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# Effect of Amendment and Composting on the Effectiveness of Saw Dust as an Organic Fertilizer

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**Abstract**
*Saw dust is an organic material that is abundant in Nigeria but which is yet to be utilized for soil improvement purposes particularly in the tree and horticultural nursery potting mixtures where organic matter addition has been described as sine quanon. A greenhouse experiment was conducted in Iwo, Nigeria to examine the effect of amended and composted saw dust on the growth of Gmelina arborea tree species, a valuable tropical hardwood. Raw saw dust (RS) was combined with partially burnt (charred) saw dust (PS), partially rotted cow dung (CD) and saw dust ash (SA) at ratio 1:1:1:0.5 (w/w) and incubated for 0, 7, 14, 21 and 42 days. The plants were grown for twelve weeks in top soil (0 – 30cm) collected from an Oxisol in the University research farm. The organic materials were applied at an equivalent rate of 5t ha$^{-1}$. The results indicated that the tree species responded positively to the organic material amendment. Irrespective of composting period, growth rate, height, stem diameter, leaf production and dry matter yield increased over the control in all treatments having organic material addition. The higher the composting period of the amended saw dust, the more beneficial its effect on plant growth. The result was comparable to that of either 15-15-15 NPK mineral fertilizer or cow dung.*

**Keyword:** *Saw dust, **Gmelina arborea**, Composting, Nursery.*

## Introduction

One of the key factors that determine growth rate and biomass production of trees in plantations is the quality of the seedlings produced in the nursery (Fagbenro 2001b). The quality of planting stock in turn depends on the nature and component of potting mixture used in the nursery for their production. According to Wilde (1958), a tree nursery soil should have at least 2% of organic matter and appreciable quantity of plant nutrients. But Nigerian foresters are not always lucky to have nursery site or soil with the desired amount of organic matter and nutrients required for the production of healthy and vigorous planting stock (Fagbenro *et al* 2000).

Mineral fertilizers are not usually used to raise tree seedlings in the nursery in Nigeria. Apart from the economic cost, nursery seedlings of maximum weight produced by application of mineral fertilizers have been reported to have succulent tissue, unbalanced top-root ratio and unsatisfactory properties which lower their ability to survive on cut-over lands (Fagbenro and Olunuga, 1989). Besides, Wangari and Sanford (1984) have observed that mineral fertilizers can only supply the specific nutrients they contain to the soil, but cannot provide the additional effects of organic matter for prevention of erosion, run-off, nutrients leaching, improvement of cation exchange capacity (CEC) and the water holding capacity of the soil. This is why Olagunju and Ekwebelam (1985) described organic matter as a component that cannot be done without in horticultural or tree potting mixtures.

Horticulturists, gardeners and tree nursery managers have traditionally utilized animal manures such as poultry droppings, cow dung or horse dung to improve the quality of the nursery potting mixtures. But there are other organic materials that are more abundant in the country and which can be processed to improve their effectiveness as organic soil conditioners or fertilizer. One of such organic materials is saw dust (Fagbenro *et al* 2000). Saw dust is a by-product of saw-milling. Titiloye (1982) reported that the country saw mills produced about 333,500$m^3$ of saw dust in 1981. This number must have been doubled by now. But in spite of its abundance, saw dust is at present regarded as an environmentally unacceptable commodity that is indiscriminately being burnt in virtually all saw mills that are scattered all over the country. The burning of the saw dust is undoubtedly contributing significantly to global warming and climate change through the release of greenhouse gases (GHGs), especially $CO_2$, into the atmosphere.

Fortunately, review of literature has indicated that saw dust can be used for productive purposes especially as a soil conditioner. It however needs to be pre-treated, amended, processed, composted, pyrolysed or otherwise treated to enhance its effectiveness as a soil organic conditioner without having to wait for months for its microbial degradation (Arends and Donkeslootshouq 1985; Stephenson 1987; Fagbenro *et al* 2000). This is because of its high lignin content and wide C:N ratio (Carbon-nitrogen ratio) which can cause nitrogen immobilization if applied directly to soil without pre-treatment. The present study was conducted to investigate the effect of amendment and composting on the effectiveness of saw dust as an organic fertilizer. The test plant is *Gmelina arborea* tree species, a valuable exotic hardwood. This investigation is one of the series of studies to know the most effective and cost-effective ways of processing saw dust for crop production.

