Original Research Article

EVALUATING THE EFFECTS OF BIOCHAR AND ORGANIC SOIL AMENDMENTS ON EARLY SEEDLING DEVELOPMENT OF ANNONA MURICATA. LINN

Abstract:

The importance of appropriate growing media for propagation of Annona muricata seedlings cannot be over emphasised. An experiment was conducted to investigate the effects of biochar and organic soil amendments on early seedling development of Annona muricata using different potting media. The treatments were T0 (Control; Topsoil only), T1 (Mineralized goat dung), T2 (Mineralized saw dust), T3 (Mineralized poultry dropping) and T4 (Mineralized biochar). The experiment was laid out in Completely Randomized Design (CRD). The data collected were subjected to analysis of variance and significant means were separated using Duncan multiple range test at 0.05 significant level. Parameter accessed include seedling height (cm), collar diameter (cm) and number of leaves. Result shows that T4 had the best performance in seedling height, collar diameter and number of leaves with mean values of 26.703±1.5488, 4867±0.22904 and 4.4451±1.55031 respectively. While the least performance in seedling height, collar diameter and number of leaves was recorded in T0 with mean values of 19.986±1.1265,0.3230±0.17363 and 3.6765±1.14724 respectively. However, there were significant differences among the treatments at 5% level of probability in seedling heights and collar diameter, but number of leaves was not significant. Annona muricata seedlings thrives excellently in biochar potting media. Hence, the use of biochar potting media should be adopted as the best growing media for early growth and development of Annona muricata seedlings.

Keywords: Annona muricata, seedlings, growth performance, soil amendments, biochar

INTRODUCTION

Tropical forest is known to be very rich in species diversity as well as a home for different variety of micro and macro-organisms including wildlife, due to the unique microclimate it creates [1]. Due to rapid forest depletion in the tropics, the supplies of many useful forest products such as *Annona muricata* are severely threatened with serious consequences on the

well-being of the local people who depend on these products. Lack of public interest in conservation efforts of so many species, especially non-timber forest products (NTFPs) like *Annona muricata* has placed the existence and perpetuity of this species at risk [2].

Annona muricata commonly known as soursop is a deciduous tropical evergreen fruit tree, belonging to the "*Annonaceae*" family, is a tropical short bushy tree that can grow up to 7 m tall with a diameter of up to 15cm, and is widely grown and distributed in tropical and subtropical regions around the world. The flowers are pollinated by Flies, Beetles, and Insects [3]. The growth of *Annona muricata* is Suitable for light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil, suitable pH: acid, neutral and basic (alkaline) soils [4].

Annona muricata has a thick, slightly shiny, long, and narrow leaves. The flowers are large, often on its own or in groups of three. It is commonly known for its edible fruits. In addition to its use as a food crop, the seeds, leaves, stem back and the roots are used in traditional medicine. Resent research have proven that *Annona muricata* is used in treatment of cancer. It is a fruit that is of great economic importance, but the supply of the fruit is however low, and its benefits scarcely known amongst the public [3].

Annona muricata according to a report released by IUCN [5] was listed among the red list of threatened species. Aside from indiscriminate logging, industrialization, pest and disease attack, the seeds are recalcitrant seeds and easily loss viability. Also lack of proper pre-nursery treatment bearing in mind that the initial seedling growth is low, hence the need to discover and improve other growing media, for fast seedling growth is highly required to save this species from extinction [6].

The use of suitable growing media or substrates is essential to produce quality seedlings, it directly affects the influence and later maintenance of extensive functional rooting system[7]. A good growing media would provide sufficient nutrients required for the plant growth, serve as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate [8]. The quality of seedling obtained from a nursery influences re-establishment in the field and the eventual in the productivity of quality crops [9].

Biochar is a solid material obtained from a pyrolysis process that performs a thermochemical transformation of biomass at high temperatures and in total or partial absence of oxygen, dramatically reducing greenhouse gas emissions [10]. Biochar has been shown to increase both soil carbon and water content as well as macro aggregates, electrical conductivity, pH, total nitrates/nitrites, ammonia, nitrogen [11], that leads to increase in crop/plant yield. When applied to the soil, biochar helps in effective sequestering of the applied carbon, increased plant productivity, mitigating anthropogenic CO2 emissions, and reduced nutrient leaching [12].

