Regeneration and Growth of *Acacia senegal* (L.) Willd Seedlings in the Nursery as Affected by Tree Manures and NPK Fertilizer

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**ABSTRACT**

This study aimed to assess the effects of tree manures in comparison with NPK fertilizer on growth of *Acacia senegal* seedlings. It was conducted in the nursery of the Faculty of Forestry, Shambat, during August 2008 and January 2009. The growing media were prepared by mixing ground foliage of tree with a clay soil (weight/volume) as follows: - *Albizia lebbeck* (AL): 25 g, 50 g and 75 g; *Azadirachta indica* (AZ): 25 g, 50 g and 75 g; *Khaya senegalensis* (KH): 25 g, 50 g and 75 g; NPK fertilizer: 30 g per seedling. *A. senegal* seed germination percentage increased significantly in tree manures in comparison with NPK and control media. *A. senegal* seedlings’ growth in the treatments varied as follows: AZ = NPK > AL > KH > control for shoot length; KH > AL > AZ > NPK > control for root length; AZ > NPK > KH > AL > control for diameter; NPK = AZ > AL > KH > control for shoot biomass and AZ > NPK > KH > AL > control for root biomass. Therefore, *A. senegal* seedlings’ growth was higher in *A. indica* and NPK fertilizer media, moderate in *A. lebbeck* media and poor in *K. senegalensis* and the control media. However, the root growth occurred at an opposite rate outlined for the other growth parameters. These findings indicate good fertilizing and ameliorating potential of tree manures and can be used in nursery growing media and as substitutes for inorganic fertilizers.

**Key words:** Tree manure; NPK fertilizer; clay soil; *Acacia senegal* seedlings; nurseries

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**INTRODUCTION**

Trees are known to contribute in ameliorating the soil conditions and replenishing nutrients to crops. Trees and forests accumulate organic matter and nutrients within their ecosystems through biogeochemical cycling, capturing atmospheric depositions and biological fixation. Forests and trees are the main sources for the soil organic matter. Through the biogeochemical mechanism, trees are capable to cycle and immobilize huge amounts of nutrients in their biomass and the solum (Johnson *et al.*, 1998; Montagnini *et al.*, 2000; Hunter 2001; Young, 2002; Deans *et al.*, 2003; Harmand *et al.*, 2004; Laclau *et al.*, 2010; Smailla *et al.*, 2011; Carnol and Bazgir, 2013). However, much
of the nutrients immobilized in the woody biomass are not readily available, and would be sequestered until the end of the tree revolution age or exploitation by the human being. The most dynamic part of the tree biomass is the litter constituted mainly from dead foliage and roots, and which is turned-over annually (Nwoboshi, 1977; MacDonald, 1981; Nair, 1993; Mafongoya et al., 1998; Semwal et al., 2003; Bot and Benites, 2005; Goma-Tchimbakala and Bernhard-Reversat, 2006; Mweta et al., 2007; Berg and McClougherty, 2008; Kiser et al., 2013; Xiaogai et al., 2013). Annual litter fall in tropical forests ecosystems may amounts to 10 - 15 tons ha$^{-1}$yr$^{-1}$ (Duchaufour, 1984; NAP, 1992; Muoghalu, et al., 1993; Vitousek et al., 1995; Priess et al., 1999; Descheemaeker et al., 2006).

Tree manure (biomass) can be incorporated through human intervention into exploitable systems such as agroforestry, or collected, transformed and transferred to other utilization practices such as farms, orchards and nurseries (Whitbread et al., 1999; Sanchez, 1999; Rao and Mathuva, 2000; Mandal et al., 2003; Schroth and Sinclair, 2003; Reddy et al., 2003; Graves et al., 2004; Sangakkara et al., 2006). Regarding the quantity and quality of biomass to be exploited for agriculture or forestry purposes; this usually does not pose much worry for concerned managers, for there are variable strategies and targets pursued in applications. In some cases, the tree biomass utilization may be destined to rapidly replenish nutrients to the soil and crops, and so, the quick decomposing type of biomass must be used. But if the target is to build up organic matter into the soil, thus slow decomposing forms of biomass must be applied (Berg and McClougherty, 2008; Mubarak et al., 2008). Usually, the tree manure has sufficient nutrients to satisfy the crop requirements the basic elements. In addition the tree manure is considered to be a clean source of nutrients to the terrestrial ecosystems, i.e. environmentally friendly (Eghball et al., 2004). Even though, some inconveniences may arise when using fresh forms of tree biomass, from being allelopathic to crops and from harboring diseases and pests (Cooperband, 2002; Uddin et al., 2007; Whiting et al., 2009).

