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Effect of Substratesand Fertilizer Application Rates on Growth of Two Cocoa Clones

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Abstract
Background:*The use of soilless media in production of seedlings is advancing.*
Materials and methods:*Seven substrate prepared from sawdust (SD), poultry manure (PM), Municipal solid waste compost (MSWC) and rice husk Biochar (RHB) including topsoil as the control was utilized to determine an alternative growing medium for raising cocoa seedlings. The treatments were soil only (M1); SD+PM+RHB at a ratio of 70:25:5 (M2); SD+PM+RHB at 60:30:10 (M3); SD+PM+RHB at 50:35:15 (4); SD+MSWC+RHB at 70:25:5 (M5); SD+MSWC+RHB at 60:30:10 (M6); SD+MSWC+RHB at 50:35:15 (M7). The fertilizer rates were 200mgN/L, 310mgN/L and 420mgN/L. The experimental design was a split-split plot with three replications with two cocoa clones PA7 andT65 as the main plot factor, the three fertilizer rates as the sub-plot factor and the substrates as the sub-subplot factor. Data was collected on plant height, leaf number, leaf area, stem girth, root growth and dry weights.*
Results: *Germination was poor in the soil medium compared to the soilless media. Cocoa seedlings grown in substrate M2-SD+PM+RHB (70:25:5)at a fertilizer rate of 310mgN/L recorded significantly (P<0.05) the highest total dry weight including high seedling height, stem girth, leaf number, leaf area and root volume. These were significantly (P<0.05) higher than that of the soil medium and MSWC media treated seedlings. Further research is required to look at the rate of MSWC in substrate mixture for quality seedling production.*
Key words: Cocoa; substrate; fertilizer application rate; seedling; growth

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I. Introduction

Cocoa replanting and rehabilitation programmes remain a challenge in Ghana over the years. Top soils is used to raise seedlings in Ghana, the removal of large quantities of fertile top soil deplete and degrade the environment thus reducing the productive capability of the land(Oldeman, 1994).Moreover, the bulky and heavy nature of the seedlings nursed in soil reduces the quantity of seedlings transported, as nurseries are located far away from farm gates.

Soilless culture and its importance are advancing(Barrett et al., 2016). Soilless substrates, are light in weight, easy to handle/carry and can be conveniently transported, they are free of weed seeds, reduces the risk of incidence of root pathogens and increases the likelihood of response of plants to nutrient management (Antliffe et al., 2007). Several researchers have studied growth of vegetable and tree crop seedlings in soilless culture under greenhouse conditions(Bustamante& Gavilanester, 2017; Mustafa et al., 2016; Raji, Hassankhah, & Aalifar, 2016). (MoyinJesu & Atoyosoye, 2002), studied sole and amended forms of wood ash, cocoa pod husk and rice bran with poultry manure on growth of coffee seedling and observed increased plant height, stem girth and shoot weight of coffee seedlings.

In Ghana, 13,000 tons of Municipal solid waste is generated daily (Herrera et al., 2008).About 4,159,000 tonnes of agricultural crop residues were generated in Ghana in 2008 (Duku et al., 2011).With the overall MSW generated in the country, 67% is deposited in the landfill and the 33% left in the surroundings, nearroads,drains, rivers, market places etc (Adamtey et al., 2009). These pollute the environment and posing public health risks. Turning these wastes into Biochar, compost and potting media could minimize the disposal problem and benefit agriculture.

However, the difficulty of use of potting media, containing high proportion of wood waste is variableness of such media in their nitrogen needs for optimum growth of plants(Buamscha et al., 2008; Jackson & Alley, 2009; Thomas & Spurway, 1999). Various researchers have confirmed that organic inputs alone might not be enough to meet the nutritional requirements of crops because they contain relatively lower amount of nutrients as compared to inorganic fertilizers (Ahmad et al., 2008). Wright & Browder(2005) showed that toincrease plant growth using Pine Tree Substrate (PTS) additional fertilizer was required. Peat-light substrate was used to grow Chrysanthemum and at each irrigation 50 – 400 mg NL^{-1} was applied (Wright et al., 2008). Handreck(1992a) grew cabbage seedlings in Pine bark substrate and observed improved seedling growth when 0.5-1g NL^{-1} equivalent 200-400 mg NL^{-1} wasapplied weekly.

The objective of this study was to determine the influence of growing mediaon cocoa seedling growth and the effect of different fertilizer concentration for optimum growth of cocoa seedling undersoillessculture.

II. Methodology

Experimental Site

The experiment was carried out at the University of Ghana farm, Department of Crop Science
The experimental design was a split-split plot with two cocoa clones as the main plot factor (PA7 and T65) obtained from Cocoa Research Institute of Ghana (CRIG), Tafo in the Eastern Region. Three-fertilizer application rates(200mgN/L, 310mgN/L and 420mgN/L) as the sub-pot factor and seven levels of growing media (M1, M2, M3, M4, M5, M6, M7) as the sub-sub plot factor with three replications. Ten (10) pots for each treatment were filled with the substrates, the number per replicate was 420, and the total pots were 1260.