Generally, growth media has been adjusted to be the most critical factor determining seedling quality in nursery [13]. The survival of the plant usually depends on favourable environmental factors, growing media is one of the most important factors required for survival of *Annona muricata* seedlings, because it not only support the plant but also provides moisture and mineral nutrients for seedling growth and development. A good potting media just like a good garden soil must meet all the basic plant requirements necessary for optimum growth and supply plants with adequate means of support, good drainage, adequate air circulation and storage for water and nutrients [8,13].

The increase in demand of *Annona muricata* because of its economic, medicinal, and timber values has led to its existence being threatened by over exploitation [2,5]. This is so because of the erroneous impression that the fruit tree will continue in perpetuity, the unavailability of seeds due to infrequent fruiting, poor seed germination and competition with wild animals, birds, and humans [14] and the decline in soil nutrient. In the past years, inorganic fertilizer was advocated for crop production to ameliorate low inherent fertility of soils in the tropics. However, the unavailability and difficulty of getting chemical fertilizers alongside its high price and potential polluting ability pose a constraint to use of inorganic fertilizer [15]. The supply of *Annona muricata* does not correspond with its high demand due to several factors such as deforestation, urbanization, and the reduction of farmers in the field leading to a reduction in the production by local farmers. This situation threatens the existence of this species. This work therefore is an effort to combat this threat of extinction of this specie by determining the appropriate potting media to enhance the optimum growth and development of *Annona muricata* seedlings, and also to meet with its high demand and sustainably preserve the existence of this fruit tree.

MATERALS AND METHOD

Study Area Description

This study was carried out at the screen house of Department of Forestry and Wildlife, Faculty of Agriculture, Nnamdi Azikiwe University Awka, Nigeria. The University is located in the eastern part of Nigeria and lies between latitude 6.245^{o}N and 6.283^{o}N longitude 7.115^{o}E and 7.121^{o} E. The climatic condition of the area is tropically dominated by rainfall pattern ranging from 1828-2002mm.

Procurement and Preparation of experimental materials

Matured ripe fruits of *Annona muricata* were collected from a phenotypically mother tree at Ifite Awka , Anambra State. The fruit were depulped and about 60 seeds were extracted and used for seedling germination. The handling of seeds, germination and seedling transplanting were carefully done as recommended by [16,17].

The poultry dropping and goat dung that were used for this experiment was gotten from the animal farm at the Emmanuel Farm, Awka Anambra State while sawdust was collect from a sawn *Ceiba petandra* tree at the Faculty of Agriculture, Nnamdi Azikiwe university, Awka. Biochar was prepared by burning wood particles from *Tectona grandis, Irvingia gabonensis* and *Gmelina arborea* with limited air supply.

The poultry droppings, saw dust, goat dung and biochar were mineralized for two weeks. This were done by mixing them respectively with topsoil in the ratio 2:1 that is; Two topsoil: one growth medium, after which the mixture was made moist but not waterlogged and covered with black nylon. This was done to enable microorganisms act on the media and in the process liberate the nutrients in the form that can be absorbed by the roots of the plants, increase aeration and light reflection. The mineralized media was then filled into poly pots each. The topsoil that was used as control was also sieved and filled into poly pot using a hand trowel.

Experimental design and treatments

The experiment was laid out in Completely Randomized Design (CRD). There were 5 treatments in all, each treatment was replicated 8 times making a total of 40 potted seedlings of *Annona muricata.*

After germination at 2-leaf stage, 40 healthy seedlings were selected and transplanted into the already filled black poly pots which contains topsoil + growth media and kept under the screen house to acclimatize. The treatment that was used for this experiment include:

T0: Topsoil only (control)

Tl - Mineralized Goat dung (Topsoil + goat dung)

T2 - Mineralized Saw dust (Topsoil + saw dust)

T3 - Mineralized Poultry droppings (Topsoil + Poultry droppings)

T4 - Mineralized Biochar (Topsoil + biochar)

Data Collection and Analysis

Data collection on seedlings growth parameters began one week after acclimatization and was carried out for a period of twelve weeks. The parameters assessed include leaf count, collar diameter and plant height. The parameters were assessed weekly using ocular estimation for leaf count, digital vernier caliper for collar diameter and meter rule for plant height. The data collected were subjected to Analysis of variance (ANOVA) and significant means were separated using Duncan multiple range test at 0.05 significant level.

