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Full Length Research Paper

Effects of organic and inorganic fertilizers on early growth characteristics of *Khaya ivorensis* Chev (African mahogany) in nursery

Focho Derek Afa[1]*, Eneke Bechem[2], Egbe Andrew[2], Fongod Augustina Genla[2], Fonge Beatrice Ambo[2] and Njoh Roland Ndah[2]

[1]Department of Plant Biology, University of Dschang, P. O. Box 67 Dschang, Cameroon.
[2]Department of Plant and Animal Sciences, University of Buea, P. O. Box 63 Buea, Cameroon.

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The effects of two inorganic fertilizers (urea and super phosphate simple) and organic manure (fowl droppings) on the early growth of seedlings of *Khaya ivorensis* in nursery were investigated using ten nutrient treatments, nine of which were nutrient combinations and one, a negative control. Urea was added at 0.75 and 112.50 mg while super phosphate simple (SPS) was added at 0.30 and 60 mg. Changes in plant height, leaf number, collar diameter and leaf area were evaluated fortnightly for 120 days. Total biomass was evaluated at the end of the experiment. All growth parameters improved with nutrient addition with the differences being significant in most cases at P=0.05. The highest seedling height (15.20 cm), leaf number (9), collar diameter (3.7 mm), leaf area (115.5 cm^2), and biomass (19.3 g) were recorded when 75 mg urea and 60 mg SPS were added to seedlings. Results obtained suggest that the treatment combination N1P1 addition is necessary to boost the growth of this plant in nursery.

Key words: *Khaya* ivorensis, growth characteristics, fertilizers, mahogany.

INTRODUCTION

The proper application of commercial and organic fertilizers to forest nursery soils is of considerable importance since it may profoundly influence the value of seedlings produced. The primary purpose of forest nurseries is to produce and supply quality seedlings to form new forests and re-forest overexploited forest stands (Stoeckeler and Jones, 1957). Improving the fertility of nursery soils is essential to guarantee the production of high quality seedlings for nursery establishment (Rafiqul et al., 2004).

Most tropical soils and forests are deficient in nitrogen and phosphorus nutrients and uptake of these limited quantities of nutrients by plant roots from litter is difficult (Lawrence, 1998; Jose, 2003). Therefore, inadequate management of nursery soil can result in depletion of site fertility and reduction in seedling growth (Ang et al., 1995; Hoque et al., 2004). A healthy seedling must be well supplied with all the nutrients in the proper proportions for efficient growth (Craven et al., 2006; Gbadamosi, 2006).

Species vary in nutrient requirements and the demand for a particular element or nutrient depends upon the growth requirements of the species in question. Nutrient requirements for species in nursery also differ with environmental conditions (Groves and Keraitis, 1976; Pinkard et al., 2007). In case a particular nutrient is limited in a forest nursery, seedlings may forage with their roots to some extent to compensate for the deficiency or pick up the element from the atmosphere through leaf pores (Hoque et al., 2004; Rafiqul et al., 2004).

Khaya ivorensis Chev is an important tree species found in the dense forests of Equatorial Africa including Cameroon. It is one of the ten most exploited and exported species of the region (Laird, 1995; Shono et al., 2007). The wood from this species is light to moderately hard, durable and serves as timber exploited commercially. It is used locally to make door and window panels, and construction of houses (FAO, 2000; Andre,

*Corresponding author. E-mail: derekfocho@yahoo.com. Tel: (237}77 65 11 37.

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

Parameter	Chemical properties
pH	5.17
Ca (Meq/100 g)	2.13
Mg (Meq/100 g)	0.75
K (Meq/100 g)	0.18
P (ppm)	3.2
Org C (%)	9.57
Tot N (%)	0.61
C/N	15.59

2001). The leaves, barks and roots of the plant are used in traditional medicine for primary healthcare (Sofowora, 1993).

