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Effect of Growth Media Nutrient Status on Cocoa (*Theobroma cacao* L.) Seedlings Growth and Biomass Characteristics in Abia State, Nigeria

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Abstract

An experiment was conducted at the National Cereals Research Institute (NCRI), Amakama sub-station, Abia State, Nigeria to evaluate the effect of nursery media on shoot and root growth parameters and biomass of cocoa (*Theobroma cacao* L.) seedling from April to August 2020. The experimental design used was Completely Randomized Design (CRD) with five treatments, poultry manure plus river sand (PM + RS) at ratio of 3:2, poultry manure plus river sand plus sawdust (PM + RS + SD) at ratio of 3:1:2, poultry manure plus top soil plus river sand (PM + TS + RS) at ratio of 3:2:1, poultry manure plus top soil plus sawdust (PM + TS + SD) at ratio of 3:1:2 and Top soil (TS). Each treatment was replicated three times. The parameters measured were seedling growth parameters, shoot biomass and root biomass. At 10 WAP (weeks after planting), 12WAP and 14WAP, PM +RS + SD and PM + TS + SD recorded the highest plant heights (cm) of 30.90, 32.40, 37.45 and 29.59, 32.30, 40.38 respectively which were significantly higher ($P<0.05$) in values than from other media. PM + TS + SD were significantly different ($P<0.05$) from others but statistically same with PM + RS + SD; it had 24.33 as number of leaves at 14 WAP while others range between 13.00 and 22.33. The results showed that at 10 WAP and 14 WAP, PM + RS + SD had highest shoot fresh weight which differed significantly from those of other media. TS produced significantly the least shoot and root values at 14 WAP. It had 18.30cm as root length while others ranged from 10.37cm and 14.00cm. There was no significant difference ($P<0.05$) obtained at 10WAP while at 14 WAP, PM + TS + SD significantly differed from PM + RS, TS, PM + TS + RS but statistically same with PM + RS + SD on the bases of root length. PM+RS+SD was significantly different ($P<0.05$) from other treatments at 14 WAP for shoot and root dry matter weight. The analysis also showed a positive correlation among and between most growth parameters and plant biomass of cocoa seedling. Media PM+RS+SD and PM+TS+SD were the best in terms of growth parameters and biomass analysis of *T. cacao*, in the context of this work they can be recommended for raising cocoa seedlings.

Keywords

Cocoa, *Theobroma cacao*, nursery media, biomass, growth parameter, shoot, seedling

1. Introduction

Cocoa is one of the world's most valuable crops, cultivated worldwide on 8.2 million hectares, grown in 58 countries, and worth over US$4 billion annually [1]. Cocoa is a well-adapted agroforestry plantation crop grown in hot, rainy climates with cultivation concentrated in a band between 0 to 20 degrees North and South of the Equator, sometimes

called the “Cacao Belt” [2].

Cocoa has been a major source of income for many Nigerians and a major source of foreign exchange earnings for the country. However, its production has been experiencing a declining trend in recent times. Many factors have been implicated. One major factor is poor seedling production [3]. Nigeria was once the second leading producer of cocoa in West Africa. During this period, cocoa was ranked as the first Nigerian foreign exchange-earning commodity. The situation remained sustained until the discovery, exploration and production of oil in commercial quantities [4] [1].

The use of a suitable growing medium is essential for the production of quality plant seedlings. It directly affects the growth, development and maintenance of the functional rooting system. Cocoa farmers in Abia State are faced with the challenge of selecting the best growth medium or media for raising cocoa seedlings. A good growing medium would provide sufficient support to the plant; it would also serve as a reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate [5]. Nursery growth media influence the quality of seedlings produced [6]. The quality of seedlings obtained from a nursery influences re-establishment in the field and the eventual productivity of a plantation [5]. Thus, the aim for this study is to evaluate five planting media to ascertain the most suitable medium for early seedling growth and biomass of *T. cacao* to enhance its success in propagation and cultivation in the study area.