The objectives of this study were: to characterize tree foliage manures of Albizia lebbeck, Azadirachta indica and Khaya senegalensis; to assess the effects of the selected tree manures on growth and development of Acacia senegal seedlings in nursery mixtures with a clay soil and in comparison with NPK fertilizer; to screen the appropriate tree manures and the adequate doses suitable for good nursery stock raising.

**MATERIALS AND METHODS**

The study was conducted in the nursery of the Faculty of Forestry, University of Khartoum, Shambat. It is located on the eastern bank of the Nile River and it is surrounded by farms and wood lots, which render the ambient microclimatic conditions of the area much cooler than the drier inlands. Seeds of Acacia senegal (L.) Wild.)
selected for the bioassay to tree manure and NPK fertilizer were procured from the Tree Seed Center, at the Forestry Research Center, Khartoum. The seeds were delivered pretreated by conc. H$_2$SO$_4$ for 30 minutes to break seed-coat dormancy and to facilitate germination. The containers for nursery stock raising consisted of black cylindrical polythene bags (15x25 cm), sealed at one end, and perforated to their third height; they were acquired from the local market. The growing meia ingredients consisted of a clayey soil (Vertisols) and tree manures from Shambat area plus NPK fertilizer (17-17-17) acquired from the local market. The tree manure was prepared from air dried and ground foliage ($\phi = 0.5$ mm) of Azadirachta indica A. Juss., Albizia lebbeck (L.) Benth. and Khaya senegalensis (Des.) A. Juss. trees. The fresh foliage was collected from different trees (5 for each species and at various positions on the crowns) and from different sites surrounding the Faculty of the Forestry.

Tree manures were thoroughly mixed with the clay soil and then packed in the polythene bags. Three doses of 25, 50 75 g from each tree manure type were chosen. The NPK fertilizer was added in five doses of 6 g per month (30 g in total) during the experimentation period, lest that the stuff might cause burning to the seedlings. Each treatment was replicated for 25 times, in view to withdraw 5 bags (seedlings) monthly and thus the total prepared bags were 275. The bags were arranged in the nursery beds in a randomized complete block design. The resulting treatments were: 1/ Control: without any addition; 2/ NPK: with addition of 6 g per month per bag; 3/ AL1: with addition of 25 g of ground A. lebbeck foliage powder; 4/ AL2: with addition of 50 g of ground A. lebbeck foliage powder; 5/ AL3: with addition of 75 g of ground A. lebbeck foliage powder; 6/ AZ1: with addition of 25 g of ground A. indica foliage powder; 7/ AZ2: with addition of 50 g of ground A. indica foliage powder; 8/ AZ3: with addition of 75 g of ground A. indica foliage powder; 9/ KH1: with addition of 25 g of ground k. senegalensis foliage powder; 10/ KH2: with addition of 50 g of ground k. senegalensis foliage powder; 11/ KH3: with addition of 75 g of ground k. senegalensis foliage powder.

A. senegal seeds were sown on 28$^{th}$ August 2008 directly in the prepared polythene bags (2 to 3 seeds per bag) and thinly covered with own substrate. Watering (tap water) was done once every two days over the experiment period. Other silvicultural operations including weeding, seedling lifting and root cutting were carried out as routinely run in the nurseries. The seedlings were later thinned to one plant per polythene bag. Monitoring of nursery trials lasted for 5 months. Growth parameters measurements started one month from sowing date, the parameters measured monthly were: 1/ Shoot length; 2/ Shoot diameter; 3/ Root length and 4/ Shoot and root masses.