There is a rapid loss of seed viability and attack by *Hypsipyla robusta* the sapwood borer, after germination. Production of quality seedlings in nursery is therefore a difficult process and usually affects the survival rate on the field after transplanting. These seedlings can easily be subjected to stress and disease attack once transplanted (Nwoboshi, 1982). In this study combinations of two inorganic fertilizers (Urea and Super phosphate simple) and organic fertilizer were added at four different levels in potting mixtures to observe their effects on seedlings of *Khaya ivorensis* in the nursery. The aim of this study was to determine the best fertilization treatments to produce quality seedlings for *K. ivorensis.*

MATERIALS AND METHODS

Study site

This study was carried out in the screen house of the Department of Plant and Animal Sciences at the University of Buea campus, Cameroon. The Buea area has a humid tropical climate with an annual rainfall of about 2800 mm, most of which is received between June and September (Ndam and Fraser., 1998; Peguy et al., 1999). The mean annual temperature is 28°C while the average annual relative humidity is about 85 % and the annual sunshine is between 900 hours to 1200 hours (Ndam and Fraser., 1998). The topography of Buea is mountainous. The soil type is basically volcanic making it suitable for agriculture (Cable and Cheek, 1998). *K. ivorensis* grows between the of altitudes of 0-450 m with mean annual temperatures of 24-27°C and mean annual rainfalls of 1600-2500 mm. The plant prefers cool land, wet alluvial soils and cool clays.

Description of *K. ivorensis* A. Chev

K. ivorensis is a large tree of up to 40 to 50 m in height and a dbh of up to 2 m. The bole is straight, unbranched up to 30 m above the ground with well-developed plank buttresses. The bark is thick and coarse, reddish-brown, and with a bitter taste. The foliage of the widely spreading crown is dark. Leaves are evenly pinnate, with 4 to 7 pairs of leaflets, 7.5 to 14 cm long by 2.5 to 4.5 cm broad, oblong, abruptly long-acuminate at the apex (the tip is long and conspicuous in seedlings and saplings). The stalk of each leaflet is about 4 mm long. Flowers are numerous, small, white, in panicles and at the ends of branchlets. Fruits are rounded woody capsules usually with 5 valves. Each valve is 7.5 to 8.5 cm long and 2.5 to 4 mm thick, thinner than those of *Khaya grandifoliola*. When fully ripe, the valves open to release about 15 flat-winged seeds, each about 2.5 cm in diameter and narrowly winged all round.

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. Visible roots, leaves and other debris were removed from the sand 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, Urea and Super Phosphate Simple were also used in the research. 120 seedlings with a mean height of 4.0 cm were pre-transplanted into polythene bags using 12 seedlings for each treatment

Treatments

The amounts of nutrients added to each potting mix and the experimental combinations were as follows: Treatment 1: N_0P_0 (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: (control top soil only). Watering was done with deionised water three times a week and the following growth characters were measured fortnightly.

Determination of soil nutrients

Soil samples were collected at different sides of the fallowed land and dried using standard procedures and the following soil components were determined: Soil pH was determined 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). Table 1 gives the chemical properties of the soil used in the research.

Information recorded

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. Measurement of diameter at collar region was taken at the ground level using an electronic calliper (G02022 165). The number of leaves produced by seedlings was 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

Table 2. Height (cm) of *K. ivorensis* seedlings at different intervals (values in the same columns followed by the same letter(s) are not significantly different).