2. Materials and Methods

2.1 The Study Location

The experiment was conducted at National Cereals Research Institute, (NCRI), Amakama out station in Umuahia South Local Government Area of Abia State, Nigeria (Latitude 05˚27´ N, longitude 07°29´ E)and altitude 161m above sea level in the rainforest agro-ecological zone. The climate is humid and tropical with distinct wet seasons (April to October) and dry season (November to March). Annual rainfall in the area ranges from 1750 mm to 3000 mm with peaks in July and September. Average temperature ranges between 27˚C and 35˚C Subsistence farming by resource poor farmers for food crop production is prevalent in the area [7].

2.2 Seed Procurement and Extraction

Fruits of *Theobroma cacao* (Amazon variety) were purchased from Ahiaeke cocoa plantation in Umuahia North LGA, Abia state, Nigeria. This community is a well-known community in *T. cacao* farming. The fruits were obtained from one tree. Viable seeds were sorted out by simple flotation techniques following the procedure of [8].

2.3 Nursery Preparation and Seed Sowing

Ten litres plastic buckets perforated at their bases were filled with 15kg of the following planting media of (1) poultry manure plus river sand (PM + RS) at ratio of 3:2, (2) poultry manure plus river sand + sawdust (PM + RS + SD) at ratio of 3:1:2, (3) poultry manure plus topsoil plus river sand (PM + TS + RS) at ratio of 3:2:1, (4) poultry manure plus topsoil plus sawdust (PM + TS + SD) at ratio of 3:1:2 and (5)Top soil (TS). The composted media were left for three weeks before seeds were planted. Similarly, samples of the media were taken for analysis of physicochemical properties at the soil science laboratory, National Root Crops Research Institute (NRCRI), Umudike, Umuahia. Seeds were planted on the 5th May 2020. Six seeds were sown per bucket and later thinned to four plants. The buckets were arranged on top of blocks to prevent the growth of the root into the ground, to avoid possible uptake of nutrients and entering of splashed rain drops. Watering was done at two days' intervals and weeds were handpicked. Ambient temperature within 6 weeks of planting, which was the period when seedling emergence was monitored, varied between 28˚C and 33˚C. Temperature of the media was similar and, in most cases, about 2˚C higher than the ambient during the first week of planting, and thereafter media temperature more or less equated the ambient. As from the 4th week after planting, there was no more appreciable increase in percentage seedling emergency. However, monitoring of seedling continued till the 5th week of planting.

The physical and chemical characteristics of the five-nursery media were determined using [9] method.

2.4 Experimental Design

The experiment was laid in Completely Randomized Design (CRD) at the National Cereals Research Institute (NCRI), Amakama out station, Abia State. The study involved the use of five (5) planting media and three (3) replications and lasted from April to August.

2.5 Data Collection

Germination evaluation of seeds was discontinued and considered to have been completed when no additional ger-

mination took place in five weeks. Parameters measured were growth parameters (plant height, number of leaves, stem girth and leaf area), root length, root fresh weight, root dry weight, shoot fresh weight and shoot dry weight

Seedling heights: These were measured from the collar region to the tip of the seedlings by the use of meter rule.

Stem girth: It was measured using a vernier caliper at the collar base of the seedling

Number of leaves: These were determined by manual counting on the seedlings [10].

Leaf area: The leaf area (cm^2) was measured with ruler by multiplying the product of the length and the breath by the correction factor of 0.75 [11]. The growth variables were measured at two (2) weeks intervals for a period of fourteen (14) weeks.

Root length and Biomass parameters: Seedlings were uprooted after every 4 weeks for the root length and biomass measurement. Root length was measured by the use of meter rule. The uprooted seedlings were weighed and thereafter sun dried for seven days and weighed by the use of a sensitive scale to obtain the fresh and dry matter weight respectively [12].

2.6 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using SPSS (statistical package for the social sciences). The significant means were separated using Fisher's least significant difference (FLSD) at 5% probability [12].

3. Results

3.1 Physical and chemical properties of nursery media used for raising cocoa (Theobroma cacao L.) seedlings

Table 1 shows the variations in both physical and chemical composition of the media. The medium PM+RS+SD had the highest percentage of sand, while medium PM+TS+RS had the highest percentage of silt and medium TS had the highest percentage of clay. Bulk density ranged from 1.29g/cm^3 (for medium PM+TS+SD) to 1.39g/cm^3 (for medium TS) and Porosity ranged from 47.54% (for medium TS) to 51.32% (For medium PM +TS+RS).