Soil and tree manure physicochemical determinations in the laboratory were carried out according to the international procedures (Page 1982; Klute 1986; Kalra 1998). Air dry composite-samples of soils and tree manure (mixture of 3 samples) were used to analyse particle size distribution, bulk density, pH, electrical conductivity (Ec.), soluble cations (Ca, Mg, Na and K), Nitrogen, Phosphorous and organic carbon.
Data from intermediate readings of growth parameters were processed by excel software and presented into temporal variation curves. While the final measurements of the growth parameters were subjected to Analysis of Variance (ANOVA) by SAS program (2004) and the significant differences between the means of the treatments were assigned according to Duncan Multiple Range Test.

RESULTS

Characterization of the Growth media (soil and tree manure):
The particle size distribution of the soil used was predominated by clay (45.7%) and sand (43.2%), hence its texture class was sandy clay. Its reaction was neutral with pH value of 7.5. It was slightly saline (with Ece of 5.0 dS/m). It was sodic with exchangeable sodium of 26.0 mmol+/l and SAR of 7.5. The soil had relatively high content of Ca and Mg (Ca+Mg = 24 mmol+/l), but it had very low organic carbon, nitrogen and phosphorus with values of 1.7%, 0.01% and 4.6 mg/l, respectively.

The organic carbon and hence the organic matter contents of these tree manures have similar values. Albizia lebbeck and Azadirachta indica have high contents of protein and nitrogen, which were very close to each other in the two species manures; value magnitudes of protein and nitrogen in these species were more than 2 folds of that in Khaya senegalensis (Table 1). Carbon to nitrogen ratios (C/N) in Albizia lebbeck and Azadirachta indica manures had similar values, which can be categorized as medium range values (~ 15). But C/N ratio in Khaya senegalensis manure was about 2 folds (32) of that in the other tree manures and it is considered to be situated in the medium to higher range values of this index. No great differences were found in the calcium and magnesium contents in the manures of these tree species. Even though, potassium and phosphorus contents in Albizia lebbeck and Azadirachta indica manures were slightly higher than that of their respective values Khaya senegalensis manure.

Effects of tree manures and NPK fertilizer on germination of A. senegal seeds:
Seeds of A. senegal were directly sown in the media without pretreatment because they germinate easily. The A. senegal seed germination percentage in the clay media amended with the different tree manures and NPK fertilizers was found to range in the following order: 52-69% in media with Azadirachta indica manures; 49-56% in media with Albizia lebbeck manures; 37% in NPK fertilizer media; 27-37% in media with Khaya senegalensis and 35% in the control media.

Temporal growth variation of A. senegal seedlings as affected by tree manures and NPK fertilizer:
A) Shoot height: Comparison of A. senegal seedlings’ shoot height growth in Albizia lebbeck tree manures, NPK fertilizer and the Control media showed that the seedlings had
almost identical values of shoot heights after one month from sowing date (August 2008); divergence of seedlings’ growth rate in the various media started as from September 2008 onwards (Figure 1a). Shoot growth in the NPK treatment preceded upwards with large increments of 8.5 cm per month on the average. Seedlings shoot height in the *Albizia lebbeck* manures grew in very close rates to each other till the end of monitoring period with monthly average increment of 5.3 cm. Seedlings shoot heights in the Control grew at slightly lower parallel rate to that in *Albizia lebbeck* manures with mean monthly increment of 4.3 cm.

Comparison of *A. senegal* seedlings’ shoot height growth in *Azadirachta indica* manures, NPK fertilizer and the Control media showed that the seedlings had almost very close values of shoot heights after one month from sowing date (Figure 1b). After wards, seedlings shoot height growth rate was very strong in NPK fertilizer and AZ3 media, in which the growth rate was identical all along the monitoring period and with a mean monthly increment of 8.5 cm. The other *Azadirachta indica* manures (AZ1 and AZ2) induced similar shoot height growth rate, with a mean monthly increment of 6 cm. Seedlings height growth rate in the Control occurred at a lower parallel rate to that of *Azadirachta indica* manures’ media.

