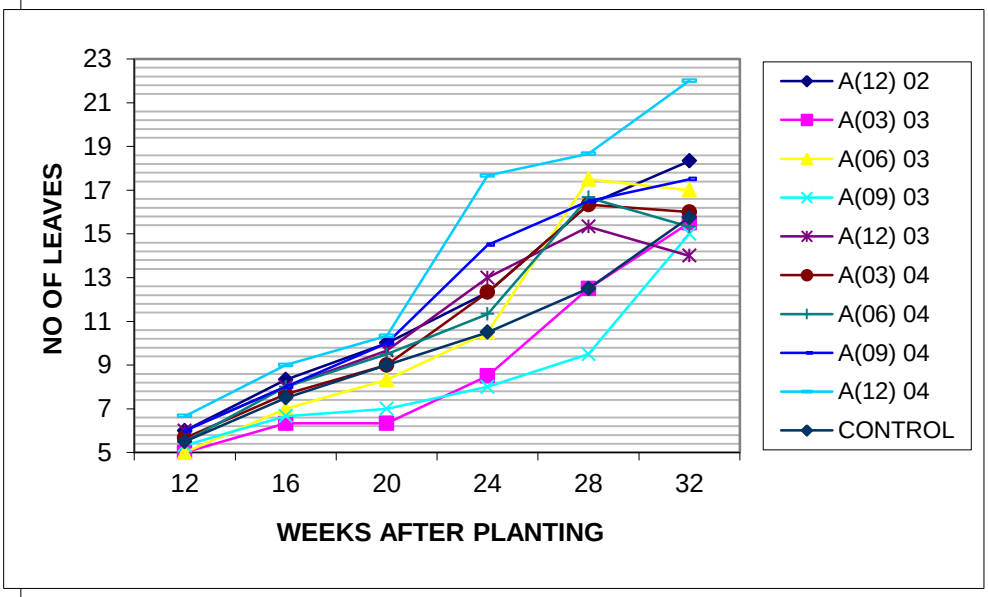
In the greenhouse, DO3 which had, comparatively, one of the least sodium and about average concentration of other elements but with one of the least conductivity levels (Table 1) produced the fastest growth rate (EGR, 0.84m). It was followed by S04 (0.45cm), and J03 (0.43cm) per week. The least was D04 with 0.21cm per week (Figure 1).

On the field DO4 which had some of the highest values of the primary and secondary plant nutrients but lowest levels of some micronutrients (Zinc and iron) (Table 1), together with




**A(12)02 = D02 , A(03)03 = M03, A(06)03 = J03, A(09)03 = S03, A(12)03 = D03, A(03)04 = M04, A(06)04 = J04, A(09)04 = S04, A(12)04 = D04.**

**Fig 2: Effects of different water samples on Root Collar Diameter of *C pentandra***




**A(12)02 = D02 , A(03)03 = M03, A(06)03 = J03, A(09)03 = S03, A(12)03 = D03, A(03)04 = M04, A(06)04 = J04, A(09)04 = S04, A(12)04 = D04.**

**Fig 3: Effects of different water samples on the Number of Leaves of *C pentandra*.**

control (which, like other treatments, on the field soil (Table 2)), produced EGR of 4.40cm and 4.48cm respectively of increase in height per week.This was followed by D02 which contained lower levels of most elements, had EGR of 3.53cm per week. The least, 2.3 cm per week was produced by M03which contained some of the lowest levels of the most essential plant nutrient (Figure 1).

### Root collar Diameter

In the greenhouse, M03, with moderately higher exchangeable bases (K, Ca and Mg) produced the highest EGR (0.024cm) increase in root collar diameter. This was followed by D02 (EGR, 0.02cm. The least was S04 (EGR, 0.009cm).

On the field, the plant treated with DO2, which was probably more favoured as a result of having about the lowest concentration of plant nutrient sand thus having a lower risk of being

inhibited by increased micronutrient levels in this new environment (Davis *et al.*, 1993)had the highest EGR of 0.072cm per week. This was followed by D04 (EGR, 0.066cm) and J03 (EGR, 0.048cm). The least was D03 (EGR, 0.028cm per week).

## Number of Leaves

In the greenhouse, each of D02, J04 and S04 recorded EGR of 0.50. These were followed by D03 and control which had EGR of o.46 and 0.44 respectively. The least was EGR of 0.16 per week, recorded by M03.

