RESEARCH ARTICLE

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Effects of organic amendments on tomato yield and electrochemical properties of soilless growing media

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Abstract
This research sought to investigate how using organic amendments derived from readily accessible materials affects both tomato production and the electrochemical characteristics of soilless growing media. A greenhouse experiment using six (6) different locally accessible and underutilized composted organic materials [cocoa peat, rice husk, ground Doum palm (*Hyphaene thebaica*) fruit, Iroko (*Milicia excelsa*) saw dust, mahogany (*Khaya senegelensis*) saw dust, and Sapele saw dust (*Entandophragma cylindricum*)] was carried out. Standard procedures were used to determine the physical, chemical, and electrochemical characteristics of the modified materials.The results revealed that the highest water retaining capacity of the media varied from 51.11% to 85.56%. Iroko palm has the highest bulk density (0.94 g cm-3) while Doum palm has the highest particle density (0.81 g cm-3). The results of the study showed that the pH of the medium in KCl ranged from 6.32 to 7.81 and 7.36 to 8.37 for pH in water. The electrical potentials for the different media ranged from -52.01 to -93.38. The point zero charge of soils was shown to be positively correlated to the properties of the medium. The pH, electrical conductivity (ECe), and cation exchange capacity (CEC) of the media all increased when the media was modified. It is recommended that rice husks and cocopeat be used as growing given their superior performance compared to the other tested media in tomato production. However, because of the cost of producing cocopeat media, rice husk can serve as an alternative to cocopeat as a growing medium. Despite a slight delay in germination in the rice husk media, a high yield was attained at the end of production.
Keywords: Soilles Media, Composting, Cation Exchange Capacity, Point of Zero Charge, Tomato

INTRODUCTION

Due to high temperatures, leaching, loss of surface soil due to erosion, an array of pH changes, low organic matter content and plant nutrient availability are critical challenges in agricultural soils in semi-arid Northern Nigeria. Furthermore, typical topsoil contains soil-borne pests and diseases, as well as a significant amount of certain heavy metals, which will ultimately lead to a decline in quantity and quality (Ibeawuchi *et al.,* 2015). This inadvertently affects the nature and composition of soil colloids (Ibrahim *et al.,* 2014). Negative charges predominate on the surfaces of soil colloids, aiding in cation attraction and retention in soils. These charges have a substantial influence on soil cation exchange capacity. These charges results from the adsorption and desorption potentials of the ions, notably H^+ and OH; hence, colloids are referred to as pH dependent (Zhang *et al.,* 1991). Because of the aforementioned losses associated with semi-arid soils, developing a more effective method to enhance nutrient use efficiency is critical (Gruda, 2019).

Recent technological developments in agriculture which involves various organic and inorganic soilless growing media have been developed as topsoil substitutes to improve greenhouse technology utilization, protect crops from soil-borne pathogens, and control environmental pollutants such as nitrate, pesticides, and other toxic chemicals (Ahmad *et al.,* 2011). However, the basic resources used to make these media are costly. Barrett *et al*. (2016), for example, named cocopeat as the best soilless media for greenhouse technology because of its unique physical and chemical features, and it has been shown to boost crop quality and output. However, the cost of production and raw material availability persist to be a major barrier limiting its application in many geographical regions.

Tomato (*Solanum lycopersicum* l.) is one of the most significant vegetable crops cultivated in NorthernNigeria. The total area under tomato cultivation worldwide is 47.82 million hectares, with a yield of 1770.93 MT (Anonymous 2016). Tomato cultivation is often done in open fields where the crop is vulnerable to biotic and abiotic stressors, the most significant of which is soil health, which restricts its growth, productivity, and quality. As a result, producing tomatoes under protected conditions is a viable option for enhancing output and quality.