Table 1: Substrates and their composition

Media	Composition	Ratio (%) w/w
M1	Top Soil	100%
M2	Sawdust + Poultry Manure + Rice Husk Biochar	70:25:5
M3	Sawdust + Poultry Manure + Rice Husk Biochar	60:30:10
M4	Sawdust + Poultry Manure + Rice Husk Biochar	50:35:15
M5	Sawdust + Municipal Solid Waste Compost + Biochar	70:25:5
M6	Sawdust + Municipal Solid Waste Compost + Biochar	60:30:10
M7	Sawdust + Municipal Solid Waste Compost + Biochar	50:35:15

Substrates:The composted substrates were prepared at the University of Ghana Farms. The Biochar was co-composted with the Sawdust, Poultry manure and Municipal Solid Waste compost in different ratios, the composting process was completedover a period of 12 weeks.

Substrate Physical and Chemical Analysis: The physical and chemical composition of the substrates were analysed in the laboratory.The organic carbon and nitrogen was determined using TrumMac CNS analyser,(Model: LECO TruMac CNS analyser).Phosphorus content of the substrate were determined using the digestion method(Watanabe & Olsen, 1965).Total potassium, magnesium and calcium content was determined (HCl digestion) usingJenway flame photometer (PFP7) and Ca and Mg in the extract were determined using the Atomic Absorption Spectrometer (AAS).Nitrogen Drawdown Index (NDI) was used to predict the fertilizer rate to apply(Handreck, 1992b, 1993).The fertilizerused was NPK 19:19:19 (Polyfeed) with trace elements. The nursery was established in January, in a plant house. Seeds were sown at one seed per pot in a polybags of size 15cm x 28cm that were filled with the various composted substrates with drainage holes at the bottom. Top soil used for the control was Adenta series collected near the farm..

Fertilizer rate: Fertilizer application begun when seedlings were 2 weeks old. Three nutrient solutions were prepared at each application time. Nutrient solution 1: 200mgN/L, 0.9g of NPK fertilizer (19:19:19) equivalent to 169mgN and 0.16g of $(CaNO_3)_2$ equivalent to 31mgN of the fertilizer was dissolved in 1L of water and the EC of the solution was measured using the EC meter and the EC value recorded.

For nutrient solution of 310mgN/L, 1.64g of NPK fertilizer (19:19:19) equivalent to 240 mg N and 0.23g $(CaNO_3)_2$ ie 70mgN giving a total of 310mgN of fertilizer was dissolve in 1L of distilled water and the corresponding EC of 1.8dSm^{-1} was recorded.

To prepare a nutrient solution of 420mgN/L, 2.2g of NPK fertilizer (19:19:19) equivalent to 354.9 mgN + 0.35g of $(CaNO_3)_2$ ie 65.1mgN was weighed and dissolved in 1L of distilled water and the EC value recorded.

These fertilizer rates were used to prepare stock solution, at each fertilizer application day, the stock solution was measured and diluted to the required Ec, and seedlings received 200ml of the various nutrient solutions per treatment three times a week.

Data Collection: Measurements of parameters started two weeks after germination and five plants were tagged for the measurements. Plant height, leaf number, leaf area, chlorophyll content, stem girth were measured every two weeks for 14 weeks which marked the end of the experiment. Root volume and dry weights were recorded at the end of the experiment.

Seedling was said to have emerged if the cotyledon appeared above the media surface, emergence was noted at every three days. Rate of seedling emergence was calculated

RE = ∑G/t G is the number of seeds emerged at 3 days interval and t is the total time of emergence(Khan & Ungar, 1984).

$$\% \text{ emergence} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

$$\text{Germination Index} = \frac{\text{Number of germinating seeds}}{\text{Days of first count}} + \frac{\text{Number of germinating seeds}}{\text{Days of final or last count}}$$

III. Results

Substrate physical and chemical properties: The physical and chemical properties of the substrates are presented in Table 2a-b. Water holding capacity (WHC) of the soilless growing media (M2 to M7) was significantly higher (P< 0.5) than that of the topsoil. There were no significant differences among the growing media in terms of air porosity. However, the bulk density of the topsoil (1.32 g/cm^3) was significantly (P<0.05) higher than that of the soilless media (M2 to M7). The lowest BD value among the growing media was recorded for M2 (0.50 g/cm^3). The pH of the topsoil was acidic (5.7) whiles that of the soilless growing media (M2 to M7) was basic ranging from 7.7 – 8.1. Among the soilless growing media, those containing PM recorded higher EC compared to those containing MSWC. Increasing the PM and MSWC with Biochar increased EC of the growing media from 0.11 dS/m (M2) to 1.91 dS/m (M4) of PM treated growing media and from 0.48 dS/m (M5) to 0.58 dS/m (M7) MSWC treated growing media. M2 displayed significantly lower Ec (0.07 dS/m) values than the rest of the soilless growing media. The C/N ratio of the growing media containing PM was lower than those containing MSWC and the difference was significant. Among all the growing media, topsoil showed significantly lower C/N ratio (9.67) (Table 2b).