On the field, D04 produced the highest increase in number of leaves of 0.96 per week. This was followed by M03 (0.77) and J03 (0.73), D02, S03 and S04 which were approximately 0.7 per week. The least was by D03 which gave 0.47 per week.

## Cumulative Growth Responses

Consequent to the observed rate of growth, the order of treatments that showed most prominent mean responses were summarized in Tables 4, 5 and 6. As at the end of greenhouse experiment (20 weeks after planting) was for: (1) Height, DO3 (27.8) > SO4 (23.3) > JO4 (22.0 cm); Control, C (15.8cm) was the least. (2) RCD, C (0.625) > JO4 (0.62) > DO4 (0.60) cm. (3) Number of leaves, DO4 (10.3) > SO4 and DO2 (10.0 each); C (5.0) was the least. On the field (32 WAP), result showed for: (1) Height DO4 (74.2) > C (69.5) > DO2 (63.0 cm); the least was MO3 (47.5 cm). (2) RCD: DO4 (1.37) > C (1.28) > JO4 (1.20 cm); DO3 (0.96cm) was the least. (3) Number of leaves: DO4 (22.0) > DO2 (18.0) > SO4 (17.5); the least was SO3 (15.0). At harvest (32WAP), the order was for: (1) Shoot Fresh Weight, D03 > D04 > C (Control); M03 being the least. (2) Shoot dry weight: D04 > D03 > C; M03 being the least. (3) Shoot Length: D03 > D04 > C; D02 being the least. `(4) Leaf Fresh Weight: C > D04 > D03; J04 being the least. (5) Leave Dry Weight: C > D04 > J03; M03 being the Least (Table 8).

## Fresh Bole Volume Factor

Further on the response of *C. pentandra* to treatment water samples, a growth index, Fresh Bole Volume Factor (FBVF), which was taken as the product of the plant height and square of root collar diameter, was calculated for all treatments, At the greenhouse stage, D03 which contained about the highest levels of the primary, secondary and micronutrients (Table 1) produced the highest FBVF (Table 4) but the control, the lowest. At the field stage, however, D04, which contained one of the highest levels of primary nutrients but lowest levels of Zn and Fe produced the highest FBVF, 142.0cm$^3$ (Davis *et al.*, 1993). The control was next but less in rank. The high fertility level of the

field soil might be a reason for the control's performance; the order relative to some of the treatments was DO4 (142.0) > C (107.7) > JO4 (84.7cm3); SO3 (41.1cm3) was the least.

**Table 4: Effect of water sample on C pentandra after 12 weeks in the Greenhouse and field respectively.**

| S/N | Treatment Code | Mean Shoot Growth Characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Height (cm) | | Root Collar Diameter(cm) | | Fresh Bole Volume Factor ($cm^3$) | | No. of Leaves | |
| | | Greenhouse | Field | Greenhouse | Field | Greenhouse | Field | Greenhouse | Field |
| 1 | D02 | 20.8 | 63 | 0.517 | 1.27 | 5.8 | 84.5 | 10 | 18.3 |
| 2 | M03 | 21.5 | 47.5 | 0.55 | 0.97 | 6.5 | 54 | 6.3 | 15.5 |
| 3 | J03 | 21.7 | 61.5 | 0.533 | 1.15 | 6.3 | 72.7 | 8.3 | 17 |
| 4 | S03 | 19.5 | 53.8 | 0.55 | 0.96 | 5.8 | 41.1 | 7 | 15 |
| 5 | D03 | 27.8 | 55.8 | 0.567 | 0.96 | 8.6 | 84 | 9.7 | 14 |
| 6 | M04 | 21 | 56.3 | 0.533 | 1.03 | 6.2 | 63.8 | 9 | 16 |
| 7 | J04 | 22 | 60.5 | 0.617 | 1.2 | 8.4 | 87.4 | 9.5 | 15.3 |
| 8 | S04 | 23.3 | 58.3 | 0.583 | 1.1 | 7.9 | 80.8 | 10 | 17.5 |
| 9 | D04 | 21.4 | 74.2 | 0.6 | 1.37 | 7.7 | 142 | 10.3 | 22 |
| 10 | Control | 15.8 | 69.5 | 0.625 | 1.28 | 5.7 | 107.7 | 9 | 15.8 |

**D02 = December 2002, M03 = March 2003, J03 = June 2003, S03 = September 2003, D03 = December 2003, M04 = March 2004, J04 = June 2004, S04 = September 2004, D04 = December 2004.**