A practical way to solve this persistent challenge is to explore other materials that are economically viable, environmentally friendly, socially acceptable and technically adaptable for use as substitutes for cocoa peat as greenhouse growing media. Hence, this study aimed to investigate different common but underutilized materials found in our surroundings, like rice husk, sapele, doum palm, iroko, and mahogany, with the goal of transforming them into sustainable growing mediums. The objective was to assess their electrochemical properties and their effect on tomato yield. This research seeks to mitigate soil-related risks and offer an alternative to traditional soil for agricultural production, thereby enhancing food security.

MATERIALS AND METHODS

Study Area

The research was carried out at the Centre for Dryland Agriculture's Research and Training Farm at Bayero University Kano, which is located at latitude 11° 59"N and longitude 8° 25"E, with an altitude of 458 m above sea level. The area's vegetation is the Sudan Savanna, with a tropical wet and dry climate. The trees in the area are comprised of numerous species and are typically no taller than 20 m. The temperature in the region is usually high all year, with seasonal variations, with a progressive increase from January to April, when the maximum value reaches 43°C (Mohammed *et al.,* 2015). The rainfall amount of the area is slightly variable between years, with a mean annual rainfall of 897.7 mm (Mustapha *et al.,* 2014).

Soilless Media Preparation and Modification

Six (6) different locally available and less utilized organic materials were collected, including cocoa peat, rice husk, ground Doum palm (*Hyphaene thebaica*) fruit, Iroko (*Milicia excelsa*) saw dust, mahogany (*Khaya senegelensis*) saw dust, and Sapele saw dust (*Entandophragma cylindricum*) across many parts of Kano State. These materials were modified via compositing. The materials were soaked in water and then transferred into plastic containers to provide adequate heat for composting. Regular sprinkling of water was maintained during the process. The materials were turned every week to supply adequate air for the aerobic microbial activities to occur. This process was maintained for 90 days before harvesting for final curing in a well-aerated place.

Soilless Media Characterization

The physical and chemical properties of the media were determined using the standard analytical procedure as follows:

Physical Characterization

Water retention capacity

30g of the materials (w) were weighed into a conical flask, and then 50 ml of water was added (V1). After 10 min, the samples were filtered using Whatman no. 1 filter paper. The filtrate was collected and measured using a measuring cylinder (V2). The percentage water retention capacity was measured using the following:

$$\%\ \text{WRC} = \frac{V1-V2}{W}\times 100$$

Particle Density

The particle density of the materials was measured using a Pycnometer. The mass of the empty Pycnometer (*Mp*) was first measured. Afterward, it was filled with distilled water and measured (*Mpw*). The mass of water (*Mw1*) was obtained by subtracting *Mp* from *Mpw* and then divided by the density of water (0.99753 g cm^{-3}) to obtain the volume of the Pycnometer (*Vp*). About half of the Pycnometer was filled with each of the materials, and its weight (*Mpm*) and *Mp* were subtracted from it to obtain the mass of the media material (*Mm*), while its volume was obtained by adding distilled water to the media in the Pycnometer (*Mpmw*), and then *Mpm* was subtracted from it to obtain the mass of water in the media (*Mw2*) and then divided by the density of water to obtain its volume (*Vw*), then *Vw* was subtracted from *Vp* to obtain the volume of the media *Vm*. Finally, the density of the material was determined using the following relation:

$$\rho m = \frac{Mm}{Vm} \text{..............} 1$$

Bulk Density

The bulk density of the media was determined by weighing the oven-dried media removed from the holes of the seed trays, which was then divided by the volume it occupied.

$$\rho B = \frac{Wm}{Vm} \text{..............} 2$$

Chemical Analysis of the Media

The electrical conductivity (EC) and pH of the materials were determined via 10g of the media with 10 ml of distilled water. The solution was agitated with a glass rod before being allowed to settle for 10 min before measuring the pH using a pH meter and EC using a conductivity meter. In addition, Organic carbon and nitrogen levels were determinedcalorimetrically using a micro plate reader. The C: N ratio was then calculated using the organic carbon and nitrogen levels. Finally, 30g of the media was weighed into the conical flask, and 50 mL of deionized Water was introduced to the flask. After 24 h, the solution was filtered to obtain a filtrate for elemental analysis of Ca, Mg, K, Na, Zn, Cu, Mn, Fe, and Al using a microplasma atomic emission spectrophotometer (MP-AES 4200).