**Table 1.** Chemical analysis of manures *Albizia lebbeck, Azadirachta indica* and *Khaya senegalensis*

<table>
<thead>
<tr>
<th>Tree species</th>
<th>OC† (%)</th>
<th>OM‡ (%)</th>
<th>Protein (%)</th>
<th>N (%)</th>
<th>C/N</th>
<th>Ca (%)</th>
<th>Mg (%)</th>
<th>K (%)</th>
<th>P (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Albizia lebbeck</em></td>
<td>47.7</td>
<td>95.4</td>
<td>20.5</td>
<td>3.3</td>
<td>14.5</td>
<td>2.1</td>
<td>0.8</td>
<td>2.0</td>
<td>1.1</td>
</tr>
<tr>
<td><em>Azadirachta indica</em></td>
<td>48.2</td>
<td>96.4</td>
<td>19.8</td>
<td>3.7</td>
<td>13.0</td>
<td>2.4</td>
<td>0.6</td>
<td>2.4</td>
<td>1.1</td>
</tr>
<tr>
<td><em>Khaya senegalensis</em></td>
<td>48.5</td>
<td>97.0</td>
<td>9.1</td>
<td>1.5</td>
<td>32.0</td>
<td>2.5</td>
<td>0.6</td>
<td>0.9</td>
<td>0.8</td>
</tr>
</tbody>
</table>

†OC: Organic carbon; ‡OM: organic matter.
Figure 1. Comparison of *A. senegal* seedlings’ shoot growth variation in the Control (○), NPK fertilizer (□) and tree manures: A: *A. lebbeck*; B: *A. indica* and C: *Kh. senegalensis* manures; Δ: 25, ○: 50 and *: 75 g.
Comparison of *A. senegal* seedlings’ shoot height growth in *Kh. senegalensis* manures, NPK fertilizer and the Control media showed that the seedlings had almost very close values of shoot heights after one month from sowing date (Figure 1c). *A. senegal* seedlings shoot height was the strongest of all media throughout the monitoring period. Media with intermediate *Kh. senegalensis* manure doses induced similar shoot height growth of the seedlings, and which occurred at a lower parallel line to that of NPK fertilizer media and with an average monthly increment of 6 cm. While seedling shoot height in the *Kh. senegalensis* highest dose medium (KH3) was less strong than in the intermediate doses (KH1 and KH2), and with a mean monthly increment of 5.6 cm.

B) Root length:

Comparison of *A. senegal* seedlings’ root length growth in *Albizia lebbeck* manures, NPK fertilizer and the Control media showed that the lower dose of *Albizia lebbeck* manure induced the highest rate of the seedlings growth, with a mean monthly increment of 6.7 cm (Figure 2A). The larger dose of *Albizia lebbeck* manure produced the lowest rate of the seedlings growth, with a mean monthly increment of only 4.9 cm. The seedlings growth rates in NPK fertilizer, the Control treatments became identical as from November 2008 until the end of the monitoring period, and their respective mean increment rates were 3.7 and 5.7 cm per month.

Comparison of *A. senegal* seedlings’ root length growth in *Azadirachta indica* manures, NPK fertilizer and the Control media showed that the lower dose of *Azadirachta indica* manure induced the highest rate of the seedlings growth, with a mean monthly increment of 9.1 cm (Figure 2B). The two higher doses of *Azadirachta indica* manures (AZ2 and AZ3) produced much weaker growth rates than the lower dose, and with corresponding mean monthly increments of 6.7 and 8.1 cm, respectively. The NPK fertilizer and the Control treatments effects on root growth were much less lower than induced by *Azadirachta indica* manures.

