**Impact of Pulverized Foliage Compost on Seedling Growth and Development of *Syzygium Cumini* in Sudano-Sahelian Ecosystem**

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**Abstract**

*This study examined the effect of pulverized foliage compost on the growth and development of Syzygium cumini seedlings in the Sudano–Sahelian ecosystem. Foliage from Khaya senegalensis, Gmelina arborea, Syzygium cumini and Ziziphus spina-christi was collected at the University of Maiduguri, sorted, sun-dried to reduce moisture, and pulverized using a motorized disc refiner. The pulverized foliage was grouped into four composting materials (M1–M4) and buried at varying depth for 60 days. A potting mixture of river sand and compost at a 3:1 ratio was prepared. Fresh S. cumini seeds from healthy mother trees were sorted and sown at 3 cm depth. Growth parameters (number of leaves, stem height, stem diameter) and developmental parameters were recorded after eight weeks and analyzed using ANOVA and regression. Results showed that S. cumini's own pulverized compost produced the lowest mean growth values after Gmelina arborea. Significant differences ($P < 0.05$) in stem height were observed for S. cumini in some weeks, although leaf number and stem diameter remained largely unchanged. Variations in stem height may reflect differences in nutrient release during early seedling stages, while non-variation in weeks one and eight could indicate incomplete compost stabilization initially or nutrient depletion later. Developmental parameters revealed that K. senegalensis compost yielded the lowest mean values (except root length), whereas Z. spina-christi compost produced the highest mean values. The findings suggest that pulverization enhances mineralization of foliage during decomposition and composting, and thus foliage should be pulverized before composting to improve seedling performance.*

**Keyword**: Pulverization, Foliage, Compost, Growth-Developmental parameters

## Introduction

Great varieties of trees, shrubs and herbs particularly *Syzygium cumini* exist in the Semi -Arid region, however due to the overpopulation through influx to Maiduguri, exploitation of timber and non-timber forest resources from *Syzygium cumini* and communal/security conflicts and other natural disasters in the semi-arid zone of Nigeria, the availability of this tree species for utilization, protection and conservation of environment becomes a major concern. *Syzygium cumini* survival in either natural or artificial forest depends largely on the growth, developmental and survival of its seedlings. Furthermore, Seedling growth and survival of *S. cumini* is a function of nutrients availability and subsequent uptake by the plant. Compost increases the concentration of other nutrients such as calcium zinc, manganese, and copper (Mylavarapu and Zinati, 2009). While

Composting is a natural process of biological decomposition and stabilisation of organic waste (Schulz *et al.*, 2013). Composting therefore helps in breaking down lumps of organic matter there by increasing the nutrient status of the soil and enhance productivity (Morales and Wolf, 2010). Composting refers to the biodegradation process of a mixture of organic substrate by bacteria (actinomycetes) and fungi (Day and Shaw, 2001). However, composting differs from other decomposition systems due to control in temperature and rate of decomposition (Misra *et al.,* 2003). Compost is widely used for agriculture and horticulture especially on poor soils. Its applications result in a range of environmental benefits which include improved soil health, water savings, reduction in the use of synthetic fertilizer and improved crop productivity (Schroth *et al*., 2003). According to Tejeda *et al*. (2009) a primary benefit of compost application on soil physical properties is to reduce bulk density and increase total porosity. However, compost application can improve soil structural stability, aggregate formation and hydraulic conductivity (Curtis and Claassen, 2005). Lakhdar *et al.* (2009) reported that compost application changes soil chemical properties and increases soil nutrients, efficiency of nutrients and partial replacement of inorganic fertilizer. Compost application improves soil fertility by increasing the concentration of nitrogen, phosphorus, and potassium (NPK) and other nutrients (Castillejo and Castello, 2010). However, the effect varies with application rate and compost type. Compost is a valuable slow-release nitrogen source with a stronger residual effect on soil fertility than chemical fertilizers (Krause *et al*. 2015).

Composting has also been gaining increasing attention as an alternative way of waste processing. In addition to the organic fraction of municipal solid waste (MSW), it is now also being adapted for treatment of various other types of organic waste such as farm manures, sewage sludge, and industrial sludge (Fiscer and Glaser,2012). Indeed, the composting process has the ability to reduce pathogenic bacteria, viruses, and parasites in such waste material, which could otherwise pose a health risk. Although pathogens cannot be eliminated completely via composting, the presence of pathogens in litter compost is lower than in livestock manures (Wébster and Fransis, 2016).