Table 2a: Physical Properties of the growing media

Codes	Growing Media	Water Holding Capacity (%)	Bulk Density g/cm^3	Porosity %
M1	Top Soil (100%)	18.7^b	1.32^a	61^a
M2	S+PM+RHB (70:25:5)	84.5^a	0.50^d	58^a
M3	S+PM+RHB (60:30:10)	83.4^a	0.58^{cd}	56^a
M4	S+PM+RHB (50:35:15)	82.2^a	0.68^{bc}	56^a
M5	S+MSWC+RHB (70:25:5)	80.2^a	0.62^{bcd}	61^a
M6	S+MSWC+RHB (60:30:10)	79.3^a	0.67^{bc}	56^a
M7	S+MSWC+RHB (50:35:15)	74.3^a	0.73^b	54^a
	Lsd (5%)	**7.8**	**0.09**	**6.1**

Table 2b: Chemical properties of the substrates

Substrates Chemical Properties	M1	M2	M3	M4	M5	M6	M7
pH	5.7^b	7.7^a	8.0^a	8.1^a	7.9^a	7.9^a	7.9^a
EC (dSm^{-1})	0.07^e	0.11^e	1.71^b	1.91^a	0.48^d	0.52^{cd}	0.57^c
C/N	9.67	22.21	18.13	18.13	95.51	75.72	62.84
N (%)	0.09	0.831	0.847	0.889	0.232	0.235	0.282
OC (%)	0.87	18.82	15.07	16.11	22.16	17.78	17.72
S (%)	0.009	0.077	0.081	0.094	0.031	0.024	0.031
OM (%)	4.7	26.8	25.5	25.8	9.3	11.3	15.5
NH_4 (mg/Kg)	144.3	403.2	360.0	367.2	309.6	367.2	388.8
NO_3 (mg/Kg)	108.0	208.8	381.6	367.2	259.2	403.2	259.2
P (%)	0.449	0.449	0.454	0.459	0.215	0.251	0.258
K (%)	0.300	0.304	0.368	0.507	0.319	0.383	0.122
Ca (%)	5.304	5.308	4.483	4.895	4.963	5.048	5.495
Mg (%)	0.910	0.913	0.625	0.413	0.606	1.019	1.035

Germination indices

Percentage emergence was not significantly (p >0.05) different among the clones. However, the soilless growing media (M2-M7), recorded significantly (p <0.001) higher percentage emergence (95.0% – 100%) compared to that of the top soil (40%) (Table 3).

Germination index (GI) was significantly (P<0.05) high for PA7 (0.98) than T65 (0.79), (Table 3). Among the soilless substrates, the least GI was recorded under M7 (0.92) whiles maximum GI was recorded for M2 (1.14) followed by M6, M5, M3 and M4 respectively. Significantly, lower GI was recorded for the top soil treatment.

The number of days from sowing to seedling emergence varied from 10.5 to 21.5 days, the clone PA7 took significantly shorter (11.4) days to reach 50% emergence whiles T65 took 14 days. The control (top soil) took longer time (21.5) days on the average to reach 50% emergence (Table 3).

Table 3. Germination indices of two cocoa clones as affected by growing media

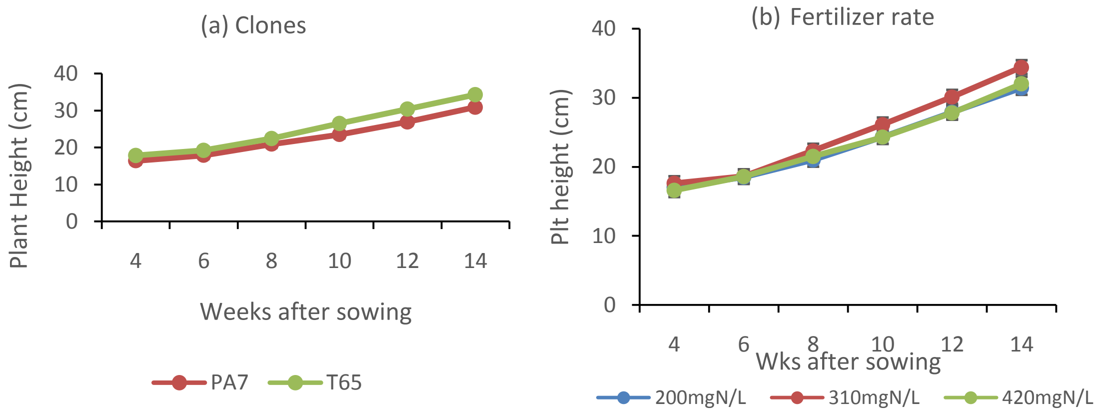
Treatments	Rate of Emergence (%)	Germination Index	Days to 50% Emergence	% Emergence
Clones				
PA7	0.80^{a}	0.98^{a}	11.1^{b}	87.6^{a}
T65	0.77^{a}	0.79^{b}	14.0^{a}	89.0^{a}
Lsd (5%)	**0.1**	**0.1**	**1.4**	**5.9**
Substrate				
M1	0.27^{b}	0.19^{c}	21.5^{a}	40.0^{b}
M2	0.92^{a}	1.14^{a}	10.5^{b}	100.0^{a}
M3	0.83^{a}	0.98^{a}	10.5^{b}	93.3^{a}
M4	0.89^{a}	0.96^{a}	11.0^{b}	100.0^{a}
M5	0.86^{a}	1.01^{a}	11.0^{b}	95.0^{a}
M6	0.90^{a}	1.03^{a}	11.0^{b}	95.0^{a}
M7	0.85^{a}	0.92^{b}	12.5^{b}	95.0^{a}
Lsd (5%)	**0.1**	**0.2**	**2.5**	**11.0**
Clone x Growing media	NS	NS	NS	NS