Comparison of *A. senegal* seedlings’ root length growth in *Khaya senegalensis* manures, NPK fertilizer and the Control media showed that all the doses of *Khaya senegalensis* manures almost induced identical seedlings growth rates, particularly as from October onwards (Figure 2C); their mean monthly growth increment was 7.2 cm. Effects of NPK fertilizer and the Control treatments on the root growth were much weaker and occurred at a lower parallel rate to that produced by *Khaya senegalensis* manures.
Figure 2. Comparison of *A. senegal* seedlings’ root growth variation in the Control (◊), NPK fertilizer (□) and tree manures: A: *A. lebbeck*; B: *A. indica* and C: *K. senegalensis* manures; Δ: 25, ○: 50 and *: 75 g.
C) Diameter:

Comparison of *A. senegal* seedlings’ diameter growth in *Albizia lebbeck* manures, NPK fertilizer and the Control media showed that the NPK fertilizer has induced stronger diameter of the seedlings than all the other media (Figure 3A), with a mean monthly increment of 1 cm. The lower *Albizia lebbeck* manure dose produced effects on diameter growth that occurred in the second range to that of NPK fertilizer and with a mean monthly increment of 0.9 cm. The higher *Albizia lebbeck* manure doses (AL2 and AL3) and the Control engendered identical diameter growth rates all along the monitoring period and with a mean monthly increment of 0.7 cm.

Comparison of *A. senegal* seedlings’ diameter growth in *Azadirachta indica* manures, NPK fertilizer and the Control media showed that the NPK fertilizer and the *Azadirachta indica* manures have induced very close diameter growth rate of the seedlings that occurred at close parallel lines through out the monitoring period (Figure 3B). The effects of the larger *Azadirachta indica* manure dose were, however, the strongest among all the other treatments with a mean monthly increment of 1.2 cm. The Control effects on seedlings diameter growth rate were the weakest among all the treatments.

Comparison of *A. senegal* seedlings’ diameter growth in *Khaya senegalensis* manures, NPK fertilizer and the Control media showed that the NPK fertilizer and the *Khaya senegalensis* manures have induced almost identical diameter growth rates of the seedlings from the sowing date up to the third month at November 2008 (Figure 3C). After that, the NPK fertilizer treatment distincted from the other treatments and produced strong seedlings diameter growth rate; even though, the general mean monthly increment groth rate of these treatments was 1 cm. The Control treatment gave the least strong diameter growth rate from all the other treatments.

**Final assessment of effects of NPK fertilizer and tree manures on growth of *A. senegal* seedlings:**

The comparison between the NPK fertilizer, tree manures and the Control has revealed that, the larger manure dose of *Azadirachta indica* (AZ3) and the NPK fertilizer gave the highest shoot length of *Acacia senegal* seedlings, and which were significantly different (p < 0.05) from the Control; mean shoot heights in these treatments was 17.6 cm greater than in the Control (Table 2). The other tree manures induced seedlings shoot heights which were invariably higher than the Control but without showing significant differences. The lower doses of tree manures, particularly those of *Khaya senegalensis* (KH1 and KH2) performed well in raising the seedlings height in the second place to NPK fertilizer and the larger dose of *Azadirachta indica* manure. The shoot/root ratio values of all the treatments were under unity except for the NPK fertilizer and the larger dose of *Azadirachta indica* manure, and which were on the other hand, significantly
different (p < 0.05) from the rest of the treatments. The lower tree manure doses had generally smaller shoot/root ratio values than the Control. Assessments on treatments’ effects on seedlings root length growth showed that the tree manures, especially, the lower doses induced the greatest root lengths; the larger tree manure doses performed less strongly. Effects of NPK fertilizer on the root length were identical to the Control. Even though, no significant differences were discerned on the effects of all treatments on the seedlings root length.