Water holding capacity ranged between 15.11% (for growth medium TS) to 28.80% (for growth medium PM + TS + SD). The percentages of organic matter and organic carbon were the least (3.36% and 1.95% respectively) for the top soil growth medium and highest (6.45% and 3.74% respectively) for PM +TS +SD growth medium. Elemental composition was relatively similar except in the case of N (nitrogen) for the medium TS which had the least value of nitrogen. In most cases, higher values of mineral elements were obtained in growth medium PM+TS+SD, and it recorded a lower pH when compared to TS medium.

Table 1. Physical and chemical properties of growth media used for raising cocoa (*Theobroma cacao* L.)

Properties	TS	PM + RS	PM + TS+RS	PM + TS + SD	PM + RS + SD
Physical					
Sand %	75.8	90.1	78.2	75.7	91.0
Silt %	10.0	6.8	12.0	11.1	6.1
Clay%	14.2	3.1	9.8	13.2	2.9
WHC %	15.11	20.63	26.13	28.80	26.72
Bulk density g/cm^3	1.39	1.32	1.36	1.29	1.34
Porosity %	47.54	50.18	51.32	49.43	48.67
Chemical					
pH H_2O	5.8	6.6	6.9	6.1	6.7
pH KCL	4.6	6.1	6.3	5.8	6.0
AV. P mg/kg	19.8	22.2	24.6	28.8	26.4
N%	0.125	2.29	2.38	2.56	2.47
OC%	1.95	3.56	2.49	3.74	3.62
OM%	3.36	6.14	4.30	6.45	6.24
Ca	5.2	8.8	9.3	9.8	9.5
Mg	2.8	4.5	5.2	6.4	5.6
K	0.36	0.58	0.66	0.88	0.72
Na	0.28	0.34	0.41	0.53	0.45
EAE	0.72	0.04	0.02	0.08	0.06
CEC	9.36	14.26	15.59	17.69	16.33

*TS = Top soil; PM + RS = Poultry manure plus River sand; PM+TS+RS = Poultry manure plus Topsoil plus River sand; PM+TS+SD = Poultry manure plus Topsoil plus Sawdust; PM+RS+SD = Poultry manure plus River sand plus Sawdust

3.2 Plant height of cocoa seedlings as affected by different growth media

The effect of growth media on cocoa seedlings at various weeks after planting was shown in Table 2. The treatments were not significantly different at 6 WAP. At 8 WAP, the plant height ranged from 13.98 to 26.52. The highest plant height was recorded in PM+TS+SD (26.52 cm) and the lowest in PM+TS+RS (13.98 cm). The media is statistically same except for PM+TS+RS which is statistically different from media PM+TS+SD and PM+RS.

At 12 WAP, medium PM +RS+SD and PM+TS+SD were significantly different from TS and PM+TS+RS treatments but statistically the same with PM+RS. At 14 WAP, medium PM+TS+SD has the highest plant height value (40.38 cm) which did not differ significantly with plant height value of medium PM+RS+SD (37.5 cm). However, the plant heights of PM+TS+SD and PM+RS+SD differed significantly with the heights obtained in growth media TS (21.7 cm) and PM+TS+RS (18.9 cm). Selected growth media differed in both physical and chemical properties and so had varying influences on plant height.

Table 2. Plant Height (cm) of Cocoa Seedlings as affected by Different Growth Media

	6WAP	8WAP	10 WAP	12 WAP	14WAP
PM + RS	17.51^{a}	26.04^{a}	26.88^{b}	28.61^{ab}	28.77^{ab}
PM + RS + SD	16.51^{a}	24.77^{ab}	30.90^{a}	32.40^{a}	37.45^{a}
PM + TS + RS	14.48^{a}	13.98^{b}	16.92^{c}	18.80^{b}	18.87^{b}
PM + TS + SD	19.35^{a}	26.52^{a}	29.59^{ab}	32.30^{a}	40.38^{a}
TS	14.38^{a}	19.89^{ab}	20.15^{bc}	21.58^{b}	21.74^{b}

Means with the same letter in the same column are not significantly different at P 0.05.