## Materials and Methods

Bulk surface soil (0 – 30cm) was collected from an unfertilized agricultural farm formerly grown to maize and cowpea during last year's planting season from Bowen University teaching and research farm. The soil is grouped as Oxisol (Arbert and Tarenier 1972; FAO/UNESCO 1977). It was air-dried, ground and sieved through 2-mm sieve. Some physical and chemical properties of the soil were determined and are presented in Table 1.

**Table 1: Some properties of soil (0-30cm) sample used for the greenhouse experiment**

| Properties | | Value |
|---|---|---|
| Texture | | |
| Sand (%) | | 86 |
| Silt (%) | | 8 |
| Clay (%) | | 6 |
| pH ($H_2O$) | | 6.2 |
| Total N (%) | | 0.032 |
| Organic C (%) | | 1.17 |
| Av. P (mg/kg) | ---------------------- | 80.81 |
| Ca (cmol/kg) | ---------------------- | 6.96 |
| Mg (cmol/kg) | ---------------------- | 0.98 |
| Kg (cmol/kg) | ---------------------- | 0.21 |
| Na (cmol/kg) | ---------------------- | 0.35 |
| Mn (mg/kg) | ---------------------- | 331.92 |
| Fe (mg/kg) | ---------------------- | 47.14 |
| Cu (mg/kg) | ---------------------- | 0.56 |
| Zn (mg/kg) | ---------------------- | 6.75 |

Viable seeds of *Gmelina arborea* were procured and were pre-treated by soaking them in cold water for 48 hours and germinated in a germination box containing a mixture of topsoil and sand (1:1, w/w).

Raw saw dust (RS), partially burnt (charred) saw dust (PS) and saw dust ash (SA) were collected from a local sawmill while a partially rotted cow dung (CD) was obtained from an abattoir within Iwo municipality. The four organic materials were combined at ratio 1:1:1:0.5 (RS:PS:CD:SA, w/w on dry basis). The materials were moistened to 50% water holding capacity (WHC) and mixed thoroughly on a polythene sheet. An equal weight of the mixture was put in a black polythene bag covered with a white transparent polythene sheet having 4 holes for gas exchange and then incubated aerobically at room temperature away from dust for 0, 7, 14, 21 and 42 days. At each due day, sample was air-dried for 72 hours and then oven-dried at 65$^{o}$C for 48 hours. Some properties of the organic materials are as indicated in Table 2.

**Table 2: Some properties of organic materials used for the greenhouse experiment**

| Organic Type | pH ($H_2O$) | C | N | P | K | Mg | Ca | Na | Mn | Fe | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ← | | | % | | | → | ← mg/g | | | → |
| Raw saw dust (SD) | 7.3 | 19.4 | 0.038 | 0.05 | 0.29 | 0.10 | 0.61 | 10.10 | 19.04 | 207.18 | 0.52 | 9.32 |
| 0 – day | 10.0 | 18.0 | 0.137 | 0.08 | 1.65 | 1.59 | 8.47 | 56.21 | 493.12 | 10,000.02 | 21.93 | 103.96 |
| 7 – day | 9.8 | 17.6 | 0.148 | 0.08 | 1.61 | 1.06 | 7.90 | 54.42 | 583.08 | 8,800.17 | 19.26 | 98.61 |
| 14 – day | 9.9 | 17.2 | 0.188 | 0.08 | 1.51 | 1.05 | 18.63 | 47.73 | 427.11 | 7,480.24 | 18.33 | 92.64 |
| 21 – day | 8.8 | 17.1 | 0.210 | 0.10 | 1.54 | 1.06 | 19.47 | 46.20 | 424.09 | 6,570.09 | 17.76 | 89.41 |
| 42 – day | 7.1 | 10.7 | 0.257 | 0.09 | 1.66 | 1.21 | 10.56 | 54.41 | 566.14 | 7,979.14 | 21.95 | 84.34 |

Four grams of each organic material was added to 2kg soil, an equivalent rate of 5 t $ha^{-1}$ while the NPK inorganic fertilizer (15:15:15) was applied at the rate of 12.9kgN$ha^{-1}$ which was the equivalent of %N contained in the amended saw dust composted for 42 days (Table 2). Each treatment was thoroughly mixed with the soil and put in a black 4-litre plastic pot having four draining holes at the bottom. The holes were lightly plugged with non-absorbent cotton wool to prevent loss of soil and nutrients. The mixture in the polypot was then moistened with deionised water to 50% water holding capacity and left for 7 days to equilibrate.