Examination of effects of tree manures and NPK fertilizer on the *A. senegal* seedlings diameter growth, has showed that the *A. indica* manures and the NPK fertilizer have induced the greatest diameter growth values, 6.3 mm on the average, and were significantly different (p < 0.05) from the rest of the treatments (Table 2). The second greater diameter growth was engendered by the manures of *K. senegalensis* and the lower dose of *A. lebbeck* manure and which were significantly different from the other treatments. Then, the Control and the larger doses of *A. lebbeck* manures were the least effective in stimulating the diameter growth and the corresponding values were significantly different from the other treatments.

For the shoot mass, the comparison between the NPK fertilizer, tree manures and the Control has shown that, the NPK fertilizer and the larger dose of *A. indica* manure (AZ3) have produced the highest *A. senegal* seedlings shoot mass, and which values were significantly different from the other treatments. Mean while, the Control and the lower dose of *K. senegalensis* manure (KH1) have given the lowest seedlings shoot masses, and with corresponding values significantly different from the other treatments. The rest of the tree manure doses produced seedlings shoot masses that fell in the second range to the two groups of treatments described above. On the other hand, the higher doses of *A. indica* manures (AZ3 and AZ2) have induced greater root masses than the other treatments and with significant differences at p < 0.05. NPK fertilizer and the larger doses of *K. senegalensis* manures have produced the second bigger values of the seedlings root masses. Whereas, root masses given by *A. lebbeck* manures were close to the Control value and did not differ significantly. The treatments effects on the masses of the whole seedlings occurred in the following sequence: the first group consisted of the higher doses of *A. indica* manures (AZ3 and AZ2) and NPK fertilizer, then *K. senegalensis* (KH3 and KH1) and lower dose of *A. indica* manure (AZ1), and in the third place were higher doses of *A. lebbeck* manures (AL3, AL2 and AL1) and middle dose of *K. senegalensis* (KH2) and lastly was the Control. The shoot/root masses ratios were all above unity value. The Control and lower doses of *A. lebbeck* manures (AL2 and AL1) had the higher values (3.1 on the average), while the larger doses of *K. senegalensis* manures (KH3 and KH2) had the smaller values (1.2 on the average).
Figure 3. Comparison of *A. senegal* seedlings’ diameter growth variation in the Control
(◇), NPK fertilizer (□) and tree manures: A: A. lebbeck; B: A. indica and C: K. senegalensis manures; Δ: 25, ○: 50 and *:75 g.
Table 2. *Acacia senegal* seedlings growth parameters as affected by clay soil treated by tree manures and NPK fertilizer