Determination of the Point of Zero Charge

The point zero charge (PZC) of the soil treatment combinations was evaluated using the equation adopted by Onokebhagbe *et al.* (2021) to determine PZC and surface electrical potential.

$$\text{PZC} = (2 \text{ x pHKCl}) - \text{pHH2O} \text{.........} 3$$

The pH values and ΔpH of the media were also calculated using the following formula:

$$\Delta\text{pH} = \text{pHKCl} - \text{pHH2O} \text{ ....} 4$$

The surface electrical potential (Ψ0) in mV was estimated using the Nernst equation, which Chaves *et al.* (2016) reduced as follows:

$$\Psi_0 = 59.1(\text{PZC} - \text{pHH2O}) \text{........... } 5$$

Experimental Design

The study was carried out in a greenhouse using a completely randomized design (CRD) with six soilless media treatments and two replications.

Data Analysis

JMP® 15 edition was used for descriptive statistics and one-way analysis of variance (ANOVA). To identify significant differences between the individual treatments, the post hoc Tukey's HSD test was performed. Pearson correlation analysis was utilized to examine the relationship between the soilless media's electrochemical properties and PZC.

RESULTS AND DISCUSSION

Physical and Chemical Properties of the Media

The properties of the media are summarized in Tables 1 and 2. The composted rice husk and composted Sapele media had a high water holding capacity, while composted Doum had the lowest moisture content (51.11%). The water retention capacity of the media could be affected by changes in surface area, density, and porosity after modification, as well as microbial activities of the composted materials. Azim *et al*. (2018) found that composting may alter water retention capacity due to microorganisms consuming water for their metabolic activities. The particle density was highest in Doum palm at 0.80 g cm^{-3}, and lowest in composted Sapele sawdust at 0.21 g cm cm^{-3}. However, the bulk density of all media was low, with the highest in Iroko at 0.91 g cm cm^{-3} and lowest in Sapele at 0.12 g cm^{-3}. Low bulk density may be due to material properties such as strength, porosity, and compaction ease. Mahogany palm had the highest pH (H_2O) of 8.37, and Iroko sawdust had the lowest pH (H_2O) of 7.06. pH (KCl) showed a similar trend to pH (H_2O). The highest EC value (0.50 dSm^{-1}) was found in Iroko, and the lowest value (0.10 dSm^{-1}) was found in cocoapeat.A similar result was observed by Azim et al. (2018).

Table 1. Physical and Chemical Properties of the Media

Media	WRC (%)	PD (gcm^{-3})	BD (gcm^{-3})	pH(H_2O)	pH(KCl)	EC (dS m^{-1})	N %	OC%	C: N
Cocopeat	83.33^{c}	0.46^{c}	0.23^{d}	7.90^{c}	7.21^{c}	0.10^{d}	0.014^{a}	0.50^{a}	35.01^{fg}
Doum Palm	51.11^{f}	0.81^{a}	0.30^{b}	8.17^{b}	7.73^{b}	0.27^{b}	0.013^{b}	0.48^{bc}	34.75^{g}
Iroko	80.00^{d}	0.26^{d}	0.94^{a}	7.06^{f}	6.32^{ef}	0.50^{a}	0.012^{c}	0.47^{cd}	36.55^{bcd}
Mahogany	67.78^{e}	0.25^{e}	0.18^{e}	8.37^{a}	7.81^{a}	0.17^{c}	0.012^{c}	0.46^{de}	36.22^{cde}
Rice Husk	84.44^{b}	0.60^{b}	0.26^{c}	7.36^{e}	6.57^{e}	0.23^{b}	0.013^{b}	0.49^{a}	38.34^{a}
Sapele	85.56^{a}	0.21^{f}	0.12^{e}	7.70^{d}	7.10^{d}	0.21^{bc}	0.013^{b}	0.46^{e}	35.72^{ef}
SE±	0.00001	0	0.0004	0.0008	0.0003	0.0009	0.0008	0.002	0.175
P-Value	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**

SE = Standard Error of Mean **Significance at 1% level of Probability Levels not connected by the same letters are significantly different. WRC denotes Water Retention Capacity; PD denotes Particle Density; BD denotes Bulk Density.