There are two main types of composting: cold composting (known as passive composting) and hot composting (known as active composting) ((Meiuer, *et al.,* 2009). Cold composting breaks down organic matter slowly, but also takes the least amount of effort and maintenance. Cold composting process is primarily anaerobic, meaning that the organic materials are broken down by microorganisms that thrive in an oxygen-deprived environment (Bar and Ori, 2014). In addition to being slower to break down, cold piles may be smelly (Bar and Ori, 2014). Hot composting is faster but involve more management process: this method requires attention to keep carbon and nitrogen in the optimum ratio (Bar and Ori, 2014).

**Methodology**

The experiment was conducted in the Nursery site of the Department of Forestry and Wildlife, University of Maiduguri in Jere Local Government of Borno State, Nigeria. Jere local government lies within Latitude $11^{o}$ 50‟and12$^{o}$ 05‟N and Longitude $13^{o}$.50‟and $12^{o}$.20‟ E. of the equator (Fig. 1). Jere local Government occupies a total landmass of 868 square kilometers at an elevation of 306 meters (1,004 feet) (Borno State Ministry of Land and Survey (MLS), 2008).

Jere local government is typically of dry tropical climate with distinct wet and dry season. Months of March and April are the hottest periods of the year with temperature ranging from $30^{0}$C to $40^{0}$C respectively. It is usually cold and dry during harmattan period (November to January). The area has an annual rainfall range of 500-700mm per annum (NIMET, 2008). Jere local government lies in the SudanoSahelian ecological zone characterized by trees and vast grassland: the grasses are seasonal and disappear during dry season (DMS, 1992).

The study area has the following grasses; *Cyperus rotundus, Cyperus arenarius,Cynodon dactylon* and some trees species which include: *Acacia Senegal, Balanite aegyptica, Piliostigma thonningii, Adansonia digitata, Azadirachta indica, Eucalyptus camaldulensis, Calotropis procera, Acacia nilotica* with some shrubs as follows; *Dichrostachys cinerea, Grewia bicholor,Ziziphus mucuronata*.