3.3 Stem girth of cocoa seedlings as affected by different growth media

The stem girth of cocoa seedlings as affected by the media at 6 WAP was statistically the same from the analysis of the stem girth of all the five treatments (Table 3). However, at 8 WAP there were differences in the stem girth as affected by the media. At 10 WAP medium PM+RS+SD was significantly different from other treatments except for PM+TS+SD. At 2 WAP medium PM+RS+SD was significantly different from TS treatment. Although there was no significant difference among the treatments in 14 WAP, medium PM+RS+SD and medium PM+TS+SD had the highest (0.93cm) stem girth.

Table 3. Stem girth (cm) of cocoa seedlings as affected by different growth media

	6WAP	8WAP	10 WAP	12 WAP	14WAP
PM + RS	0.45^{a}	0.57^{ab}	0.57^{b}	0.70^{ab}	0.70^{a}
PM + RS + SD	0.51^{a}	0.63^{a}	0.83^{a}	0.93^{a}	0.93^{a}
PM + TS + RS	0.42^{a}	0.47^{b}	0.55^{b}	0.60^{b}	0.72^{a}
PM + TS + SD	0.46^{a}	0.53^{ab}	0.66^{ab}	0.71^{ab}	0.93^{a}
TS	0.39^{a}	0.48^{ab}	0.48^{b}	0.53^{b}	0.62^{a}

Means with the same letter in the same column are not significantly different at P=0.05.

3.4 Number of leaves of cocoa seedlings as influenced by different growth media

Although not statistically different, PM+RS+SD had a lower number of leaves compared to PM+TS+RS and PM+TS+SD on 10WAP (Table 4).

Table 4. Number of leaves of cocoa seedlings as affected by different growth media

	6WAP	8 WAP	10 WAP	12 WAP	14WAP
PM + RS	9.33^{a}	14.64^{a}	14.33^{a}	18.00^{a}	18.50^{ab}
PM + RS + SD	9.67^{a}	16.33^{a}	16.00^{a}	22.33^{a}	22.33^{a}
PM + TS + RS	8.67^{a}	14.33^{a}	17.00^{a}	19.00^{a}	20.00^{ab}
PM + TS + SD	9.00^{a}	14.67^{a}	18.00^{a}	19.67^{a}	24.33^{a}
TS	7.00^{a}	11.00^{a}	12.00^{a}	13.00^{a}	13.00^{b}

Means with the same letter in the same column are not significantly different at P=0.05.

3.5 Leaf area of cocoa seedlings as affected by different growth media

The leaf area recorded at 6 WAP shows that there was no significant difference between the treatments. However, medium PM+RS+SD had the highest leaf area, (89.81 cm^2) and medium TS the lowest leaf area (54.67 cm^2) Table 5. At 8 WAP medium PM+TS+SD recorded the highest leaf area (174.18cm^2) which differed significantly with the medium TS that had the lowest (81.55 cm^2). At 10 and 12 WAP media PM+RS+SD and PM+TS+SD was statistically different from media PM+TS+RS and TS respectively. While at 14 WAP, it was statistically same except in the case of medium TS (121.53cm^2**).**

Table 5. Leaf area (cm^2) of cocoa seedlings as affected by different growth media

	6WAP	8WAP	10 WAP	12 WAP	14WAP
PM + RS	82.93^{a}	168.78^{a}	168.79^{ab}	198.88^{ab}	198.47^{ab}
PM + RS + SD	89.81^{a}	166.67^{a}	257.12^{a}	270.92^{a}	271.33^{a}
PM + TS + RS	62.31^{a}	94.84^{b}	130.45^{b}	137.88^{b}	142.72^{ab}
PM + TS + SD	76.09^{a}	174.18^{a}	232.61^{a}	273.98^{a}	275.33^{a}
TS	54.67^{a}	81.85^{b}	90.18^{b}	116.08^{b}	121.53^{b}

Means with the same letter in the same column are not significantly different at P=0.05.