*Gmelina arborea* seedlings of similar height were transplanted at 2-leaf stage into the polypots at one per pot. Apart from the control, there were eight treatments altogether, namely organic material incubated for zero day (0-day), 7 days (7-day), 14 days (14-day), 21 days (21-day) and 42 days (42-day), raw saw dust (SD), cow dung (CD) and inorganic NPK fertilizer (IN). The pots were left on the greenhouse benches using random numbers to determine their respective positions. Watering was done as necessary. The statistical design adopted was a completely randomized one, while the treatments were replicated three times.

At fortnight intervals, seedling height was measured with a ruler from the soil surface to the seedling tip while the stem diameter was measured with a micrometer at the crown line to the nearest mm. The leaf count was also recorded fortnightly. At the end of 12 weeks, the experiment was terminated. The fresh shoot (leaf + stem) and root were weighed and then oven-dried separately at 70ºC until constant weight was obtained. Total dry matter weight was then determined.

Particle size analysis of the <2mm soil sample was determined by the improved Bouyocous hydrometer method (Bouyocous 1962) while all chemical analyses were done using routine procedures (IITA 1982).

Monthly increase in heaight, stem diameter and leaf growth rates of G*melina arborea* was determined by finding the difference between parameter measurement at the beginning of each month and measurement at the end of the month.

Analysis of variance was conducted and least significant differences at the 5% level of probability estimated to test for significance of results.

## Results and Discussion

### The effects of all treatments on growth rate

Data on monthly increase in seedling height, stem diameter and leaf growth rates as affected by various treatments are presented in Table 3.

**Table 3: Monthly increase in height (cm), stem diameter (mm) and number of leaf growth rates of *Gmelina arborea* seedlings as affected by raw saw dust amended composted saw dust, cow dung and inorganic NPK fertilizer.**

| Treatment | 1 Month | | | 2 Months | | | 3 Months | | |
|---|---|---|---|---|---|---|---|---|---|
| | Height | Stem Diameter | No of Leaf | Height | Stem Diameter | No of Leaf | Height | Stem Diameter | No of Leaf |
| Control | $2.4^{d}$ | $0.5^{b}$ | $4^{a}$ | $2.2^{d}$ | $1.0^{bc}$ | $2^{b}$ | $1.5^{c}$ | $0.7^{bc}$ | $2^{b}$ |
| 0 – day | $4.8^{bc}$ | $1.2^{a}$ | $4^{a}$ | $5.4^{bc}$ | $1.7^{ab}$ | $3^{ab}$ | $3.8^{b}$ | $1.0^{ab}$ | $3^{ab}$ |
| 7 – day | $4.8^{bc}$ | $1.2^{a}$ | $3^{a}$ | $6.4^{ab}$ | $1.2^{abc}$ | $3^{ab}$ | $4.8^{ab}$ | $0.9^{abc}$ | $4^{a}$ |
| 14 – day | $5.3^{abc}$ | $1.5^{a}$ | $4^{a}$ | $6.5^{a}$ | $1.3^{abc}$ | $3^{ab}$ | $5.3^{a}$ | $1.0^{ab}$ | $4^{a}$ |
| 21 – day | $5.5^{ab}$ | $1.5^{a}$ | $3^{a}$ | $5.1^{c}$ | $1.9^{a}$ | $3^{ab}$ | $4.0^{ab}$ | $1.0^{ab}$ | $3^{ab}$ |
| 42 – day | $6.5^{a}$ | $1.5^{a}$ | $3^{a}$ | $6.2^{ab}$ | $1.8^{a}$ | $4^{a}$ | $5.1^{ab}$ | $1.2^{a}$ | $4^{a}$ |
| SD | $4.4^{bc}$ | $1.0^{ab}$ | $3^{a}$ | $5.4^{bc}$ | $0.8^{c}$ | $2^{b}$ | $4.6^{ab}$ | $0.8^{bc}$ | $2^{b}$ |
| CD | $4.3^{bc}$ | $1.0^{ab}$ | $4^{a}$ | $6.0^{abc}$ | $1.5^{abc}$ | $4^{a}$ | $5.0^{ab}$ | $1.0^{ab}$ | $3^{ab}$ |
| IN | $4.2^{c}$ | $1.0^{ab}$ | $4^{a}$ | $5.9^{abc}$ | $1.6^{ab}$ | $3^{ab}$ | $4.7^{ab}$ | $0.6^{c}$ | $3^{ab}$ |