RESULTS

Growth variables of Annona muricata under different organic manure

Table 1. Shows the descriptive statistics of growth variables, of *Annona muricata,* under T0 (Topsoil only). The result shows the mean diameter as 0.32 ± 0.2170mm, mean height of 22.337 ± 1.2160mm, mean number of leaves3.6765 ± 0.14341

Table 1: Descriptive statistics for T0 (Topsoil only /Control)

Seedling growth Variables	N	Minimum	Maximum	Mean	Std. Error	Std. deviation
Diameter	64	0.10	0.70	0.32	0.2170	0.17363

Height	64	5.1	36.1	19.986	1.1265	9.0119
No. leaf	64	1.41	5.39	3.6765	0.14341	1.14724

Descriptive statistic for T1 (Topsoil and goat dung)

Table 2 shows the descriptive statistics of growth variables of *Annona muricata* under T1 (Topsoil + goat dung). The result shows the mean diameter as 0.3847±0.02204mm, mean height of 22.337 ± 1.2160mm, mean number of leaves 3.8087 ± 0.15718.

Table 2: Descriptive statistics for T1 (Topsoil + goat manure)

Seedling growth Variables	N	Mini mum	Maxi mum	Mean	Std. Error	Std. deviation
Diameter	64	0.1	0.8	0.3847	0.02204	0.17630
Height	64	6.8	39.3	22.337	1.2160	9.7277
No. leaf	64	1.41	5.39	3.8087	0.15718	1.25744

Descriptive statistic for T2 (Topsoil and saw dust)

Table 3 shows the descriptive statistics of growth variables of *Annona muricata* under T2 (Topsoil + saw dust). The result shows the mean diameter as 0.4155 ± 0.02343mm, mean height of 24.886 ± 1.4082mm, mean number of leaves 4.0176 ± 0.15739.

Table 3: Descriptive statistics for T2 (Topsoil + saw dust)

Seedling growth Variables	N	Minimum	Maximum	Mean	Std. Error	Std. deviation
Diameter	64	0.12	0.80	0.4155	0.02343	0.18746
Height	64	7.0	40.7	24.886	1.4082	1.4082
No. leaf	64	1.41	5.92	4.0176	0.15739	1.25915

Table 4 shows the descriptive statistics of growth variables of *Annona muricata* under T3 (Topsoil + poultry droppings). The result shows the mean diameter as 0.4731±0.2634mm, mean height of 25.191 ± 1.3709mm, mean number of leaves 4.2353±0.16889

Table 4: Descriptive statistics for T3 (Topsoil + poultry droppings)

Seedling growth Variables	N	Minimum	Maximum	Mean	Std. Error	Std. deviation
Diameter	64	0.13	0.90	0.4731	0.2634	0.21069
Height	64	7.5	42.7	25.191	1.3709	10.9676
No. leaf	64	1.73	6.48	4.2353	0.16889	1.35110

Table 5 shows the descriptive statistics of growth variables of *Annona muricata* under treatment four (Topsoil + biochar). The result shows the mean diameter as 0.4867± 0.02863mm, mean height of 26.703 1. ±1.548mm, mean number of leaves 4.4451±0.19379.

Table 5: Descriptive statistics for T4 (Topsoil + biochar)

Seedling growth Variables	N	Minimum	Maximum	Mean	Std. Error	Std. deviation
Diameter	64	0.13	0.90	0.4867	0.02863	0.22904
Height	64	7.3	47.2	26.703	1.5488	12.3908
No. leaf	64	1.73	6.71	4.4451	0.19379	1.55031

Table 6 shows the result of the one-way analysis of variance (ANOVA) for seedling height, collar diameter and number of leaves under different potting growth media. There were significant differences in mean seedling heights and collar diameter ($p<0.05$). However, there were no significant difference in the mean seedling number of leaves ($p>0.05$).