Values followed by same letter are not significantly different at P<0.05, NS = Not significant

Seedling height

At 14 WAS, the clone T65 was significantly (P<0.05) the tallest (34.3 cm) compared to PA7 (30.9 cm).The highest height was recorded for M2 (44.2 cm) followed by M3 and M4 (37.7 cm and 33.0 cm) respectively, and these were significantly (P<0.001) higher than the seedling height of M1 (31.2 cm) and those containing MSWC. Nevertheless, the seedling height of M1 was significantly higher than that of those containing MSWC.

Increasing fertilizer rate has a significant effect on the seedling height with 310mgN/L recording the highest seedling height of (32.9 cm) followed by 420mgN/L (30.7 cm) and 200mgN/L (29.3 cm) (Figure 1b). The interaction between fertilizer rate and type of substrate at 14 WAS produced significantly (P<0.05) lowest seedling height at 420mgN/L for soil only (25.5 cm), however, the seedling height was significantly (P<0.05) higher for M6 at fertilizer rate 420mgN/L (32.0 cm). Furthermore, the seedling height was significantly higher for M2 at fertilizer rate 310mgN/L (46.2 cm) as compared to fertilizer rate 420mgN/L (40.5 cm).



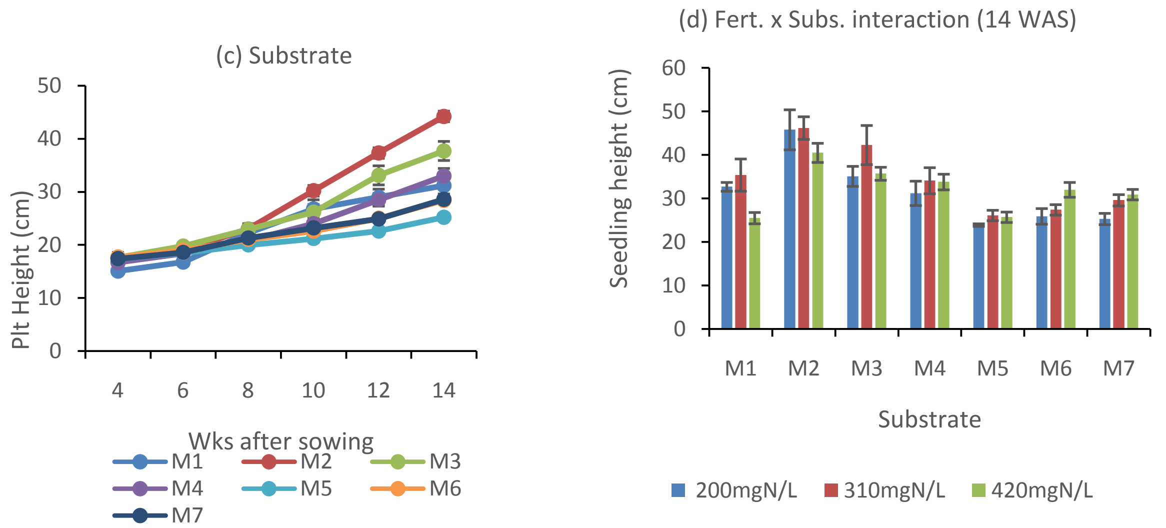


Fig 1: Effect of fertilizer rates and substrates on cocoa seedling height

Leaf Number

Leaf production was significantly (p< 0.05) affected by the type of growing media,at 4 WAS, M4 produced significantly more leaves (5.4) than M1 (4.7), M5 (4.7) and M7 (4.6) respectively. At 6 WAS, all the growing media containing PM produced significantly (P<0.01) more leaves than the soil only and those containing MSWC. At 8 WAS, the fertilizer rate applied significantly (p = 0.01) affected the number of leaves produced. At the higher fertilizer rate 420mgN/L, more leaves were recorded (13.5) than at 200mgN/L (12.2) and 310mgN/l (12) respectively (Figure 2b). Similarly, the type of growing media significantly (p<0.001) affected the leaf number produced (Figure 2c). Treatment differences at 10 and 12 WAS followed a similar pattern. At 14 WAS, growing media M2, M3 and M4 distinctively produced greater number of leaves than the rest of the treatments and the difference was significant.