H. 2 Week	H. 4 Week	H. 6 Week	H. 8 Week	H. 10 Week	H. 12 Week
7.4[a] (N0P0)	8.2[a] (N0P0)	10.0[a] (N0P0)	10.2[a] (N0P0)	10.8[a] (N0P0)	11.9[a] (NOPO)
7.1[a] (N1P0)	11.1[a] (N1PO)	11.8 [a] (N1P0)	12.9[a] (N1P0)	13.7[a] (N1P0)	14.1[a] (N1P0)
7.2[a] (N2P0)	10.3[a] (N2P0)	11.8[a] (N2P0)	12.6[a] (N2P0)	13.1[a] (N2P0)	13.8[a] (N2P0)
8.3[ac] (N0P1)	11.6[ac] (N0P1)	12.0[ac] (N0P1)	12.4[ac] (N0P1)	14.2[a]-c (N0P1)	15.2[a-c] (N0P1)
8.1[a] (N1P1)	10.9 [a] (N1P1)	12.1[a] (N1P1)	12.8[a] (N1P1)	13.7[a] (N1P1)	14.1[a] (N1P1)
8.0[ab] (N2P1)	12.1[ab] (N2P1)	12.9[ab] (N2P1)	13.3[ab] (N2P1)	14.2[ab] (N2P1)	14.9[ab] (N2P1)
8.0[ad] (N0P2)	11.7[ad] (N0P2)	12.3[ad] (N0P2)	13.0[ad] (N0P2)	13.9[ad] (N0P2)	14.3[ad] (N0P2)
8.1[a] (N1P2)	10.7[a] (N1P2)	11.7[a] (N1P2)	12.4[a] (N1P2)	13.0[a] (N1P2)	13.7[a] (N1P2)
8.4[ae] (N2P2)	11.8[ae] (N2P2)	12.4[ae] (N2P2)	13.6[ae] (N2P2)	14.1[ae] (N2P2)	14.9[ae] (N2P2)
8.2[a] (control)	10.5[a] (control)	11.6[a] (control)	11.8[a] (control)	12.2[a] (control)	11.6[a] (control)

Table. 3 Analysis of variance of different growth parameters main factors.

Parameter	Treatment	Control
Height	**	N.S
No. leaves	N.S	N.S
Leaf collar dia	N.S	N.S
Leaf area	***	N.S
Biomass		
Oven dry wt of leaf	***	N.S
Oven dry wt of stem	**	N.S
Oven dry wt of root	**	N.S
Total dry wt of plant	**	N.S

and root components. The fresh and dry weights of the different seedling components were recorded using an electronic balance. Total biomass (total dry weights) was obtained by adding dry weights of leaves, stems and roots.

Data analysis

Analyses of variance were utilised to examine the growth parameters. Turkey's highest significant differences were used to compare mean values for the different treatment combinations.

RESULTS

Seedling heights

Treatment combinations of N and P were generally not significantly different (Table 2). Application of nutrients at different levels however, showed significant differences at P=0.05 (Table 3). The best height increase after 120 days was 15.2 cm recorded for the treatment combination of N0P1 and the least height recorded was 11.2 cm observed in the control treatment (Table 2).

Number of leaves

Fertilizer application did not show significant differences with treatment addition (Table 3). Leaf numbers were not significantly different for the different treatment combinations (Table 4). However, the best mean leaf number was 9 with treatment combination of N1P1 after 120 days of recording and the least recorded leaf number observed was 7 with N1P0. Table 3 indicates that the application of nitrogen and phosphorus treatments to seedlings result in significant differences at 1%. **: Significant at 5% level; *** Significant at 1%, N.S: Non significant

In Table 4, for a period of 12 weeks, is no significant difference between the values. However, there is some difference between the control and the N2P2 application over time.

Table. 4 Number of leaves of *K. ivorensis* seedlings at different intervals (values in the same columns followed by the same letter(s) are not significantly different).

L. 2 Week	L. 4 Week	L. 6 Week	L. 8 Week	L. 10 Week	L. 12 Week
2.3[a] (N0P0)	3.5[a] (N0P0)	4.5[a] (N0P0)	5.6[a] (N0P0)	6.2[a] (N0P0)	7.3[a] (N0P0)
2.2[a] (N1P0)	3.5[a] (N1P0)	4.3[a] (N1P0)	5.6[a] (N1P0)	6.0[a] (N1P0)	6.8[a] (N1P0)
2.1[a] (N2P0)	3.7[a] (N2P0)	4.5[a] (N2P0)	5.0[a] (N2P0)	6.0[a] (N2P0)	8.2[a] (N2P0)
2.1[a] (N0P1)	3.7[a] (N0P1)	5.2[a] (N0P1)	6.3[a] (N0P1)	7.2[a] (N0P1)	7.5[a] (N0P1)
2.3[a] (N1P1)	4.0[a] (N1P1)	5.0[a] (N1P1)	5.0[a] (N1P1)	7.2[a] (N1P1)	9.0[a] (N1P1)
2.1[a] (N1P1)	4.3[a] (N1P1)	4.3[a] (N1P1)	5.0[a] (N1P1)	6.0[a] (N1P1)	7.5[a] (N1P1)
2.3[a] (N0P2)	4.5[a] (N0P2)	5.5[a] (N0P2)	6.0[a] (N0P2)	6.6[a] (N0P2)	7.3[a] (N0P2)
2.4[a] (N1P2)	4.2[a] (N1P2)	4.3[a] (N1P2)	5.0[a] (N1P2)	5.8[a] (N1P2)	7.0[a] (N1P2)
2.0[a] (N2P2)	3.3[a] (N2P2)	5.5[a] (N2P2)	6.6[a] (N2P2)	7.4[a] (N2P2)	7.7[a] (N2P2)
2.0[a] (control)	4.2[a] (control)	4.6[a] (control)	5.2[a] (control)	5.8[a] (control)	7.0[a] (control)