The nitrogen content of Cocopeat was found to be the highest at 0.014%, while the lowest amount was 0.012% (shown in Table 1). The variation in the nitrogen content of the media can be attributed to the release of mineralized N into ammonium (NH_4^+) and nitrate (NO_3^-) during nitrification. The percentage of organic carbon in the media was low and the variation among the media is likely due to microbial activity and the presence of anaerobic sites in the compost that may result in methane (CH_4) emissions during the fermentation process, which is consistent with the findings of Thiyageshwari *et al*. (2018). The highest C: N ratio was found in rice husk (38.34) and the lowest value of 34 was found in Doum. The slight decrease in the C: N ratio of the media after modification methods could be due to the increase in the humification of organic matter during the composting process, which is consistent with the findings of Qasim *et al*. (2018). However, the variation in the C: N ratio in the media indicates that the compost is not fully matured as no additional N source was added during composting. The highest calcium content was found in rice husk, while the lowest value was found in cocoapeat (16.26 mg kg^{-1}). The concentrations of the remaining exchangeable bases were all within range, with potassium being slightly higher than the other metals (Table 2). The micronutrients were also within range, with rice husk having the highest concentrations of Mn, Cu, and Fe, while Iroko had the highest Zn and Al concentrations (Table 2). The variation in the mineral compositions of the exchangeable bases can be attributed to the mineralization of minerals by microbial activity during the composting process. Another factor that may influence the availability of nutrients is the change in pH of the media. This result is consistent with earlier literature that found that the mineralization of compost may alter the concentration of nutrients due to microbial activities(Cappuyns and Swennen, 2008).

Table 2. Chemical Composition of the Media

Media	Ca Cmol kg^{-1}	Mg Cmol kg^{-1}	K Cmol kg^{-1}	Na Cmol kg^{-1}	Zn mg kg^{-1}	Cu mg kg^{-1}	Mn mg kg^{-1}	Fe mg kg^{-1}	Al mg kg^{-1}
Cocopeat	16.26^{d}	6.74^{c}	27.72^{e}	36.02^{ab}	0.06^{b}	0.08^{cd}	0.06^{ef}	0.21^{c}	0.10^{c}
Doum Palm	17.70^{cd}	7.58^{bc}	223.72^{bc}	40.34^{a}	0.08^{a}	0.18^{ab}	0.10^{cd}	0.18^{cd}	0.11^{c}
Iroko	19.08^{cd}	7.71^{b}	307.29^{a}	14.90^{cd}	0.08^{a}	0.11^{b}	0.12^{bcd}	0.30^{b}	0.48^{b}
Mahogany	17.63^{cd}	6.77^{c}	168.99^{cd}	8.98^{d}	0.06^{b}	0.09^{cd}	0.04^{f}	0.11^{e}	0.06^{d}
Rice Husk	48.35^{a}	19.79^{a}	39.24^{e}	36.00^{ab}	0.02^{c}	0.20^{a}	0.34^{a}	0.54^{a}	1.29^{a}
Sapele	20.97^{b}	5.79^{d}	128.92^{cde}	21.46^{bcd}	0.07^{ab}	0.09^{cd}	0.09^{cde}	0.18^{cd}	0.11^{c}
SE±	1.3	0.79	25.14	3.14	0.005	0.003	0.01	0.008	0.007
P-Value	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**	<0.0001**

SE = Standard Error of Mean **Significance at 1% level of Probability. Levels not connected by the same letters are significantly different.