**Table 5: Comparative effect of water sample on C pentandra after 12 weeks in the Greenhouse and field respectively.**

| Location | S/N | Growth Characteristics | Treatment Position in Magnitude of Response | | | |
|---|---|---|---|---|---|---|
| | | | 1st | 2nd | 3rd | 10th (Least) |
| Greenhouse | 1 | Height | D03[27.8cm] | S04[23.3cm] | J04[22.0cm] | Control[15.8cm] |
| | 2 | RCD | Control[0.625cm] | J04[0.616cm] | D04[0.6cm] | D02[0.517cm] |
| | 3 | NL | D04[10.3] | S04,d02[10.0] | D03[9.7] | Control[5.0] |
| Field | 1 | Height | Do4[74.2cm] | Control[69.5] | J03[61.5] | M03[47.5] |
| | 2 | RCD | D04[1.37cm] | J04[1.20cm] | J03[1.15cm] | D03[0.90] |
| | 3 | NL | D04[22.0] | D02[18.3] | S04[17.5] | D03[14.0] |

**RCD = Root Collar Diameter, NL=No of Leaves. The mean values are shown in the brackets.**

**Table 6: Comparative effect of different water sample on C.pentandra with 12 weeks of field study.**

| S/N | Growth Characteristics | Treatment Position in Magnitude of Response | | | |
|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 10th(Least) |
| 1 | SFW | D03[52.4g] | D04[51.6g] | Control[41.6g] | M03[19.1g] |
| 2 | SDW | D04[14.0g] | D03[13.5g] | Control[11.6g] | M03[4.2g] |
| 3 | SL | D03[76.7cm] | D04[75.8cm] | Control[65.8cm] | D02[45.5g] |
| 4 | RCD | G04[1.37cm] | Control[1.28cm] | J04[1.2cm] | S03,d03, [0.96cm] |
| 5 | LFW | D04[33.6g] | D03[27.6g] | Control[25.4g] | J04[12.5g] |
| 6 | LDW | C[9.7g] | J03[8.6g] | D03[7.9g] | M03[3.9g] |

**SFW = Shoot Fresh Weight, SDW = Shoot Dry Weight, SL = Shoot Length, RCD = Root Collar Diameter, LFW = Leaf Fresh Weight, LDW = Leaf Dry Weight. The mean values are shown in the brackets.**

Analysis of variance, followed by Duncan's Multiple Range Test at 95% probability showed: (1) at the greenhouse stage (20 weeks after planting; Table 7), there were no significant differences among the treatments for root collar diameter (RCD) but in the height, the control treatment was less than S04 (September 2004) and D03 (December 2003) water sample .For number of leaves, the control and S03 were lower than D03 but not different from other treatments**.** (2) On the field (32WAP; Table 8), there were no significant differences between the treatments means for each of shoot length, root collar diameter and leaf fresh weight of *C. pentandra*. However, there were for shoot fresh weight, shoot dry weight and leaf dry weight, respectively.In the shoot fresh weight D03 (52.4g), the highest, was not significantly different from D04 (51.6g), the second highest as well as between other treatments except MO3 (19.0g). Similarly, in the shoot fresh weight, D04 (14.0g) was not significantly different from DO3 (13.5g) but not different from others except M03 (4.2g). The leaf dry weight of control (9.7g), the highest was not significantly different from other except M03 (3.9g). There were generally no significant differences for shoot length, root collar diameter, number of leaves.

**TABLE 7: Follow up test of ANOVA on effect of different water sample on C.pentandra with 12 weeks of greenhouse study.**

| S/N | Water Sample | NL | Diameter(cm) | Height(cm) |
|---|---|---|---|---|
| **1** | D04 | 10.333$^{a}$ | 0.60000$^{a}$ | 21.4333$^{abc}$ |
| **2** | S04 | 10.000$^{a}$ | 0.58333$^{a}$ | 23.333$^{ab}$ |
| **3** | D02 | 10.000$^{a}$ | 0.51667$^{a}$ | 20.667$^{bc}$ |
| **4** | D03 | 9.667$^{a}$ | 0.56667$^{a}$ | 27.833$^{a}$ |
| **5** | J04 | 9.500$^{a}$ | 0.61667$^{a}$ | 22.000$^{abc}$ |
| **6** | M03 | 9.00$^{a}$ | 0.53333$^{a}$ | 21.000$^{abc}$ |
| **7** | J03 | 8.33$^{ab}$ | 0.53333$^{a}$ | 21.667$^{abc}$ |
| **8** | M04 | 6.33$^{bc}$ | 0.55000$^{a}$ | 21.500$^{abc}$ |
| **9** | S03 | 5.500$^{c}$ | 0.55000$^{a}$ | 19.500$^{bc}$ |
| **10** | Control | 5.000$^{c}$ | 0.62500$^{a}$ | 15.750$^{c}$ |