3.6 Effect of growth media on biomass fresh weight of shoot, root and root length of cocoa seedling

3.6.1 Shoot Seedling Fresh Weight

The results obtained from the weight of the plants (Table 6) show that at 6 WAP medium PM+RS+SD gave the highest weight (11.98 g) followed by medium PM+RS (11.23 g), medium PM+TS+RS (8.67g), PM + TS+ SD (8.24 g) and medium TS (7.98 g). Medium PM+RS+SD maintained the highest weight through 10 WAP and 14 WAP, while medium TS had the least through 6 WAP to 14 WAP. The PM + RS + SD medium recorded the highest fresh weight (11.98g) at 6 WAP. The results were significantly not different.

3.6.2 Root Seedling Fresh Weight

There was a significant difference among the media. Medium TS gave the highest weight recorded (2.51 g) at 6 WAP (Table 6). At 10 WAP medium PM+ RS gave the highest weight (4.14 g) with medium PM+TS+RS (2.29 g) as the least. At 14 WAP medium PM+RS+SD gave the highest weight (31.00g) followed by PM +TS+SD (22.30 g) PM+RS (22.08 g), PM +TS + RS (16.08.g) and TS (12.51 g) respectively.

3.6.3 Root Length

The treatments did not differ significantly in the mean values of the root length at 10 WAP. However, treatment TS gave the highest roots length at 6 WAP (18.30cm) and 10 WAP (20.77cm) respectively (Table 6).

Table 6. Effect of growth media on cocoa seedlings shoot fresh weight, root fresh weight and root length

	Shoot Fresh Weight (g)			Root Fresh Weight (g)			Root length (cm)		
	6WAP	10WAP	14 WAP	6 WAP	10WAP	14WAP	6 WAP	10WAP	14WAP
PM + RS	11.23^{a}	19.05^{ab}	130.05^{abc}	1.60^{b}	4.14^{a}	22.08^{ab}	11.37^{b}	17.27^{a}	16.53^{b}
PM + RS + SD	11.98^{a}	20.94^{a}	169.21^{a}	1.87^{ab}	3.01^{ab}	31.00^{a}	14.00^{ab}	19.25^{a}	19.63^{a}
PM + TS + RS	8.67^{a}	12.08^{ab}	90.43^{bc}	0.99^{b}	2.29^{b}	16.08^{b}	10.37^{b}	14.57^{a}	15.87^{b}
PM + TS + SD	8.24^{a}	18.40^{ab}	160.08^{ab}	1.42^{b}	2.71^{ab}	22.30^{ab}	13.73^{ab}	16.07^{a}	21.10^{a}
TS	7.98^{a}	9.08^{b}	73.76^{c}	2.51^{a}	2.58^{b}	12.51^{b}	18.30^{a}	20.77^{a}	16.27^{b}

Means with the same letter in the same column are not significantly different at P=0.05.

3.7 Effect of growth media on seedling dry matter weight and root dry matter weight

3.7.1 Shoot Seedling Dry Matter weight

As indicated on Table 7 there were no significant differences (P=0.05) in shoot dry matter weight at 6 WAP of cocoa seedlings. AT 10WAP seedlings grown in PM+TS+SD and PM+RS recorded 7.70g and 7.23g respectively higher than

other treatments. Treatment PM+RS+SD recorded the highest (74.03g) at 14 WAP, with treatment TS recording the lowest (4.42g).

3.7.2 Root Seedling Dry Matter weight

Shown on Table 7 at 6 WAP, treatment TS recorded significantly higher (P=0.05) dry matter compared to the other treatments. At 10 WAP treatment PM+RS gave the highest (1.40g) followed by TS (1.01g), PM+TS+RS (0.65g) in that order. PM+RS+SD although not significantly different (P<0.05) compared to other treatments at 14 WAP.

Table 7. Effect of growth media on shoot dry matter weight and root dry matter weight

	Shoot Seedling Dry Matter Weight (g)			Root Seedling Dry Matter Weight (g)		
	6WAP	**10WAP**	**14 WAP**	**6 WAP**	**10WAP**	**14WAP**
PM + RS	3.51^{a}	7.23^{a}	56.20^{ab}	0.47^{b}	1.40^{a}	10.28^{ab}
PM + RS + SD	3.91^{a}	7.70^{a}	74.03^{a}	0.47^{b}	0.98^{ab}	14.00^{a}
PM + TS + RS	2.90^{a}	4.02^{ab}	33.28^{b}	0.27^{c}	0.65^{b}	6.65^{b}
PM + TS + SD	2.93^{a}	5.57^{ab}	63.52^{ab}	0.47^{b}	0.73^{b}	9.3^{ab}
TS	3.00^{a}	2.94^{b}	4.42^{c}	0.65^{a}	1.01^{ab}	4.85^{b}

Means with the same letter in the same column are not significantly different at P=0.05.