The interactive effect of fertilizer and growing media was significant (p<0.001). The leaf number produced in the soil only- M1 at fertilizer rate 420mgN/L was lowest (16.8), while in the growing media M2, the leaf number produced at fertilizer rate 420mgN/L was the highest (32.5). Similar observations in fertilizer rate 420mgN/L recording highest leaf number in M3 (35.6) and M4 (32.0), (Figure 2d).

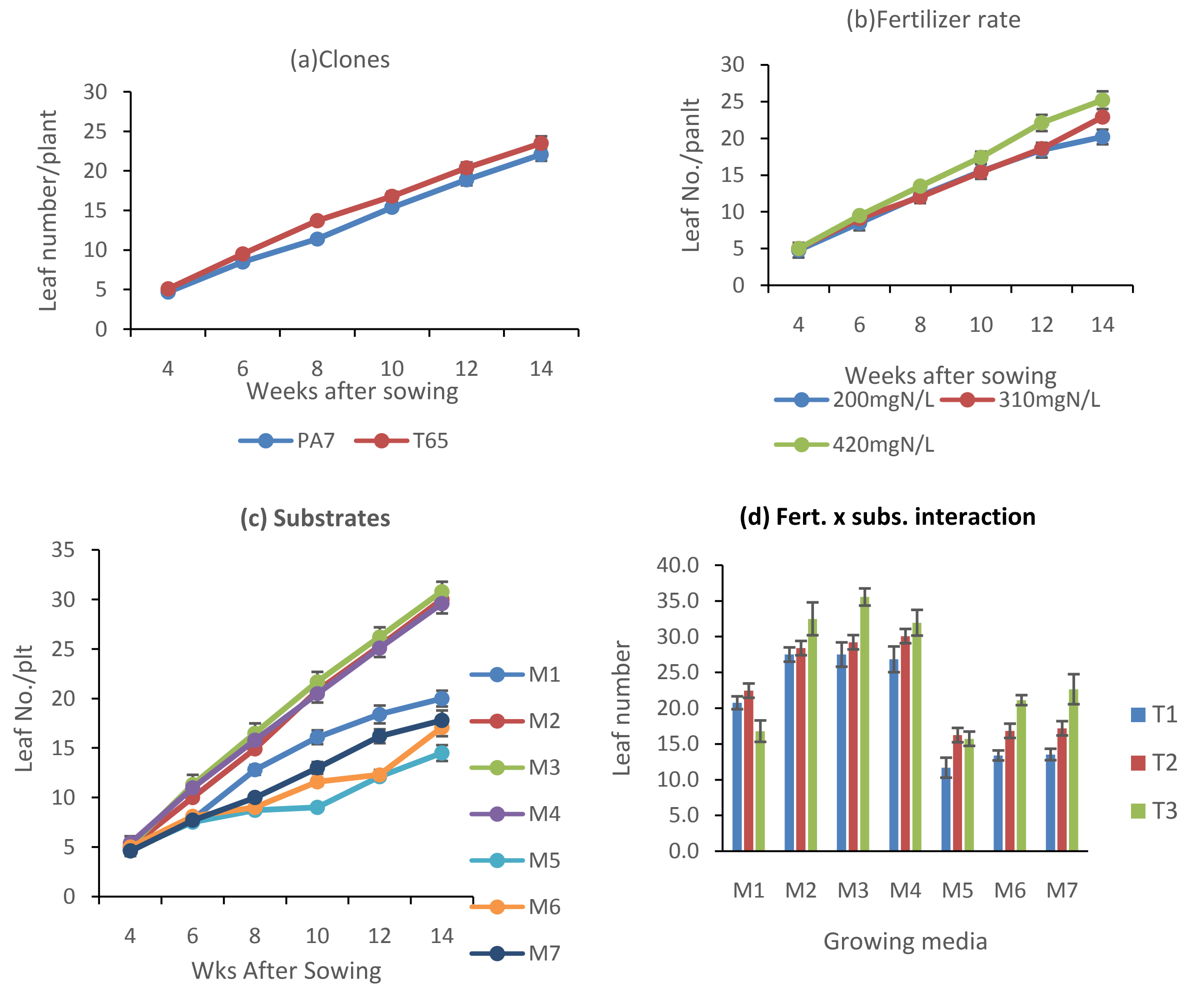


Fig 2: Effect of fertilizer rates and substrates on cocoa seedling leaf number

Leaf Area (LA)

The clone T65 produced greater leaf area than PA7 from week 6, 8, 10, 12 and 14 weeks after sowing, (Figure 3a). Increasing fertilizer application rate did not significantly (P>0.05) affect the leaf area produced at all the sampling dates (Figure 3b). However, the type of growing media significantly (P<0.05) affected the LA with M4 producing the highest leaf area of (306.6 cm^2), followed by the M1 (274.8), the least LA value was recorded for M5 (196.6 cm^2) at 6 WAS. At 8 WAS, the growing media containing PM produced significantly higher leaf area than the those in the soil medium treatment and those containing MSWC and the same trend was observed at 12 and 14 WAS sampling dates (Figure 3c).