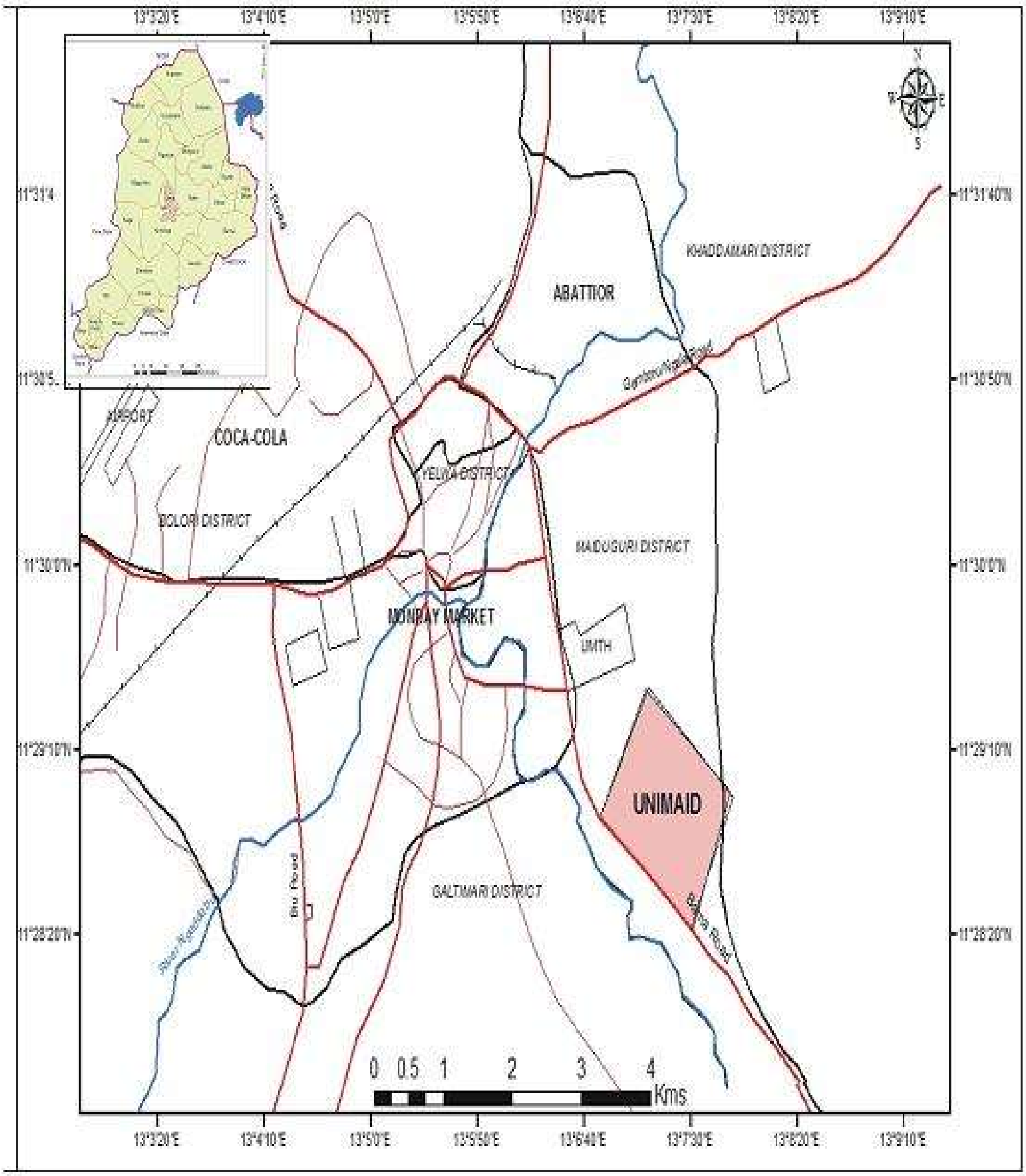


**Fig.1:** Map of Jere Local Government Showing the Study Area
**Source**: Department of Geography, University of Maiduguri

### Collection of samples and procedure for composting

Foliage of *Khaya senegalensis, Gmelina arborea, Syzygium cumini* and *Zizipus spins-christi* were collected within the premises of the University of Maiduguri. The collected foliage were further sundried to minimize the moisture content and to aid pulverization using a motorized disk refiner.

Pit composting (subsurface) and surface composting were adopted in line with Kuo (2004) procedure. With regards to pit composting, the pulverized foliar materials after collection undergo pulverization using motorized disc refiner, two kilogram (2kg) of pulverized foliar materials was used in a polythene sacs and buried at 60cm depth, while another 2kg of same pulverized foliar materials were poured in tight polythene sac containers and kept in open spaces for composting for 60 days . The composts were turned through the vent and added two liters of water every 15 days throughout the composting duration of 60 days. At the end of the composting period (60 days), all the pulverized foliage composts were ready and was applied to the potting medium which was used to raise the seedlings of *Syzigium cumini* for the experiment.

### Treatments and Experimental Design

Pulverized foliar of selected tree species for the experiment were formed into five treatments (M0 (Control: no compost)), $M_1$ (*Khaya senegalensis* (Ks)), $M_2$ (*Gmelina arborea* (Ga)), $M_3$ (*Syzygium cumini* (Sc)), $M_4$ (Zizipus spina-christi (Zs)) and arranged in 5x3x3 factorial in complete randomized block (CRD) The factors include the pulverized composting materials, depths and durations.

### Data collection

Data on seedling growth/development parameters were collected for eight weeks starting after 2 weeks of seedling establishment. The growth parameters include Stem diameter (mm), stem height (cm) and number of leaves were collected and recorded on weekly bases, while developmental parameters include: root length (cm) and biomass (g) were measured at the end of the experiment.

### Method of Data analysis

Analysis of variance (ANOVA) was used to ascertain the mean differences between growth and developmental parameters.

Analysis of Variance was used for the growth and developmental parameters.

Analysis of Variance (ANOVA).

One way ANOVA tool that was used for this study as presented below:

$$Y_{ij}=\mu+\alpha j+\epsilon_{ij}$$

Where:

- $Y_{ij}$ is the i-th observation in the j-th group.
- μ is the overall grand mean of the dependent variable across all groups.
- αj is the effect of the j-th group (the difference between the mean of the j-th group and the overall grand mean).

$\epsilon_{ij}$ is the random error term for the i-th observation in the j-th group.