Electrochemical properties of the media

The charge properties of the different media are shown in Table 3. There were significant ($p<0.0001$) variations in the ECe means obtained from the media. Treatments containing composted Iroko had the highest EC with value of 0.51dSm^{-1}, with the lowest being cocoapeat with value 0.10 dSm^{-1}. The PZC of the media was within the same range. In comparison to the natural pH values, the medium produced higher pH values. The high pH levels obtained from the medium were comparable to the pH range found by Azim *et al*. (2018). This contradicts the conclusions of Chen *et al*. (2022), who found that the pH of soils increased with the addition of compost. Citak and Sonmez (2011) found that increasing compost rates resulted in an increase in pH. The increase in pH values of the media might be attributed to the oxygen containing functional group's dissociation reactions on the surfaces of the organic material, which is consistent with the findings of Marta et al. (2019). Furthermore, the liming effects of full compost may have contributed to a rise in soil pH, which may have reduced cationic attraction and mobility due to less competition between H^+/metal cations for exchange sites on the media (Beesley *et al.,* 2011). Similarly, the negative electric potential (Ψ0) values observed in the current study were caused by an increase in compost media pH as well as low PZC values (Table 3).Rice husk, Iroko and cocoapeat produced more negative charges. It is reasonable to believe that the study's negative potential values were directly impacted by the composting of the media content. This is consistent with Chaves *et al.* (2016)'s discovery that "this negative sign and magnitude of Ψ0 were directly influenced by the related magnitude of the ΔpH." The increase in negative charges during composting might be directly related to the dissociation of functional groups and the action of potential determining ions (e.g., H^+ and OH^-).The negative ΔpH values indicated that the media had a higher concentration of negative charges. Under altered pH conditions, the cation exchange capacity (CEC) exceeded the anion exchange capacity (AEC). However, as seen in Table 3, the magnitude of pH decreased with varied media, indicating a decrease in CEC. The increase in CEC is mostly due to the negative charge on the organic media's outer surface, which results from the dissociation of functional groups (Cheng *et al.* 2006).

Table 3. Electrochemical Properties of the Media

Treatment	pH (KCl)	pH (H_2O)	ECe (dSm^{-1})	ΔpH	PZC	Ψ_0 (mV)
Cocopeat	7.21^{c}	7.90^{c}	0.10^{e}	-0.69	6.52	-81.56
Doum Palm	7.73^{ab}	8.17^{b}	0.27^{b}	-0.44	7.29	-52.01
Iroko	6.32^{f}	7.06^{e}	0.50^{a}	-0.74	5.58	-87.47
Mahogany	7.81^{a}	8.37^{a}	0.17^{d}	-0.56	7.25	-66.19
Rice Husk	6.57^{e}	7.36^{d}	0.23^{c}	-0.79	5.78	-93.38
Sapele	7.10^{d}	7.70^{cd}	0.21^{cd}	-0.6	6.5	-70.92

Levels not connected by the same letters are significantly different at the 1% level of probability.

Correlation Coefficient between PZC and Selected Media Properties

Table 4 shows the correlation coefficient between PZC and several media characteristics. The results showed that pH and Ψ0were significantly correlated with the PZC of the medium in the experiment, with an*R* value of 0.91 suggesting that ΔpH and Ψ0 influenced 91% of the change in PZC. Table 4 shows that electrical conductivity (ECe) has no influence on the PZC of the media.

Table 4. Correlation between PZC, pH and Ψ0 of the Media.

	Media	
Factors	**R**	**Significance level**
Ece	-0.54	NS
pH	0.91	***
Ψ0	0.93	***

, **, * are significance levels of < 0.05, < 0.01 and < 0.001, respectively; NS: not statistically significant.*

Effects of Media on Tomato Root Volume (cm^3)

The effect of media on root volume of tomato test crop is shown in Fig 1, where there was a highly significant difference ($\rho < 0.0001$) among the media with the highest volume in cocopeat, mahogany, and rice husk (0.03) followed by Iroko and Sapele (0.2) and lowest in Doum Palm (0.01). The variation observed in the root volume between the media could be attributed to the difference in the density of the media, which is the weight of the media per unit volume, which has a negative effect on root penetration and, in turn, retards its volume. Another factor that may influence root volume is nutrient availability, especially nitrogen, which directly affects root growth (Best *et al.,* 2014).