The interactive effect due to growing media and fertilizer rate at 14 WAS,was higher forthe soilless media at fertilizer rate 420mgN/L however the LA reduced significantly for the soil treatment, (Figure 3d).

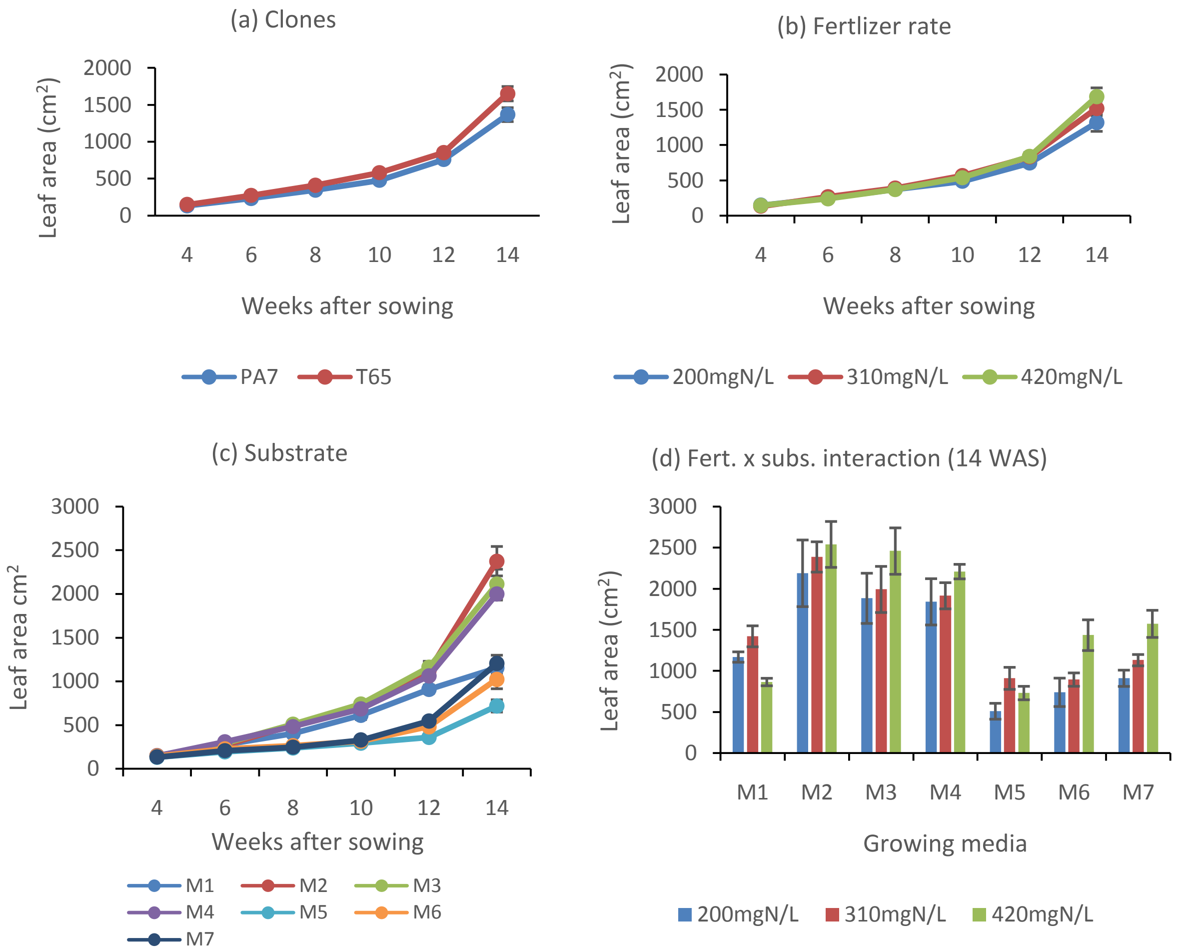


Fig 3: Effect of fertilizer rates and substrates on leaf area

Stem Girth

Throughout the sampling period, no significant differences were recorded on stem girth of the two clones. Increasing fertilizer concentration did not significantly affect the stem girth. However, the substrates significantly affected stem girth, at 4 to 10WAS, all the soilless substrates developed significantly bigger stem than the contro1. However, at 12 and 14 WAS, the stem diameter of the control thickened and was significantly bigger than the substrates mixtures containing MSWC. The substrates mixtures containing PM also developed significantly bigger stem diameter than those containing MSWC. Significant fertilizer x substrate interaction was recorded at 12 and 14 WAS, the control M1 developed bigger stem diameter at the lower fertilizer concentration 200mgN/L (7.89 mm) than at M1 x 420mgN/L (6.6 mm).