**D02 = December 2002, M03 = March 2003, J03 = June 2003, S03 = September 2003, D03 = December 2003, M04 = March 2004, J04 = June 2004, S04 = September 2004, D04 = December 2004. Mean with the same superscript alphabets are not signicantly different at P ≤ 0.05.**

**TABLE 8: Follow up test of ANOVA on effect of different water sample on C.pentandra with 12 weeks of field study.**

| S/N | Treatment Water Sample | Growth Characteristics | | | | | |
|---|---|---|---|---|---|---|---|
| | | SL(cm) | SFW(g) | SDW(g) | RCD(cm) | LFW(g) | LDW(g) |
| **1** | D04 | 75.80$^{a}$ | 51.61$^{a}$ | 13.953$^{a}$ | 1.3733$^{a}$ | 33.560$^{a}$ | 8.597$^{ab}$ |
| **2** | D03 | 76.05$^{a}$ | 52.40$^{a}$ | 13.530$^{a}$ | 0.9600$^{a}$ | 27.580$^{a}$ | 7.930$^{ab}$ |
| **3** | Control | 65.75$^{a}$ | 41.58$^{ab}$ | 11.620$^{a}$ | 1.2750$^{a}$ | 25.350$^{a}$ | 9.690$^{a}$ |
| **4** | J03 | 60.00$^{a}$ | 36.02$^{ab}$ | 10.285$^{ab}$ | 1.1500$^{a}$ | 22.995$^{a}$ | 8.595$^{ab}$ |
| **5** | D02 | 45.47$^{a}$ | 34.48$^{ab}$ | 10.273$^{ab}$ | 1.1267$^{a}$ | 20.650$^{a}$ | 6.697$^{ab}$ |
| **6** | S04 | 58.33$^{a}$ | 28.13$^{ab}$ | 9.527$^{ab}$ | 1.1000$^{a}$ | 20.270$^{a}$ | 7.610$^{ab}$ |
| **7** | J04 | 61.25$^{a}$ | 36.07$^{ab}$ | 9.640$^{ab}$ | 1.2000$^{a}$ | 19.970$^{a}$ | 6.960$^{ab}$ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **8** | S03 | 53.67$^{a}$ | 7$^{ab}$ | 8.957$^{ab}$ | 0.9600$^{a}$ | 19.620$^{a}$ | 5.683$^{ab}$ |
| **9** | M04 | 57.00$^{a}$ | 25.27$^{ab}$ | 9.140$^{ab}$ | 1.0333$^{a}$ | 18.290$^{a}$ | 5.230$^{ab}$ |
| **10** | M03 | 48.50$^{a}$ | 19.03$^{b}$ | 4.210$^{b}$ | 0.9700$^{a}$ | 14.305$^{a}$ | 3.945$^{b}$ |

**SFW = Shoot Fresh Weight, SDW = Shoot Dry Weight, SL = Shoot Length, RCD = Root Collar Diameter, LFW = Leaf Fresh Weight, LDW = Leaf Dry Weight.**
**D02 = December 2002, M03 = March 2003, J03 = June 2003, S03 = September 2003, D03 = December 2003, M04 = March 2004, J04 = June 2004, S04 = September 2004, D04 = December 2004. Mean with the same superscript alphabets are not signicantly different at P ≤ 0.05.**

## CONCLUSION

Application of D04 (Awba Lake water sample collected in December 2004) which produced relatively higher responses for the growth parameters considered in this study (Tables 4 - 8) was most promising as nutrient amendment for *C. pentandra* seedlings; especially when it is complemented with other materials higher in primary nutrients and moderately low in micronutrients.

Generally, water samples collected in the month of December appear to be more supportive for raising *C. pentandra* as the average shoot production (Tables 4 - 8) was higher than that for each of other months. Approximately, the quarterly variation in growth responses may be summarized in order of treatments as: Water samples collected in December was ≥ June ≥ September ≥ March.

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