3.8 Correlation among and between some growth parameters and plant biomass

Correlation between some growth parameters is presented in Table 8. Plant height was positive and highly correlated to seedling leaf area (r = 0.852, p = 0.01) stem girth (r = 0.830, P = 0.01), Number of leaf (r = 0.679, P = 0.01), root length (r = 0.666, p = 0.05) shoot fresh weight (r = 0.T57, P = 0.01) root fresh weight (r = 0.95, P = 0.01), shoot dry matter (r = 0.808, P = 0.01), root dry matter (r = 0.772, P = 0.01). leaf area was also found to be positively and highly correlated to other growth parameters except for number of leaves.

Stem girth in the same vein was found to be positively and highly correlated to growth parameters except for root length. Root length was positive and highly correlated to shoot fresh weight (r = 0.072, P = 0.05), root fresh weight (r = 0.736, P = 0.01) shoot dry matter (r = 0.904, P = 0.01), root dry matter (r = 0.684, P = 0.05).

Table 8. Correlations among and between some growth parameters and plant biomass of cocoa seedlings as affected by the media

	PHt	**LA**	**GS**	**NL**	**R Length**	**SFW**	**RFW**	**SDMW**	**RDMW**
P.Ht	1.00								
LA	0.852**	.1.00							
GS	0.830**	0.735**	1.00						
NL	0.679**	0.482	0.808**	1.00					
R Length	0.666**	0.592*	0.480	0.458	1.00				
SFW	0.757**	763**	0.734**	0.598*	0.702*	1.00			
RFW	0.795**	0.816**	0.727**	0.582*	0.736**	0.946**	1.00		
SDMW	0.808**	0.803**	0.807**	0.669*	0.904**	0.673*	0.922**	1.00	
RDMW	0.772**	824**	0.667*	0.512	0.684*	0.980**	0.904**	0.819**	1.00

Note: *significant at 0.05, ** significant at 0.01. PHt- Plant Height; LA - Leaf area; GS – Girth size, NL – No of leaf; R Length – Root length; SFW–Shoot Fresh Weight; RFW – Root Fresh Weight; SDMW –Shoot Dry Matter Weight; RDMW–Root Dry Matter Weight.

4. Discussions

Differences in physicochemical properties of growth media could be ascribed to the media components [13]; [14]. Thus, the top soil medium had the lowest value for water holding capacity and lower amount of mineral element, prob-

ably why it recorded the least in most of the parameters measured. Among the chemical attributes, its values for organic carbon, organic matter and percentage nitrogen were also the least. Conversely, due to the higher proportion of sawdust and lower ratio of top soil component, PM+TS+SD medium had the least bulk density and highest water holding capacity. On a general note, the properties of the media are in agreement with those of [14]. The significant media effects on onset of seedling emergence, and duration of emergence was probably due to differences in the physical characteristics as stated by [14].

Composition of growth medium influences the quality of seedlings [13], and might have been responsible for the poor observation under medium TS. However, in terms of plant height, sawdust amended media recorded greater values than the top soil and river sand treated cocoa seedlings. Top soil may not be the right choice for plants in pots or poly bags. This could be due to the frequent watering of pot plants causing soil compaction, which leads to the formation of a tight and brick-like mass impeding growth performance. The incorporation of organic material into the soil offers a great advantage over the conventional top soil as this enhances adequate nutrient supply to seedlings, better root substrate relation and minimally pre-disposes the seedlings to soil borne pests and disease [15].