Table 5 .Collar diameter (mm) of *K. ivorensis* seedlings at different intervals (values in the same columns followed by the same letter(s) are not significantly different).

Co. 2 Week	Co. 4 Week	Co. 6 Week	Co. 8 Week	Co. 10 Week	Co. 12 Week
1.8[a] (N0P0)	2.1[a] (N0P0)	2.3[a] (N0P0)	2.7[a] (N0P0)	3.2[a] (N0P0)	3.5[a] (N0P0)
1.8[a] (N1P0)	2.3[a] (N1P0)	2.6[a] (N1P0)	3.0[a] (N1P0)	3.3[a] (N1P0)	3.5[a] (N1P0)
1.8[a] (N2P0)	2.2[a] (N2P0)	2.6[a] (N2P0)	3.1[a] (N2P0)	3.4[a] (N2P0)	3.6[a] (N2P0)
1.8[a] (N0P1)	2.2[a] (N0P1)	2.6[a] (N0P1)	3.1[a] (N0P1)	3.5[a] (N0P1)	3.6[a] (N0P1)
1.8[a] (N1P1)	2.2[a] (N1P1)	2.7[a] (N1P1)	3.2[a] (N1P1)	3.4[a] (N1P1)	3.6[a] (N1P1)
1.8[a] (N2P1)	2.5[a] (N2P1)	3.0[a] (N2P1)	3.2[a] (N2P1)	3.4[a] (N2P1)	3.7[a] (N2P1)
1.8[a] (N0P2)	2.3[a] (N0P2)	2.6[a] (N0P2)	3.2[a] (N0P2)	3.3[a] (N0P2)	3.6[a] (N0P2)
1.8[a] (N1P2)	2.3[a] (N1P2)	2.7[a] (N1P2)	3.2[a] (N1P2)	3.5[a] (N1P2)	3.7[a] (N1P2)
1.[8a] (N2P2)	2.2[a] (N2P2)	2.8[a] (N2P2)	3.1[a] (N2P2)	3.4[a] (N2P2)	3.6[a] (N2P2)
1.8[a] (control)	2.1[a] (control)	2.6[a] (control)	2.7 [a] (control)	3.1[a] (control)	3.2[a] (control)

Collar diameter increment

The seedlings used in the fertilizer experiment were not significantly different in their initial growth (Tables 3 and 5). The highest collar diameter of 3.7 mm was obtained with treatment combination N1P1 and the lowest mean diameter recorded after 120 days was 3.2 mm observed with the control treatment.

Total leaf area

Treatment combinations generally showed significant differences at the different intervals of the experiment (Table 6). The best treatment recorded after 12 weeks of observation was 115.5 cm^2 with N2P2 and the least was 56.1 cm^2 with N0P0.

Dry weight of leaf, stem and root

The different growth parameters (dry weight of leaf, stem and root) were significantly different at 1% and 5% levels (Table 3). The total biomasses of seedlings increased the most when the fertilizers were combined than when Nitrogen (N) and Phosphorus (P) were applied singly (Figure 1). The best seedling dry weight increment was 19.3 g with treatment N1P2 (Figure 2). The best treatments for application of nitrogen and phosphorus singly were 18.5 g (N1P0) and 14.9 g (N0P2) (Figures 3 and 4). The control experiments gave the least weights for leaf, stem and root (Figure 1).