**Footnote:** In this and other tables, values in one column followedby the same letter are not significantly different at $P \leq 0.05$

The result indicated that *Gmelina arborea* seedlings responded positively to soil amendment. Seedling height growth rates were rapid during the first month and increased thereafter. Height growth rates of seedlings in all treatments having organic materials and inorganic fertilizer were statistically higher than the control. Generally, the longer the composting period of amended saw dust, the higher its effectiveness on seedling height growth rate. Throughout the 3-month growth period, seedlings in the treatment that received 42-day composted saw dust were tallest when compared to other treatments. However, there was no significant difference between height growth rates of seedlings in treatments amended with 14, 21 and 42-day composted saw dust during the first month of growth. Similar trend was observed for stem diameter growth rate and number of leaves produced. However, increase in stem diameter growth and leaf production during the first month did not differ significantly among all treatments with the exception of the control that was significantly inferior in stem diameter to other treatments.

The peak of seedling growth rate in height and stem diameter appeared to be at the end of 2 months of growth except for the seedling height growth rate in the control that was slightly reduced during the second month. The trend for monthly increase in number of leaf was not so apparent. Increase in the number of t leaf produced by the seedling during the second and third months was statistically similar in all treatments. However, the control and raw saw dust treatment produce seedling that had significantly less monthly increase in number of leaf when compared to 42-day compost treatment (second month) and 14-day and 42-day compost treatments (third month).

The initial higher growth rate of seedlings in the control is probably due to the flux of nutrients already present in the soil which was later depleted as a result of plant growth and hence the observed reduction in plant height growth during the second month. This finding is similar to the one reported by Aluko (1982) and Fagbenro and Agboola (1993). The positive response of *Gmelina arborea* seedlings to fertilization confirms the fact that all plants, whether arable orforest crop, require adequate supply of essential nutrients to grow optimally. Several workers have reported similar result (Nwoboshi 1973; Aluko 1982; Fagbenro *et al* 1999; Fagbenro 2001b). The increased seedling growth rate in all treatments amended with organic materials throughout the 3-month growing period is probably indicative of the continuing mineralization of the added organic materials which possibly resulted in increase in nutrients and other low and high molecular weight organic compounds which stimulated plant growth (Fagbenro and Agboola 1993). According to Flaig (1975), the effect of physiologically active substances, including humic acid (HA) which is believed to be present in the composted organic material, is to improve plant yield if one or several growth factors are in deficit or in excess. The reduced rates of seedling growth in all treatments during the 3rd month of growth might not be unconnected with reduced mineralization of added organic materials with consequent reduction in plant nutrients which resulted in reduced plant growth. The fast depletion of nutrients in the raw and amended saw dust treatments could also be attributed to the inherent low level of nutrients in saw dust which actually is limiting its uses agriculturally.

**The effects of all treatments on plant terminal parameters**

Data on the effect of various treatments on height, stem diameter, leaf production, total dry matter and root/shoot ratio of 12-week old *Gmelina arborea* seedlings are presented in Tables 4 and 5.

**Table 4: Effect of amended composted saw dust, cow dung and inorganic NPK (fertilizer) on height (cm) and stem diameter (mm) growth of 12-week old *Gmelina arborea* seedlings**

| Treatment | Height | Stem Diameter |
|---|---|---|
| Control | 10.3[b] | 4.3[c] |
| 0 – day | 17.0[a] | 4.7[abc] |
| 7 – day | 17.2[a] | 4.6[bc] |
| 14 – day | 17.1[a] | 4.7[abc] |
| 21 – day | 16.8[a] | 5.1[ab] |
| 42 – day | 20.5[a] | 5.5[a] |
| SD | 16.3[a] | 4.6[bc] |
| CD | 16.6[a] | 4.7[abc] |
| IN | 17.0[a] | 4.4[bc] |

**Table 5: Effect of amended composted saw dust, cow dung and inorganic NPK fertilizer on number of leaf, total dry matter production and root/shoot ratio of 12-week old *Gmelina arborea* seedlings**

| Treatment | No of Leaf | Total dry matter yield (g) | Root/Shoot Ratio |
|---|---|---|---|
| Control | 17[b] | 3.0[ab] | 0.5[a] |
| 0 – day | 18[b] | 2.9[b] | 0.5[a] |
| 7 – day | 17[b] | 3.1[ab] | 0.4[a] |
| 14 – day | 19[b] | 3.4[ab] | 0.4[a] |
| 21 – day | 20[b] | 3.0[ab] | 0.5[a] |
| 42 – day | 23[a] | 3.7[a] | 0.4[a] |
| SD | 17[b] | 2.8[b] | 0.5[a] |
| CD | 17[b] | 2.9[ab] | 0.5[a] |
| IN | 17[b] | 2.7[b] | 0.5[a] |