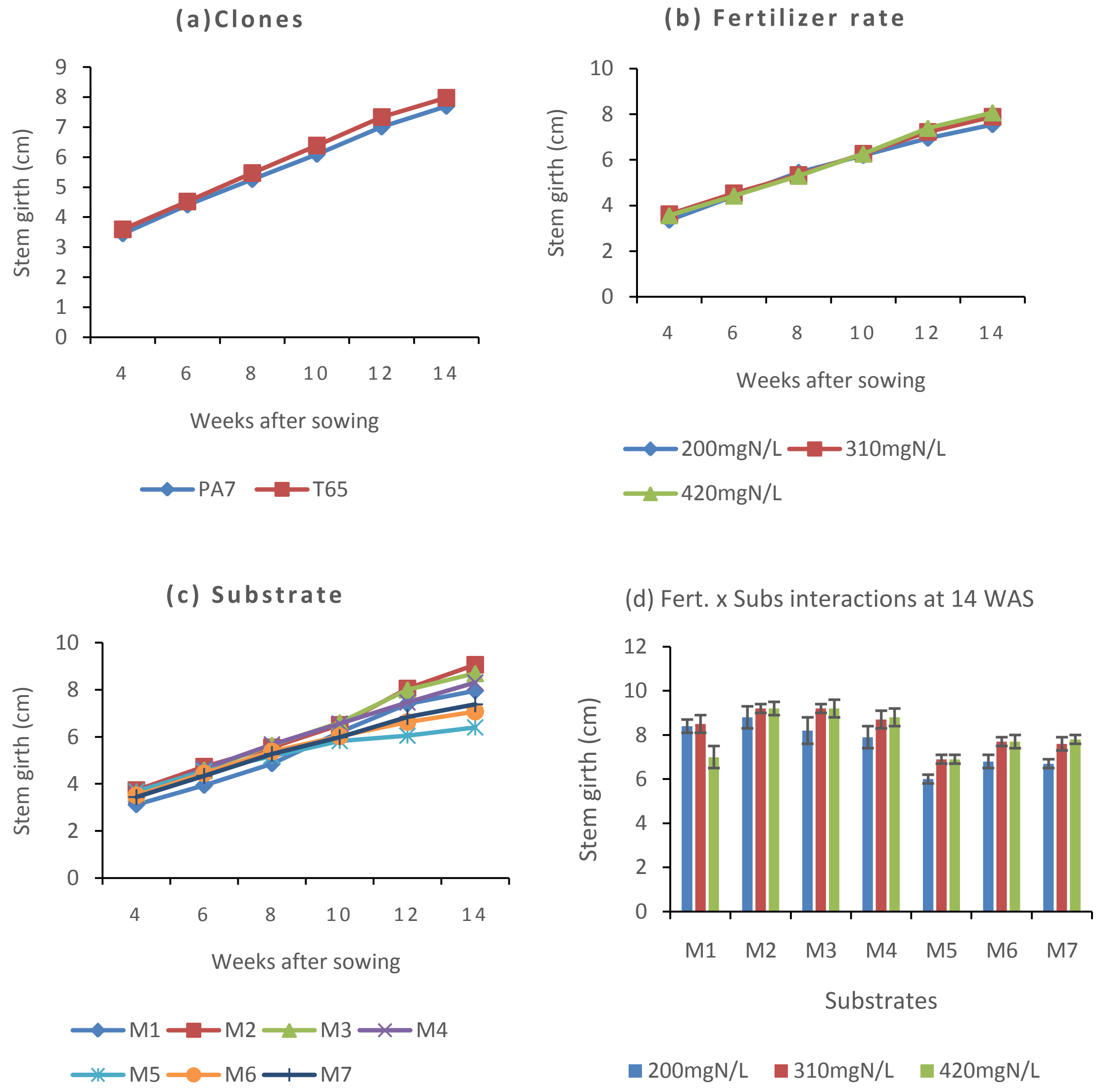


Fig 4: Effect of fertilizer rates and substrates on stem girth of two cocoa clones

Tap Root Length

The clones did not differ significant in the mean values of the taproot length ($p>0.05$), likewise the fertilizer rate. The substrates however significantly affected the taproot development ($p = 0.01$). M2 recorded the longest taproot length of (31.9 cm) followed by M3 (27.5 cm) and the control M1 (26.0 cm). Among the PM treated substrates, M4 has the shortest taproot length (22.6 cm); increasing Biochar and PM reduced taproot development.The interaction between fertilizer application rate and substrate has significant effect on taproot development. Significantly,longer taproot length was recorded for M3 at 200mgN/L (36.5 cm), M3 x310mgN/L (19.1) and M3 x 420mgN/L (26.9 cm) respectively. Significantly, longer taproot length was recorded for M6 at 420mgN/L (30.2 cm), 200mgN/L x M6 (19.2). Taproot development was enhanced for M7 at 310mgN/L (32.0 cm) than at 420mgN/L (18.2 cm), (Fig 5).