Table 6: ANOVA results for ***Annona muricata*** seedlings height, collar diameter and number of leaves under different growth media

Growth variables	**Source of Variation**	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Height (cm)	Between Groups	1806.405	4	451.601	3.916	0.04^{s}
	Within Groups	36324.798	315	115.317		
	Total	38131.204	319			
Collar diameter (cm)	Between Groups	1.145	4	.286	7.410	0.01^{s}
	Within Groups	12.173	315	.039		
	Total	13.318	319			
Leaf count	Between Groups	24.852	4	6.213	3.566	0.07^{ns}
	Within Groups	548.837	315	1.742		
	Total	573.689	319			

Table .7 shows the results of mean separations (Duncan tests) for seedling height under different potting mixtures. T4 recorded the highest seedling height followed by T3, T2,T1 and the least was T0 with means of 26.703±1.5488, 25.191±1.3709, 24.886±1.4082 22.337±1.2160 and 19.986±1.1265 respectively. The highest collar diameter was recorded in seedlings which were raised under T4 followed by T3, T2, T1 and T0 with means of 0.4867±0.22904, 0.4731±0.21069, 0.4155 ± 0.18746 ,0.3847±0.17630 and 0.3230±0.17363[c] respectively. T4 also had the highest number of leaves followed by T3, T2, T1, T0 with means of 4.4451±1.55031,4.2353±1.35110, 4.0178±1.25915,3.8087±1.25744 and 3.6765±1.14724 respectively.

The result further revealed that there was no significant difference observed between the heights of seedlings raised under treatments T4 and T3 but there was significant difference between T4 and T1, T2 and T0. No significant difference was recorded between the collar diameter of seedlings raised under treatments T4 and T3, but there was significant difference between collar diameters of T4 and T0, T1. Also there was no significant difference between number of leaves for seedlings raised under treatments (T4, T3, T2) and (T1,T0) but there were significant difference between the two groups respectively

Table. 7: Duncan Results for the growth variables of *Annona muricata* seedlings under different growing media.

Treatments	Seedling growth variables (Mean ± Std. error)		
	Height (cm)	Collar diameter (cm)	Number of leaves
T0	19.986±1.1265[c]	0.3230±0.17363[c]	3.6765±1.14724[b]
T1	22.337±1.2160[bc]	0.3847±0.17630[bc]	3.8087±1.25744[b]
T2	24.886±1.4082[b]	0.4155±0.18746[ab]	4.0178±1.25915[a]
T3	25.191±1.3709[ab]	0.4731±0.21069[a]	4.2353±1.35110[a]
T4	26.703±1.5488[a]	0.4867±0.22904[a]	4.4451±1.55031[a]

Where, T0 = topsoil only, T1=mixture of topsoil and goat dung, T2= mixture of topsoil and sawdust, T3 = mixture of topsoil and poultry droppings and T4 = mixture of topsoil and

Biochar. Means with the same alphabets had no significant difference at 5% probability level.

DISCUSSION

The result shows that the use of biochar as soil amendments has more positive effects on the seedling early growth of *Annona muricata* when compared to other organic soil amendments. Biochar is carbon rich material obtained by pyrolysis of biomass with little or no oxygen.

The highest seedling mean height was recorded under T4 (To soil + biochar), According to Lehmann and Joseph [18], Pyrolysis of plant biomass normally results in highly alkaline biochar, which when added to soil, enhances crop/ plant productivity. This finding supports the findings of Hamzah and Snashuhaimi [19] who found out that the addition of biochar to oil palm and Rubber seedlings enhanced the height growth of the perennial crops making them to produce earlier. Biederman and Harpole [12] reported that, the addition of biochar to soils resulted, on increased above ground productivity, crop yield, soil phosphorus (P), soil microbial biomass, soil phosphorus (P), soil potassium (K), rhizobia nodulation, total soil nitrogen (N), and total soil carbon (C) compared with control conditions.

Biochar is most considered for its use as a soil amendment, where it has gained attention for its potential to improve agricultural production and soil health [11]. McDonald et al. [20] also maintained that biochars derived from hardwood and softwood have greater surface area and carbon content than those from manure or grass, while manure and grass biochar have more abundant oxygen-containing functional groups and mineral constituents. Nan et.al [21] also recorded increase in crop height and yield using biochar.

This increase in height was followed by seedlings under T3 (Topsoil + poultry manure). Poultry manure is sometimes pelletized for use as a fertilizer because of it nutrient content as noted by Ano and Ubochi [22] who stated that poultry droppings have additional phosphorus, potassium or nitrogen added that leads to increase in soil fertility. This also support the research done by Aniefiok et al.[23] who observed that poultry droppings greatly influenced the plant height, stem diameter, and leaf production of T*alinum fructicosum*.