**Results and Discussion**

**Effects of pulverized foliar compost on the early growth and development of *S. cumini***

Variations in the growth parameters of *S. cumini* seedlings by weeks from various composting materials at 60cm for 90 days, revealed that stem height (SHT) varied significantly ($P \leq 0.05$) in weeks 2, 3, 4, 5, and 6. However, no significant difference was observed for stem height in weeks 1, 7 and 8. The results also showed no significant difference ($P \leq 0.05$) in number of leaves (NOL) and stem diameter (SDM) from the foliar composting materials across all weeks (Table 1). The weekly growth parameters' data for *Syzygium cumini* indicated that pulverized compost produced from the foliage of *Syzygium cumini* showed the least mean value of growth (stem height) after *Gmelina arborea*. This varies with Adeogun *et al*. (2021), who observed the least mean values for *Khaya senegalensis* seedlings obtained from compost of *Khaya senegalensis* foliar materials used. Wani and Rao (2013) suggest that while plant-available macronutrients increase during vermicomposting and composting, their concentration decreases over time without additional inputs. Conversely, an increase in macronutrients has been linked to a decrease in weight and organic matter within the growth medium (Wari and Rao, 2013). Kaur (2017) found foliar compost to be most effective for germination, growth, biomass, physiological attributes, and survival of mango and *Khaya* seedlings. Compost significantly improves soil fertility by increasing nitrogen, phosphorus, and potassium concentrations (Castillago and Castello, 2010).

**Table 1. Effects of pulverized foliar compost on the stem height of *S. cumini***

Table 1 below shows the effect of pulverized compost on a plant growth parameter (stem height) of *S. cumini* seedlings from 4 different sources of foliar materials over the period of 8 weeks data collection.

| Parameters | Stem Height (cm) (Weeks) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
| *Gmelia arbore* | $4.643^{a}$ | $5.090^{a}$ | $6.115^{a}$ | $7.107^{a}$ | $8.705^{a}$ | $10.266^{a}$ | $11.679^{a}$ | $12.781^{a}$ |
| *Khaya senegalensis* | $5.710^{a}$ | $5.923^{ab}$ | $6.950^{ab}$ | $7.899^{ab}$ | $9.459^{ab}$ | $10.651^{ab}$ | $11983^{a}$ | $12.964^{a}$ |
| *Syzygium cumini* | $5.866^{a}$ | $6.355^{ab}$ | $7.513^{ab}$ | $8.636^{ab}$ | $10.161^{ab}$ | $11.617^{ab}$ | $12.943^{a}$ | $13.973^{a}$ |
| *Ziziphus spina-christi* | $6.013^{a}$ | $6.807^{b}$ | $8.168^{b}$ | $9.140^{b}$ | $10.945^{b}$ | $12.525^{b}$ | $13.705^{a}$ | $14.803^{a}$ |
| Mean | $1.432^{ns}$ | 1.939** | 2.295** | 2.033* | 2.045** | 1.918* | $1.414^{ns}$ | $1.272^{ns}$ |
| *P* | 0.05 | 0.01 | 0.01 | 0.05 | 0.01 | 0.05 | 0.05 | 0.05 |

**Source**: Analyzed from Field Data, 2024.

Means with different letters(s) along the column are significantly different: ns=not significant, ** ($p \leq 0.01$) and *($p \leq 0.05$)

The growth parameters from pulverized foliar compost showed a significant difference ($P<0.05$) in stem height (SHT) for *Syzygium cumini* in some weeks, (Table 1). The observed variations in stem height could be due to the nature of nutrient release to the *Syzygium cumini* experimental plant at the seedling stage. The non-variation in weeks one and eight might indicate that the compost was not fully stabilized initially, or that nutrients were depleted by week eight. These findings align with Adeogun *et al*. (2022), who reported compost effects on growth parameters, particularly stem height and stem diameter, from week five. Organic compounds are biodegraded and mineralized by microbial activity, leading to carbon dioxide release (Khatua et al., 2018)

**Table 2. Effects of pulverized foliar compost on the number of leaves of *S. cumini***

Table 2 below shows the effect of pulverized compost on a plant growth parameter (number of leaves) of *S. cumini* seedlings from 4 different sources of foliar materials over the period of 8 weeks data collection.