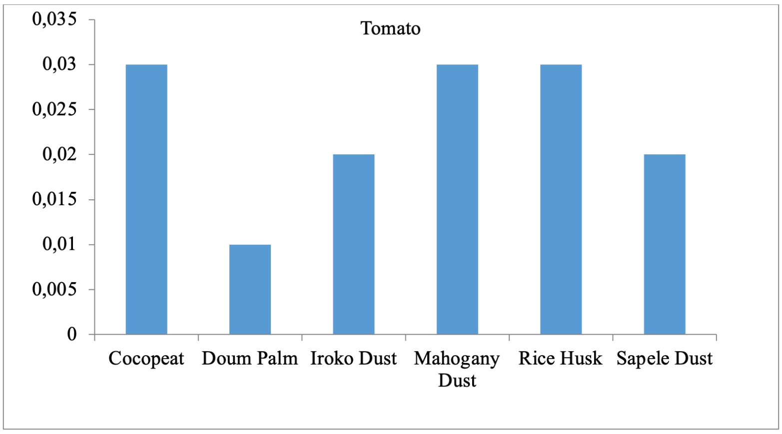

Figure 1. Effects of Media on Root Volume (cm^3)

Effect of Media on Root Density

The effect of media on root density is shown in Fig. 2, where a significant difference ($p < 0.0001$) among the media was observed. The variation observed in the root density between the media can be attributed to the difference in the density of the materials. Furthermore, since soilless media mostly maximize space utilization, allowing for higher plant densities in a given area. This close spacing can stimulate competition among plants, leading to increased root density as plants vie for available nutrients and space (Best *et al.,* 2014). However, nutrient availability, particularly nitrogen, which directly affects root growth may influence root density.

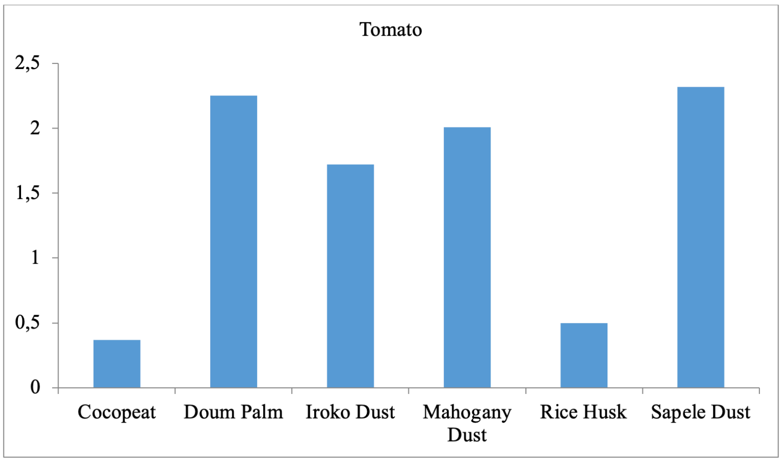

Figure 2. Effects of Media on Root Density ($g\ cm^{-3}$)

Effects of Media on Days to Flowering

Table 5 shows a significant ($p<0.0001$) effect of media on days to flowering of the test crop. The lowest number of days to flowering was observed in rice husk (20.67), followed by cocopeat, mahogany, Sapele, and Iroko dust. The Doum palm has the highest number of days to flowering (30), with slight variation observed between the media. The variability observed in the number of days to flowering could be attributed to the germination of the media and the initial plant height and root volume of the test crop. The capacity of the media to supply adequate moisture, nutrients, and proper aeration amongst many other physical and chemical attributes needed by the crop to grow might attribute to the delay in days to flowering (Ahmad *et al.,* 2009).