DISCUSION

Physical characteristics are the visually determinable attributes of tree seedlings in nursery. The major morphological criteria often used to describe timber seedling potentials are shoot height, leaf number, seedling collar diameter, leaf area, root mass and plant root ratio. These are some of the bases to qualify good seedlings for nursery establishment. The findings of this fertilizer experiment show that when there is adequate

Table 6. Leaf area (cm2) of *K. ivorensis* seedlings at different intervals (values in the same columns followed by the same letter(s) are not significantly different

L. A. 2 Week	L.A. 4 Week	L.A. 6 Week	L.A. 8 Week	L.A. 10 Week	L.A. 12
25.2^{a} (N0P0)	30.3^{a} (N0P0)	31.0^{a} (N0P0)	38.0^{a} (N0P0)	52.5^{a} (N0P0)	56.1^{a} (N0P0)
25.4^{a} (N1P0)	27.1^{a} (N1P0)	28.0^{a} (N1P0)	30.1^{a} (N1P0)	47.1^{a} (N1P0)	63.0^{a} (N1P0)
30.3^{ab} (N2P0)	46.7^{ab} (N2P0)	48.0^{ab} (N2P0)	52.2^{ab} (N2P0)	86.3^{ab} (N2P0)	90.0^{ab} (N2P0)
48.9^{ac} (N0P1)	504.0^{ac} (N0P1)	54.0^{ac} (N0P1)	90.2^{ac} (N0P1)	92.2^{ac} (N0P1)	115.9^{ac} (N0P1)
46.8^{a-c} (N1P1)	50.9^{a}-^{c} (N1P1)	62.3^{a-c} (N1P1)	64.1^{a}-^{c} (N1P1)	70.3^{a-c} (N1P1)	84.0^{a}-^{c} (N1P1)
31.5^{af} (N2P1)	50.3^{af} (N2P1)	52.4^{af} (N2P1)	54.4^{af} (N2P1)	62.4^{af} (N2P1)	63^{af} (N2P1)
22.5^{a} (N0P2)	27.6^{a} (N0P2)	30.3^{a} (N0P2)	42.3^{a} (N0P2)	70.0^{a} (N0P2)	82.0^{a} (N0P2)
30.8^{a} (N1P2)	38.3^{a} (N1P2)	39.1^{a} (N1P2)	42.6^{a} (N1P2)	42.3^{a} (N1P2)	58.2^{a} (N1P2)
30.4^{ad} (N2P2)	36.1^{ad} (N2P2)	42.4^{ad} (N2P2)	48.4^{ad} (N2P2)	79.7^{ad} (N2P2)	90.0^{ad} (N2P2)
22.2^{a} (control)	24.3^{a} (control)	28.1^{a} (control)	30.3^{a} (control)	48.0^{a} (control)	70^{a} (control)

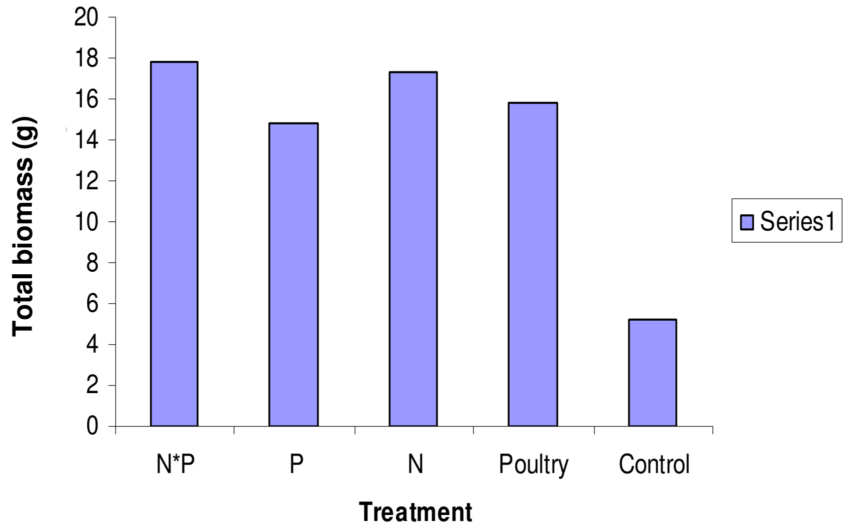

Figure 1. Biomass increment of nutrient application of seedlings of *Khaya ivorensis.*