<table>
<thead>
<tr>
<th>Treatments†</th>
<th>Shoot height (cm)</th>
<th>Root length (cm)</th>
<th>Shoot/Root Lengths ratio</th>
<th>Diameter (mm)</th>
<th>Shoot mass (g)</th>
<th>Root mass (g)</th>
<th>Seedling mass (g)</th>
<th>Shoot/Root mass ratio</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
<td>36.9b</td>
<td>45.2a</td>
<td>0.8b</td>
<td>4.6c</td>
<td>1.6d</td>
<td>0.7d</td>
<td>2.3e</td>
<td>3.2a</td>
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<tr>
<td>NPK</td>
<td>54.5a</td>
<td>45.4a</td>
<td>1.3a</td>
<td>6.3a</td>
<td>4.5a</td>
<td>2.0b</td>
<td>6.5a</td>
<td>2.3bc</td>
</tr>
<tr>
<td>AL1</td>
<td>44.1ab</td>
<td>61.4a</td>
<td>0.7b</td>
<td>5.2b</td>
<td>2.4b</td>
<td>0.8d</td>
<td>3.3d</td>
<td>3.0ab</td>
</tr>
<tr>
<td>AL2</td>
<td>40.7b</td>
<td>54.6a</td>
<td>0.8b</td>
<td>4.5c</td>
<td>2.8c</td>
<td>0.9d</td>
<td>3.7d</td>
<td>3.0ab</td>
</tr>
<tr>
<td>AL3</td>
<td>41.5b</td>
<td>49.4a</td>
<td>0.9b</td>
<td>4.5c</td>
<td>2.8c</td>
<td>1.1c</td>
<td>3.8c</td>
<td>2.6ab</td>
</tr>
<tr>
<td>AZ1</td>
<td>44.8ab</td>
<td>66.4a</td>
<td>0.7b</td>
<td>6.5a</td>
<td>3.3bc</td>
<td>1.4b</td>
<td>4.7b</td>
<td>2.5ab</td>
</tr>
<tr>
<td>AZ2</td>
<td>43.0b</td>
<td>51.1a</td>
<td>0.9b</td>
<td>6.4a</td>
<td>3.9b</td>
<td>2.5a</td>
<td>6.3a</td>
<td>1.6cd</td>
</tr>
<tr>
<td>AZ3</td>
<td>54.6a</td>
<td>53.8a</td>
<td>1.3a</td>
<td>6.7a</td>
<td>4.2a</td>
<td>2.7a</td>
<td>6.9a</td>
<td>1.6cd</td>
</tr>
<tr>
<td>KH1</td>
<td>47.9ab</td>
<td>63.7a</td>
<td>0.8b</td>
<td>5.8b</td>
<td>2.9c</td>
<td>1.2c</td>
<td>4.1bc</td>
<td>2.6ab</td>
</tr>
<tr>
<td>KH2</td>
<td>45.5ab</td>
<td>65.0a</td>
<td>0.7b</td>
<td>5.7b</td>
<td>1.9d</td>
<td>1.8b</td>
<td>3.8c</td>
<td>1.1d</td>
</tr>
<tr>
<td>KH3</td>
<td>42.0b</td>
<td>61.0a</td>
<td>0.7b</td>
<td>5.5b</td>
<td>2.7c</td>
<td>2.1b</td>
<td>4.7b</td>
<td>1.3d</td>
</tr>
</tbody>
</table>

*Control (zero addition); NPK fertilizer (addition of 30 g); AL: *A. lebbeck*, AZ: *A. indica* and KH: *K. senegalensis*; 1, 2 and 3 correspond to 25, 50 and 75 g of tree manure. Values in the column followed by different letter(s) are significantly different at p < 0.05.
DISCUSSION

The contents of protein, N, P, K and organic carbon in the *K. senegalensis* manure are lower than that in the *A. indica* and *A. lebbeck* tree manures. Our findings regarding N, P and K contents are in agreement with the Roy *et al.* (2006) who mentioned that nitrogen is the most abundant mineral nutrient in plants. It constitutes 2–4 percent of plant dry matter. Phosphorus is much less abundant in plants (as compared with N and K) having a concentration of about one-fifth to one-tenth that of N in plant dry matter. Also potassium is the second most abundant mineral nutrient in plants after N; it is 4 to 6 times more abundant than the macronutrients P, Ca, Mg and S. Organic carbon contents in these tree species are similar to what is observed in legumes tree species; even though, it is slightly lower in *K. senegalensis* than in the other species. C/N ratios in *A. lebbeck* and *A. indica* are low (15) denoting riches manure which should decompose readily. But, C/N ratio in *K. senegalensis* is twice higher than that in the precedent species, which implies that the foliage of this species is of acidic type (with high contents of polyphenols) which would not decompose easily and may tend to accumulate.