Table 5. Effects of Media on Days to Flowering

Media	Tomato
Cocopeat	21.33[a]
Doum Palm	30.17[d]
Iroko Dust	26.17[b]
Mahogany Dust	21.50[a]
Rice Husk	20.67[a]
Sapele Dust	22.83[bc]
SE±	0.58
P- Value	<0.0001**

SE = Standard Error of Mean **Significance at 1% level of Probability Levels not connected by the same letters are significantly different.

Effect of media on number of tomato fruits (yield)

Table 6 illustrates the tomato yield data. A highly significant difference ($p < 0.0001$) was observed in the number of fruits per hectare. The highest tomato yield was recorded in cocopeat media (4,604,444), followed by rice husk, Sapele, mahogany, and Iroko dust. Doum palm exhibited the lowest fruit yield (1,175,556), with minor variations observed among the media. The variance in fruit yield could be attributed to factors such as the absence of transplanting shock during transplantation and the initial height of the plants. Robust seedlings tend to establish quickly and vigorously due to their efficient absorption of water and nutrients through developing roots, resulting in higher fruit yield and quality. Additionally, nutrient content, particularly the high phosphorus content in rice husk, may influence fruit yield (Olle *et al.,* 2012). Moreover, Ahmad et al. (2011) reported that rice husk media possess exceptional physical, chemical, and biological properties, translating to optimum growing condition, which aligns with the findings of this study (as presented in Table 1 and 2). This similarity in properties could explain the higher yield observed in rice husk media compared to other media types.

Table 6. Effect of media on number of fruits (yield) per hectare

Media	Tomato (ha^{-1})
Cocopeat	4,604,444[a]
Doum Palm	1,175,556[d]
Iroko Dust	1,593,333[cd]
Mahogany Dust	2,120,000[bcd]
Rice Husk	3,420,000[ab]
Sapele Dust	2,606,667[bc]
SE±	253,636
P- Value	<0.0001**

SE = Standard Error of Mean **Significance at 1% level of Probability Levels not connected by the same letters are significantly different.

Effect of Media on Fresh Weight of Tomato

Table 7 shows the effect of the media and modification methods on fresh weight (t ha^{-1}) in the test crops. The highest fresh weight in tomato was observed in cocopeat (69.30), followed by rice husk, Sapele, Iroko dust and mahogany. Doum palm has the lowest yield (17.10), with slight variation observed between media. The differences noticed in fresh weight can be attributed to various factors such as the germination process in different growing media, the initial height of plants, root volume, and the duration until flowering. These aspects vary across different media types due to the distinct materials they contain.

Table 7. Effect of Media on Fresh Weight (kg ha^{-1})

Media	Tomato kg ha^{-1}
Cocopeat	69.30[a]
Doum Palm	17.10[d]
Iroko Dust	22.67[cd]
Mahogany Dust	21.70[bcd]
Rice Husk	51.63[ab]
Sapele Dust	39.10[c]
SE±	4.41
P- Value	<0.0001**

SE = Standard Error of Mean **Significance at 1% level of Probability Levels not connected by the same letters are significantly different.

CONCLUSION

This study revealed that composted rice husk and cocopeat were the best growing medium as they showed more promise in terms of yield both in number of fruits and weight. Furthermore, the study shows that the modification (composting) of the growing media decreased ΔpH and CEC levels, however the media's PZC and pH was increased. This study also demonstrated the significance of the function performed by composted media owing to the rise in negative charges that will aid in plant nutrient (cations) adsorption and retention, hence boosting the soil's fertility status. It is recommended that rice husk and cocopeat be used as the growing media. However, due to the cost of producing cocopeat media, rice husk can serve as an alternative to cocopeat as a growing medium. Despite a slight delay in germination shown by rice husk media, a high yield was attained at the end of the production.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declare that they have no competing, actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the text, figures, and tables are original and that they have not been published before.

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Data availability

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

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