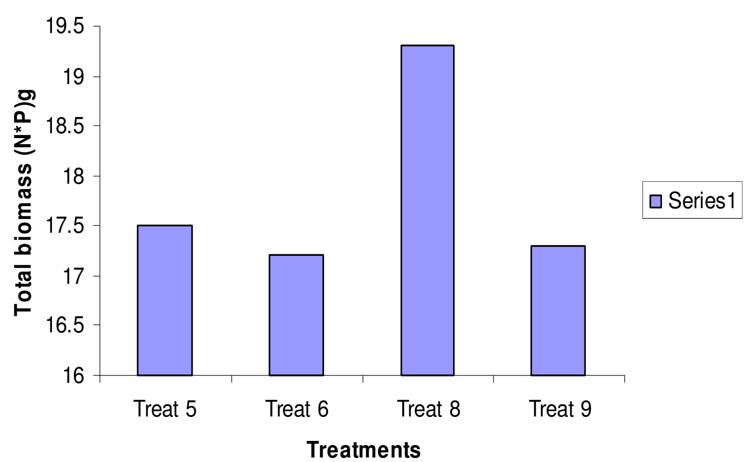

Figure 2. Biomass increment of N*P combination of seedlings of *K. ivorensis.*

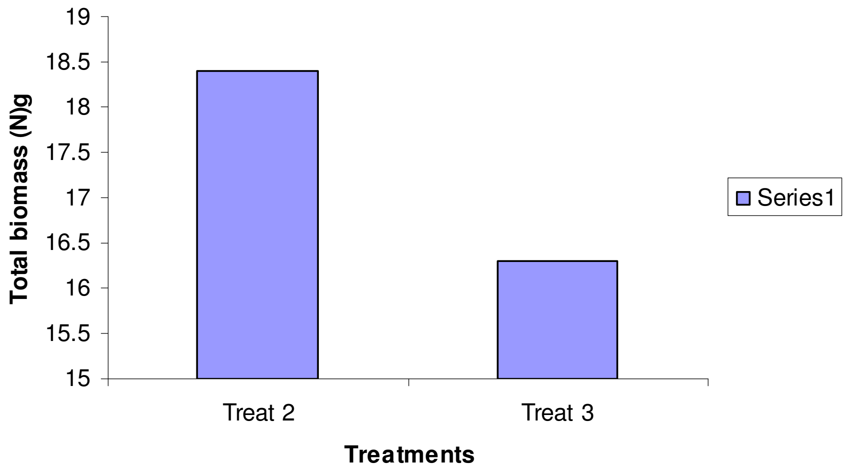

Figure 3. Biomass increment with application of Nitrogen (N) levels to seedlings of *K. ivorensis.*