*A. senegal* seed germination percentage was higher in the tree manure, particularly in the media containing *A. indica* and *A. lebbeck* manures when compared with the NPK fertilizer and the Control; seed germination percentages in *K. senegalensis* were similar to those in the Control. The higher germination percentages recorded in the media of tree manures could be attributed to the fact that tree manure when mixed with clay soil tend to lower bulk density, increase aeration and water holding capacity of the media and should eventually maintain higher germination. Önenli (2004) reported that seedling emergence vigor increases exponentially with increasing soil organic matter content. Bot and Benites (2005) reported that some of the humic and fulvic substances function as natural plant hormones (auxines and gibberillins) and are capable of improving seed germination; also some sugars may stimulate seed germination. TTSA (1996) reported that one kg of *A. senegal* seeds contains about 9000 seeds and may produce 8000 seedlings under ideal conditions. But, in many cases only 7000 seedlings per kg are obtained i.e. with germination percentage about 77.8%. Kung’u *et al.* (2008) found that compost-based growing medium gave higher seed germination percentage of *Tamarindus indica* as compared to sand and farm media (which gave the lowest seed germination percentage). Also, they reported that some researchers who work on *A. indica*, found a mixture of sand, soil and humus in the ration of 1:1:1 exhibiting higher germination percentage than either sand, red soil or black soil. Sangakkara *et al.* (2004) also found that the organic materials (rice straw and fresh Gliricidia leaves) increased germination. The low germination percentage recorded in the clay medium may be due to its impervious nature causing water logging, which in turn hampers gaseous exchange that inhibits seed germination and mortality ultimately (Kung’u *et al.*, 2008). Even though, *K. senegalensis* manure did not stimulate *A. senegal* seeds germination with the
same vigor as the other tested tree manures. In fact some types of organic matters are known to suppress seed germination through a process generally termed as allelopathic effects; in which phytotoxic compounds (polyphenols) damage or inhibit seed germination of many plant species (Magdoff and van Es, 2000; Said-Pullicino et al., 2007; Kung’u, et al., 2008; Mubarak et al., 2009).

The results summary of the effects of tree manures and NPK fertilization on the growth of A. senegal seedlings has shown that the performance of the various treatments were as follows: NPK > A. indica (AZ) > A. lebbeck (AL) > K. senegalensis (KH) > Control (Cont). The stimulation of A. senegal seedlings growth by these substrates was due to their amelioration of the physicochemical conditions of the growing media. The treatments with the application of inorganic NPK fertilizer had a relatively higher performance than the tree manures, because the nutrients were availed readily through solubilization (Davey, 1984; Brozek and Wanic, 2002; Gungula and Tame, 2006). However, it is remarkable that the performance of the tree manures on A. senegal seedlings growth stimulation, particularly that of A. indica and A. lebbeck was identical to that of NPK fertilizer. This indicates that, the manures of these tree species are easily decomposable (have low C/N ratios) and release plenty of nutrients, and in addition to the organic matter that amends the media and nourish the seedlings (Mafongoya et al., 1998; Giller, 2001; Young, 2002; Mandal et al., 2003; Schroth and Sinclair, 2003). Besides, manure of A. indica is known to act as pest and disease control, thus helping to create healthy growing environment for the seedlings (NAS, 1992; Mordue et al., 2005; Agyarko et al., 2005; Helmy et al., 2007; Solomon et al., 2008).

The low growth of A. senegal observed in the media amended with KH tree manure comparing to the other tree manures could be due to poor nutrient contents in this material and reduced decomposition rate due to high C/N ratio (Bot and Benites, 2005; Roy et al., 2006). More over, the seedlings growth might has been affected by high lignin and polyphenols in the KH manure, which are considered as phytotoxic substrates for some plants (Giller et al., 2006; Zeng et al., 2008). However, seedlings in KH manures had longer roots than the other used manure types; a plausible reason to this response may stem from the fact that, the manure of KH had low nutrient content and in addition its high lignin and polyphenols might have caused further nutrients immobilization, especially N and P, from the surroundings. In these conditions roots have to explore more soil volume in search of nutrients to aid the growth of the seedlings (Harris, 1992; Sileshi et al., 2007).

CONCLUSIONS

Results showed the great potential of tree manures (in comparison with NPK fertilizer and control treatments) which can be incorporated in the nursery growing media. Azadirachta indica tree manures applications induced the highest effects on
A. senegal seedlings followed by Albizia lebbeck. Khaya senegalensis manure was however found unfavorable to A. senegal seedlings shoot height growth; but was inducive to root growth. Tree manures effects on A. senegal seedlings growth increased with increasing amounts of applications: 75 g > 50 g >> 25 g doses. Further work is needed to confirm these findings and to explore more combinations of other tree manures-seedlings treatments.

REFERENCES


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