All treatments that received amended composted saw dust produced seedlings that were statistically taller than those grown in the control (Table 4). However, addition of amended saw dust composted for 0, 7, 14, 21 and 42 days did not result in significant difference in height growth. Although, all treatments that had amended composted saw dust produced seedlings that had greater stem diameter than that in the control, the differences were not statistically significant except for the seedlings in the treatment that received 21-day and 42-day composts. Similar trend was observed for total dry matter yield where seedlings produced in all treatments that received amended composted saw dust were not statistically different from the control (Table 4). As for the number of leaves produced, it was only the seedling grown in the 42-day compost treatment that produced leaves that were significantly more than those in the control and in other compost treatments. Seedling root/shoot ratio generally decreased from the control to the 42-day compost treatment although the differences were not significant.

In all cases, seedling grown in the treatment that received 42-day compost was superior in height, stem diameter, number of leaf and total dry matter to those produced in the other treatments having 0, 7, 14 and 21-day composts, though, in most cases, not significantly. Tables 4 and 5 also show that seedling in the 42-day composted amended saw dust treatment was statistically better in all the plant parameters considered than those produced either in treatment that had inorganic NPK fertilizer, cow dung or raw saw dust.

Addition of composted amended saw dust increased land production suggesting that saw dust can be effectively processed to increase its effectiveness as a soil conditioner and organic fertilizer. The result obtained is similar to the finding of Fagbenro and others (2000) who reported positive effect of chemically treated and composted saw dust on plant growth. Length of composting period was found to be very critical in the processing of saw dust as a soil conditioner for plant growth. The longest composting period of 42 days employed in this study was probably not the optimum as composting period tended to improve the effectiveness of the amended saw dust. This is suggesting that further investigation is required in this area. The enhanced effectiveness of amended saw dust with length of composting period is probably due to the continuous humification of saw dust over time which effectively reduced its carbon content, leading to increase in other plants nutrients. This is probably the case when the analytical data presented in Table 2 for each amended saw dust composted for different periods of time are considered.

Equal production of root and shoot is a desirable property in nursery tree seedlings. Such balanced seedlings are believed to withstand drought better than the unbalanced ones when planted out in the field (Wilde *et al* 1972). Application of amended composted organic materials however resulted in the production of unbalanced *Gmelina* seedlings. The lower than unit root/shoot ratio, which decreased with composting period, implies that the length of composting period encouraged greater production of shoot at the expense of root. This is probably due to the effect of relatively high N content in the soil and in the applied composted amended saw dust when compared to their P content. Tauseau *et al* (1953) and Tisdale and Nelson (1975) reported that root/shoot ratio is inversely proportional to N concentration supply in soil. Phosphorus is known to encourage plant root growth (Aluko 1982).

Data recorded in this study also showed that effect of composted amended saw dust on plant growth was comparable to that of either inorganic NPK fertilizer or cow dung. In fact, amended saw dust composted for 42 days appeared to be superior to both of them. The superiority of 42-day composted amended saw dust over the inorganic NPK fertilizer was probably due to the presence of nutrients other than N, P and K in the composted amended saw dust which were not present in inorganic NPK fertilizer. Wangari and Sanford (1984) have observed that mineral fertilizers can only supply the specific nutrients they contain to the soil, but cannot provide the additional effects of organic matter for prevention of erosion, run-off, nutrient leaching, improvement of cation exchange capacity (CEC) and the water holding capacity of the soil apart from the nutrients it contained. This is why Olagunju and Ekwebelam (1985) described organic matter as an indispensable component of horticultural or tree potting mixtures.

**Conclusion**

Optimum composting period for the amended saw dust used in this study was inconclusive. Nevertheless, the data presented in this investigation showed a trend that co-composting a high quality organic material such as cow dung with saw dust which is a low quality organic material, can enhance the effectiveness of the latter as an organic soil amendment. There is however the need for further study on the optimum composting period and optimal application rate for the composted amended saw dust using different soil types and tree species.

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