| Parameters | Number of Leaves (cm) (Weeks) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
| *Gmelia arbore* | $4.380^{a}$ | $4.939^{a}$ | $6.445^{a}$ | $7.514^{a}$ | $8.821^{a}$ | $9.377^{a}$ | $9.867^{a}$ | $10.423^{a}$ |
| *Khaya senegalensis* | $4.510^{a}$ | $4.459^{a}$ | $6.643^{a}$ | $7.556^{a}$ | $8.823^{a}$ | $9.533^{a}$ | $10.157^{a}$ | 10.445a |
| *Syzygium cumini* | $4.800^{a}$ | $5.356^{a}$ | $6.933^{a}$ | $7.910^{a}$ | $9.223^{a}$ | $9.577^{a}$ | $10.866^{a}$ | $11.221^{a}$ |
| *Ziziphus spina-christi* | $5.330^{a}$ | $6.021^{a}$ | $7.421^{a}$ | $8.298^{a}$ | $9.712^{a}$ | $10.400^{a}$ | $11.135^{a}$ | $11445^{a}$ |
| Mean | $1.284^{ns}$ | $1.005^{ns}$ | $0.835^{ns}$ | $0.668^{ns}$ | $0.730^{ns}$ | $0.595^{ns}$ | $1.237^{ns}$ | $0.760^{ns}$ |
| *P* | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |

**Source**: Analyzed from Field Data, 2024.
Means with different letters(s) along the column are significantly different: ns=not significant, ** ($p \leq 0.01$) and *($p \leq 0.05$)

**Table 3. Effects of pulverized foliar compost on the stem diameter of *S. cumin* seedling**

Table 2 below shows the effect of pulverized compost on a plant growth parameter (stem diameter) of *S. cumini* seedlings from 4 different sources of foliar materials over the period of 8 weeks data collection.

| Parameters | Stem Diameter (mm) (Weeks) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
| *Gmelia arbore* | $1.203^{a}$ | $1.338^{a}$ | $1.450^{a}$ | $1.580^{a}$ | $1.755^{a}$ | $1.949^{a}$ | $2.103^{a}$ | $2.225^{a}$ |
| *Khaya senegalensis* | $1.325^{a}$ | $1.459^{a}$ | $1.581^{a}$ | $1.735^{a}$ | $1.885^{a}$ | $2.057^{a}$ | $2.215^{a}$ | $2.304^{a}$ |
| *Syzygium cumini* | $1.417^{a}$ | $1.587^{a}$ | $1.754^{a}$ | $1.893^{a}$ | $2.092^{a}$ | $2.278^{a}$ | $2.415^{a}$ | $2.519^{a}$ |
| *Ziziphus spina-christi* | $1.478^{a}$ | $1.675^{a}$ | $1.785^{a}$ | $1.914^{a}$ | $2.118^{a}$ | $2.305^{a}$ | $2.443^{a}$ | $2.550^{a}$ |
| Mean | $1.359^{ns}$ | $1.729^{ns}$ | $1.688^{ns}$ | $1.563^{ns}$ | $1.616^{ns}$ | $1.476^{ns}$ | $1.236^{ns}$ | $1.123^{ns}$ |
| *P* | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |

**Source**: Analyzed from Field Data, 2024.
Means with different letters(s) along the column are significantly different: ns=not significant, ** ($p \leq 0.01$) and *($p \leq 0.05$)

The result obtained from number of leaves (NOL) and stem diameter (SDM) did not show variation throughout the 8 weeks (Table 2 and 3). The non-variance observed in the 2 growth parameters could be due the stage of seedlings that requires enough time to absorb the available organic fertilizer (compost) applied. These findings is in variance with the findings of Adeogun *et al*. (2021), who reported pulverized compost showed significant difference on growth parameters, particularly number of leaves and stem diameter from week five to week eight. Organic compounds like tree foliage are biodegraded and mineralized by microbial activities which in turn releases carbon dioxide into the atmosphere (Khatua *et al*., 2018).

**Table 4. Variations in developmental parameters of *Syzygium cumini* seedlings from various pulverized foliar composting materials**

Table 4 shows the variations in the developmental parameters of Syzygium cumini obtained from 4 sources of foliage used for the pulverized composting.