[16] opined that better plant height is attained in mixed amended media than in sole media. According to [17] a suitable growth medium plays four vital functions: serving as a reservoir for plant nutrient, supplying available water to plants, providing gases to enhance aeration which enable root to respire and retaining sufficient available water all together and acting as plant support anchorage for the planting root. This current study conforms to [18] that sawdust treated tomato plants increased the vegetable growth of tomato plants compared to the control (i.e, without sawdust). Greater scores (19.35, 26.52, 29.59, 32.20 and 40.38cm) recorded in the case of plant height for the medium PM+TS+SD throughout the study than the control (top soil) indicates that the use of soil amendment is beneficial to cocoa seedlings during nursery. [19] revealed that greater plant growth observed on organic amendment treated media could be ascribed to the fact that the materials released a considerable amount of nutrients for plant use since their decomposition could enrich soil properties, which agrees with the present study.

[20] found considerable improvement in the germination of *T. ivorensis* when amended sawdust was resorted to as a growth medium. On 6 WAP, the mean height for cocoa seedlings did not greatly differ as compared to those of 8 WAP, 10 WAP, 12 WAP and 14 WAP. This could be that plants take their nutrients from the cotyledons or rhizomes at their initial growth phase until the depletion of nutrients [20]

Plants rely on their roots for up-take of nutrients from the growth media following nutrient depletion. Erstwhile studies by [21], and [22] indicated that germination and seedling emergence are dependent on soil nutrient status. However, they depend entirely on cotyledons attached to the seedling, which are rich in stored food reserves until the seedling becomes autotrophic and utilizes nutrients from the growth medium.

The PM + RS + SD medium recorded the greatest seedling stem girth (0.51cm) which was not statistically different from the control (0.39cm) on 6WAP. This may be attributed to the excellent water holding capacity of the medium, good aeration property and availability of plant nutrients in the medium, which facilitated photosynthetic activity (i.e, more reserved food) and, thus, increased seedling stem girth. This finding conforms to that of [23] which found *Uapacakirkiana* planted on forest soil amended with sawdust (3:1) recorded the greatest root collar diameter. The efficacy of sawdust amended poultry manure and river sand has successfully been proven to be the best growth medium for this study in terms of most of the parameters measured. Top soil treated cocoa seedlings recorded the least stem girth (0.39cm) at 6 WAP. [24] suggested that an ideal nursery medium should provide porosity to enhance good aeration, which offers better growth to plants. This might be the reason why most of the media recorded better growth when compared to the TS medium which had the least porosity.

Vegetative growth per number of leaves generally depends on the nutrients absorbed from the media mixtures or substrates [25]. Irrespective of the WAP, there was no significant difference among the media. At 14 WAP, PM+TS+SD and PM+RS+SD were significantly different from TS. However, the greatest value (24.33) was recorded for PM + TS+SD. This may be due to the release of available plant nutrients and water for plant uptake.

Medium PM + RS + SD gave the highest fresh weight in most of the weeks after planting; this can be attributed to the composition of growth medium which influences the weight of the seedling [26].

The treatments did not differ significantly in the mean values of the root length at 10WAP. However, treatment TS gave the highest roots length at 6 WAP (18.30cm) and 10WAP (20.77cm) respectively (Table 6). This probably, may be as a result of the seedling growing more roots in search of nutrients [27].

Generally, the correlations were strong and highly significant for most of the factors.

5. Conclusion

It is apparent from this study that the different media have varying quantities of the growth parameters in the different WAP`s. Although PM+RS+SD and PM+TS+SD recorded higher than other media in most of the parameters measured, statistically they do not differ from other media except for the medium TS. Combining all the growth parameters eva-

luated in this study, performance of the treatments or media can be ranked in this order; PM + RS + SD >PM + TS + SD > PM + RS > PM + TS + RS > TS respectively. In most parameters at 8 WAP, 10 WAP and 14 WAP, PM + RS + SD and PM + TS + SD recorded significant values than others and this could be further evaluated in another experiment.

6. Recommendation

- Poultry manure, river sand and sawdust mixture positively influence the biomass of cocoa seedling and are recommended for efficient, vigorous and high productivity of cocoa seedlings.
- On the basis of plant height, stem girth, leaf area and number of healthy leaves the best were obtained from Poultry manure, top soil, and sawdust mixtures followed by poultry manure, river sand and sawdust and are recommended.
- Since good morphological developments of seedling were obtained in media amended with sawdust and poultry manure, the use of these components in growth medium for raising cocoa seedlings are highly recommended.
- In places where good topsoil is scarce, cocoa seedlings could be raised with poultry manure, river sand and sawdust mixture.

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