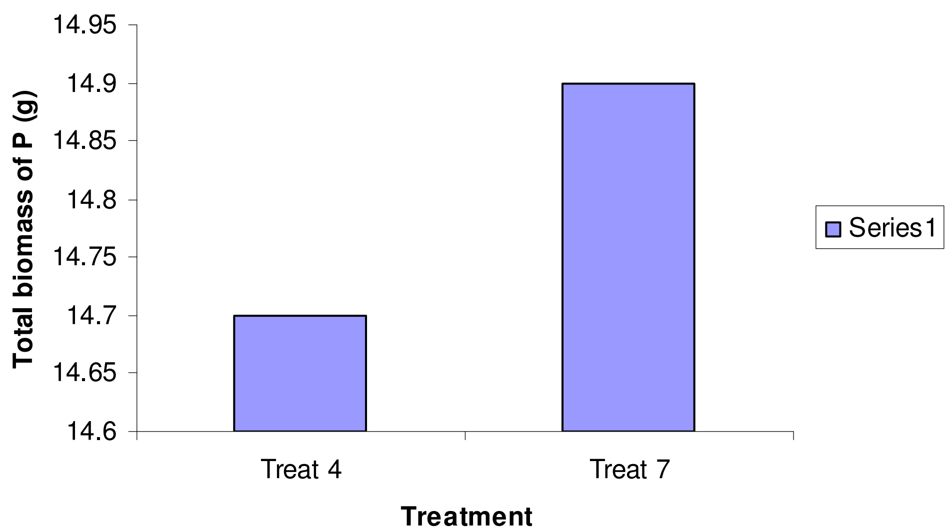

Figure 4. Biomass increment with application of Phosphorus (P) levels to seedlings of *K. ivorensis.*

fertilizer application to seedlings the yield is better than when there is no fertilizer application. This is also in conformity with reports on plantation trees like *Michelia chapaca* L, *Tectonia grandis* Teak*,* and *Entandrophragma cylindricum* Sprague (Hall et al., 2003; Rafiqul et al., 2004). Similar positive results have been reported on growth performance of timber seedlings (Bungard et al., 2000 and Ong et al., 2003). Ong et al. (2003) recorded negative results on the growth performance of some timber seedlings with no fertilizer application. In this present experiment on fertilizer treatment, no toxic effect was noticed.

Growth in heights of seedlings showed differences with nutrient application ($P < 0.05$). This is in conformity with results obtained for seedlings of C*edrela liloi* C.DC, *Dryobalanop lanceolata* Burck. and *Shorea platyclados* Sloot. ex Foxw. treated with different nutrients (Hector 2000; Ichie et al., 2001 and Ong et al., 2003). Height increments were highest with treatment the combination N0P1. The application little of doses of fertilizer stimulates cell differentiation and multiplication leading to height increments. Similar results have been reported for *Michelia champaca* L seedlings in which minimal doses of Phosphorus yielded positive effects on height increments (Hoque et al*.,* 2004). High doses of phosphorus application may become toxic to seedlings since absorption of this element may affect regular metabolic processes. Some of these processes which may be affected by high doses of phosphorus and uptake of other important minerals from the soil, and poor cell differentiation and multiplication (Jose, 2003).

There were no significant differences in the number of leaves produced by seedlings during the experiment. However, the best treatment combination recorded was N1P1. This indicates that nitrogen and phosphorus play pertinent roles in leaf production. Small doses of N and P result to leaf production in the seedlings. Pinkard et al. (2007), working with reported for *Eucalyptus globules*, reported that seedling collar diameter increment did not show significant differences (P > 0.05) with nutrient application. Seedling collar diameter increments for fertilized seedlings were generally better than those of the control experiment. Burslem et al. 1995 and Gbadamosi 2006 also reported similar results for tree seedlings. The combination which yielded the best diameter increments was N1P1, indicating that minimal combination of nitrogen and phosphorus will stimulate growth. This is probably by means of stimulating protein formation, rapid cell division and differentiation resulting in collar diameter increment (Bungard et al., 2000; Ong et al., 2003; Hoque et al., 2004). Higher doses of N and P may interfere with metabolic processes and hinder growth (Burslem et al., 1995; Gbadamosi 2006; Raaimakers and Lambers 1996). Application of phosphorus and nitrogen resulted in significant increments in leaf area of the species. Fertilised seedlings had better leaf areas than unfertilised ones. This finding is in line with that of Guantilleke (1997) working with *Shorea* species. Pooter (1990) has reported that proper combinations of nitrogen and phosphorus, and other organic compounds may result in increases in leaf area. A combination of the different nutrients stimulates cell division and promotes stomata opening for cell expansion (Pooter, 1990). The results of the present study reveal that N+P fertilization over time result in significant increases in biomass. Bungard et al., 2000; Ong et al., 2003; Hoque et al., 2004 have reported similar findings.

Conclusion

This study shows that heights of *K. ivorensis* seedlings increase with the application of different doses of nitrogen and phosphorus. The best result is obtained with N0P1. Leaf number, collar diameter, leaf area and biomass are increased by addition of the fertilizers.

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