Least mean seedling heights were observed on seedlings raised under T0 (Topsoil) This could be due to the lack of essential nutrients in the soil necessary for plant growth. Khan et al [24] and Anozie et al. [25] found out in their studies that adding organic manure to potting media is

important because it supplies essential nutrients required by seedlings for optimum growth. This however contradicts the work of Marjenah et al. [26] on two species of *Dipterocarps* seedlings which had increase in plant height in treatment with only topsoil.

The result reveals that the highest mean collar diameter was recorded under T4 (Topsoil + biochar). Biochar can increase growth of plants in some circumstances such as in collar diameter and is more effective in giving desire plant performance unlike other larger amount of compost and fertilizer [27]. Agegnehu et al [28] also recorded increase in stem girth of maize when used biochar as soil amendment.

This followed by seedlings under T3 (Topsoil + poultry manure) this support the research done by Aniefiok et al. [23] who observed that poultry droppings greatly influenced the plant height, stem diameter, and leaf production of Talinum *fructicosum*.

Seedlings under T2 (Topsoil + sawdust) produced the third highest collar diameter. This supports the research done by Marjenah et al.[26] that sawdust influenced the plant height, stem diameter, and leaf production of two species of *Dipterocarps* seedlings. This contradicts the findings of Anozie et al [25] who recorded low collar diameter with *Newbouldia laevis* in treatment with sawdust.

Least mean seedling collar diameter were observed on seedlings raised under T0 (Topsoil) This could be due to the lack of essential nutrients necessary for growth. Khan et al [24] found out in their study that adding organic manure to potting media is important because it supplies essential nutrients required by seedlings. This however contradicts the work of Marjenah et al., [26] on two species of *Dipterocarps* seedlings which had the highest increase in collar diameter performing in treatment with only topsoil.

The highest mean number of leaves was recorded under T4 (Topsoil + biochar). This result support the findings of Simiele et.al. [10] who reported that the addition of biochar also increased leaf area with a rise of 26% and 36% compared with the values measured in the untreated plants.

This is followed by seedlings under T3 (Topsoil + poultry manure) this may be because poultry manure contains higher nitrogen and phosphorus compared to other bulky organic manures. this support the research done by Aniefiok et al. [13] who observed that poultry droppings greatly

influenced the plant height, stem diameter, and leaf production of *Talinum fructicosum*. Egwunatum et al [29] also recorded increase in number of leaves of *Gambeya albida* seedlings when poultry media was applied.

Least mean seedling number of leaves were observed on seedlings raised under T0 (Topsoil only). This could be due to the lack of essential nutrients necessary for growth as observed by Anozie et al [17] who recorded the least growth in Dennettia *tripatala* seedlings in terms of height, collar girth and number of leaves in treatment with topsoil only. Khan et al [24] found out in their study that adding organic manure to potting media is important because it supplies essential nutrients required to enhance seedlings leaf count.

CONCLUSION

This work investigated the effect of different growth media on the early growth of *Annona muricata* seedlings**.** The results shows that the application of organic matter has positive effect on the seedling growth and development of *Annona muricata.*

The study reviewed that T4 has the highest growth performance in plant height, collar diameter and number of leaves followed by T3, T2, T1. However, the control (T0) which was the treatment with only topsoil had the least growth mean in all the growth variables which is an indication that, growth media such as biochar and organic manure are important for the early growth of *Annona muricata* seedlings. There was no significant differences between the numbers of leaves produced among treatments (T2, T3, T4) and (T0,T1) used in this research.

RECOMMENDATION

Based on the results obtained, the following recommendations are made for early growth of *Annona muricata* seedlings.

1. to obtain the best and optimum growth of *Annona muricata* seedlings in terms of plant height, collar diameter and number of leaves, treatment T4 (Topsoil + biochar) is recommended to be best.
2. but in the absence of the T4, T3 (Topsoil + poultry manure) could be used for raising the seedlings of *Annona muricata.*

This study is an asset to domestication and regeneration of *Annona muricata* seedlings and can easily be adopted by resource poor farmers and tree growers.

Further research should be carried out on the use of other materials or other wood species for biochar production for the raising of *Annona muricata* seedlings since the biochar used in this research proved to be good in the raising of *Annona muricata* seedlings.

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