| Materials | RL | PFW | PDW | RFW | RDW | LFW | LTW | LDW | LA |
|---|---|---|---|---|---|---|---|---|---|
| Gmelina a. | $23.093^{a}$ | $2.821^{a}$ | $0.937^{a}$ | $0.906^{a}$ | $0.353^{a}$ | $0.192^{a}$ | $0.237^{a}$ | $0.068^{a}$ | $9.836^{ab}$ |
| Khaya s. | $20.033^{a}$ | $2.323^{a}$ | $0.723^{a}$ | $0.802^{a}$ | $0.269^{a}$ | $0.157^{a}$ | $0.203^{a}$ | $0.059^{a}$ | $7.720^{a}$ |
| Syzygium c. | $19.653^{a}$ | $2.539^{a}$ | $0.935^{a}$ | $0.831^{a}$ | $0.357^{a}$ | $0.171^{a}$ | $0.235^{a}$ | $0.059^{a}$ | $8.751^{a}$ |
| Ziziphus s. | $21.047^{a}$ | $4.354^{a}$ | $1.507^{b}$ | $1.498^{b}$ | $0.553^{b}$ | $0.268^{b}$ | $0.341^{b}$ | $0.099^{b}$ | $12.45^{4b}$ |
| F-value | $1.094^{ns}$ | $8.331^{ns}$ | 7.051** | 6.923** | 6.012** | 4.605* | 4.532* | 5.598* | 3.095* |

**Source**: Analyzed from Field Data, 2024.
Means with different letters(s) along the column are significantly different: ns=not significant, ** ($p \leq 0.01$) and *($p \leq 0.05$)
**Key:** RL= Root length, PFW= Plant fresh weight, PDW= Plant dried weight, RFW= Root fresh weight, RDW= Root dried weight, LFW= Leaf Fresh weight
LTW= Leaf turgid weight, LDW= Leaf dried weight, LA= Leaf area,G-a= *Gmelia arbore, K-s= Khaya senegalensis. S-c= Syzygium cumini, Z-s= Ziziphus spina-christi*

The result obtained from developmental parameters of *Syzygium cumini* seedlings revealed that there were variations (P≥0.05) among the following developmental parameters (Table 4); Plant dried weight, Root fresh weight, Root dry weight, Leaf Fresh weight, Leaf turgid weight, Leaf dried weight, and Leaf area, while the Root length and Plant fresh weight showed no significant difference. However, the developmental parameters of *Syzygium cumini* seedlings revealed that pulverized foliar compost from *Khaya senegalensis* materials produced the least mean values in all parameters except root length, while *Ziziphus spina-christi* compost produced the highest mean value for all developmental parameters. The low mean values from *K. senegalensis* pulverized compost might be due to composting methods or compost maturity of the foliar material, affecting growth and developmental performance. This contrasts with Adeogun *et al*. (2021), who found optimal performance for *Syzygium cumini* seedlings using *Khaya senegalensis* foliar compost. However, Benjamin *et al*. (2019) observed that different growing media treatments significantly increased seedling height, collar diameter, and number of leaves per seedling.

Variations were observed in plant dry weight, root fresh weight, root dry weight, leaf fresh weight, leaf dried weight, and leaf area for *Syzygium cumini* across different composting materials, while root length and plant fresh weight showed no significant difference. These variations could be due to differences in compost materials and the positioning of developmental parameters on the tree (root, leaf, stem, etc.). These results are similar to the findings of Adeogun *et al*. (2021).

Thomas (2009) reported that allocating plant resources from compost to roots and shoots increases biomass production and is crucial for maximizing plant performance. Liu *et al*. (2019) consider root dry matter and root length important root quality indicators that reflect plant quality, though they are sometimes underutilized. Long roots signify plant strength in sourcing moisture and nutrients and are associated with enhanced growth and increased capacity to withstand post-transplanting stress due to their high exploration capacity in growing media (Nyoka *et al*., 2018).

## Conclusion and Recommendation

From the findings of this study, it can be concluded that *Ziziphus spina-christi* pulverized foliar materials showed significant effects on the growth parameters of *S. cumini* seedlings (stem diameter, stem height, number of leaves) and *Gmelina arborea* pulverized foliar materials showed insignificant effects on *Syzygium cumini* seedlings. Similarly, *Ziziphus spina-christi* pulverized foliar materials showed significant effects on developmental parameters (PDW, RFW, RDW, LTW, LDW, RL, PFW, LFW, LA ) while *Gmelina arborea* pulverized foliar materials showed insignificant effects on and *Syzygium cumini* seedlings. Based on this, it is recommended that foliage from

*Ziziphus spina-christi* should be used in pulverized composting to raise seedlings of *Syzygium cumini* in sudano-sahelian ecosystem due to its effects on seedling growth and development.

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**References**

Bar, M. and Ori, N. (2014). Leaf development and Morphogensis. *Development*:14(22).

Castillejo, J. M., and Castello, R. (2010). Influence of the Application Rate of An organic Amendment (municipal solid waste [MSW] compost) on Gypsum Quarry Rehabilitation in Semi-Arid Environments, *Arid Land Research and Management* 24, 344-364.

Curtis, M. J. and claassen, V.P. (2005). Composts Incorporation increase Plant Available Water in a Drastically Disturbed Serpentine soil. *Soil Science*, 170, 939-953

Day, M. and Shaw, k. (2001). Biolographical, Chemical and Physical Processes of Compositing. In *Compost Utilization in Horticultural Cropping System*; stofffela, PJ and Kaln, BA (Eds). Pp, 17-50 (Lewis publishers, bocaraton).

DMS (2002). Department of Metrological Service, Borno State, Nigeria

Fischer, D. and Glaser, B. (2012). Synergisms between compost and biochar for sustainable soil amelioration. In S. Kumar & A. Barthi (Eds.), *Management of organic waste*. 167–199. Rijeka: InTech.

Insam, H. and De- Bertodi, M. (2007). Microbiology of the Compositing Process. *In Compost Science and Technology*, Volume 8 Waste Management. (Eds) pp.26-45. (Elsevier science, Amsterdam).

Krause, A., Kaupenjohann, M., George, E., and Koeppel, J. (2015). Nutrient recycling from sanitation and energy systems to the agroecosystem- ecological research on case studies in Karagwe, Tanzania. *African Journal of Agricultural Research, 10*(43), 4039–4052.

Kuo, S., Ortiz, M. E., Hue, N. V., and Hummel, R. L. (2004). Composting and compost utilization and container crops. *Soil Sci. Soc.* Am. J., 61. 1392.

Lakhdar, A., Rabh, M., Ghnaya, T., montemuro, F., Jedidi, N. and Abdelly, C. (2009). Effectiveness of Compost use in Sacl-affected Soil, *Journal of hazardous Materials*, 171, 29-37.

Meieru, U. Bleiholder, H. Buhr, L. and Feller, C. (2009). The BBCH System to coding the phonological growth stages of plants. *History and publication journal,* 61,41-43.

Ministry of Land and Survey (MLS) (2008) Borno State. Borno Land Reports

Morales, G.E. and Wolff, M.(2010). Insects associated with the composting process of solid urban waste separated at the souce. *Revista Brasileira de Entomologia,.54, 645-653*

Mylavarapu, R.S. and Zinati, G.M. (2009). Improvement of Soil Properties Using Compost for Optimum Parsley Production in Sandy Soils, *Scientific Horticultures* 120, 426430.

NIMET (2008). Nigerian Metrological Agency, National Weather Forecasting and Climate Research Centre, Nnamdi Azikiwe International Airport, Abuja. Nigeria.

Nyoka, B.I.; Kamanga, R.; Njoloma, J.; Jamnadass, R.; Mng"omba, S. and Muwanje, S. (2018). Quality of tree seedlings produced in nurseries in Malawi: An assessment of morphological attributes. *For. Trees Livelihoods*, *27*, 103–117.

Pinamonte, F. (1998). Compost Mulch Effects on Soil Fertility, Nutritional Status and Performance of Grapevine: *Nutrient cycling in Agro ecosystem*. 51, 239-248.

Polprasent, C. (1989). *Organic Waste Recycling*, (John Wiley and sons, Chichester United Kingdom).194-197.

Schroth, G., Vanlauwe, B. and Lehmann, L. (2003). Soil Organic Matter. In tree. Crops and Soil Fertility: *Concepts and Research Methods*. pp. 77- 89 (CABI publishing, cambridge).

Schulz, H., Dunst, G., and Glaser, B. (2013). Positive effects of composted biochar on plant growth and soil fertility. *Agronomy for Sustainable Development, 33*, 814–827.

Tejeda, M., Hernandez, M.T. and Garcia, C. (2009). Soil restoration using composed plant residence: Effects on soil properties, *Soil and Tillage Research*. 102, 109-117.

Webster, P., and Francis, R. (2016). Green shoots of success. Drivers and approaches towards a successful bioeconomy. *The Chemical Engineering, 900*, 24–28.

Wetbrench, K. Muller, K. Leubner, G. (2011). Early seed germination *Journal of Experimental Botany,* 62:32893309.