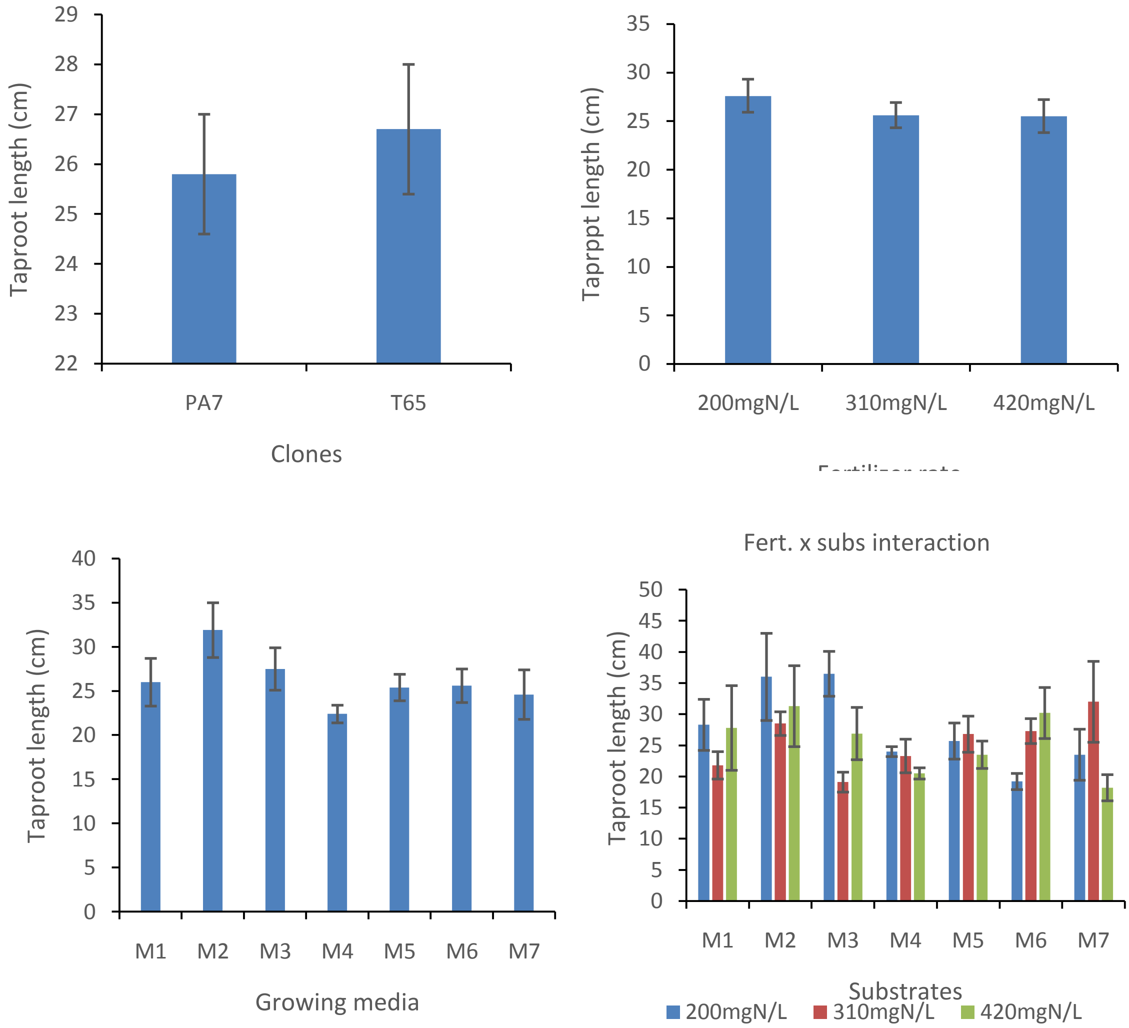


Fig 5: Effect of fertilizer rates and substrates on taproot length at 14 WAS

Root Volume

The clones including the fertilizer rate applied did not significantly (P>0.05) affect theroot volume developed.However, root volume was significantly influencedby the substrates (p<0.001), bigger root volume was recorded for M2 (13.4 cm^3) among the substrate mixtures containing PM. Whiles those containing MSWC, M7 developed significantly bigger root volume and the lowest root volume was recorded for M5 (7.5 cm^3), (Fig 6c). The fertilizer x substrate interaction produced significantly (P<0.05)bigger root volume at M1 x 200mgN/L (13.08 cm^3) compared to M1 x 420mgN/L (9.17 cm^3) and for M7 significantly bigger root volume was recoded at 420mgN/L (17.67 cm^3) than 200mgN/L x M7 (9.50 cm^3) (Fig 6d).

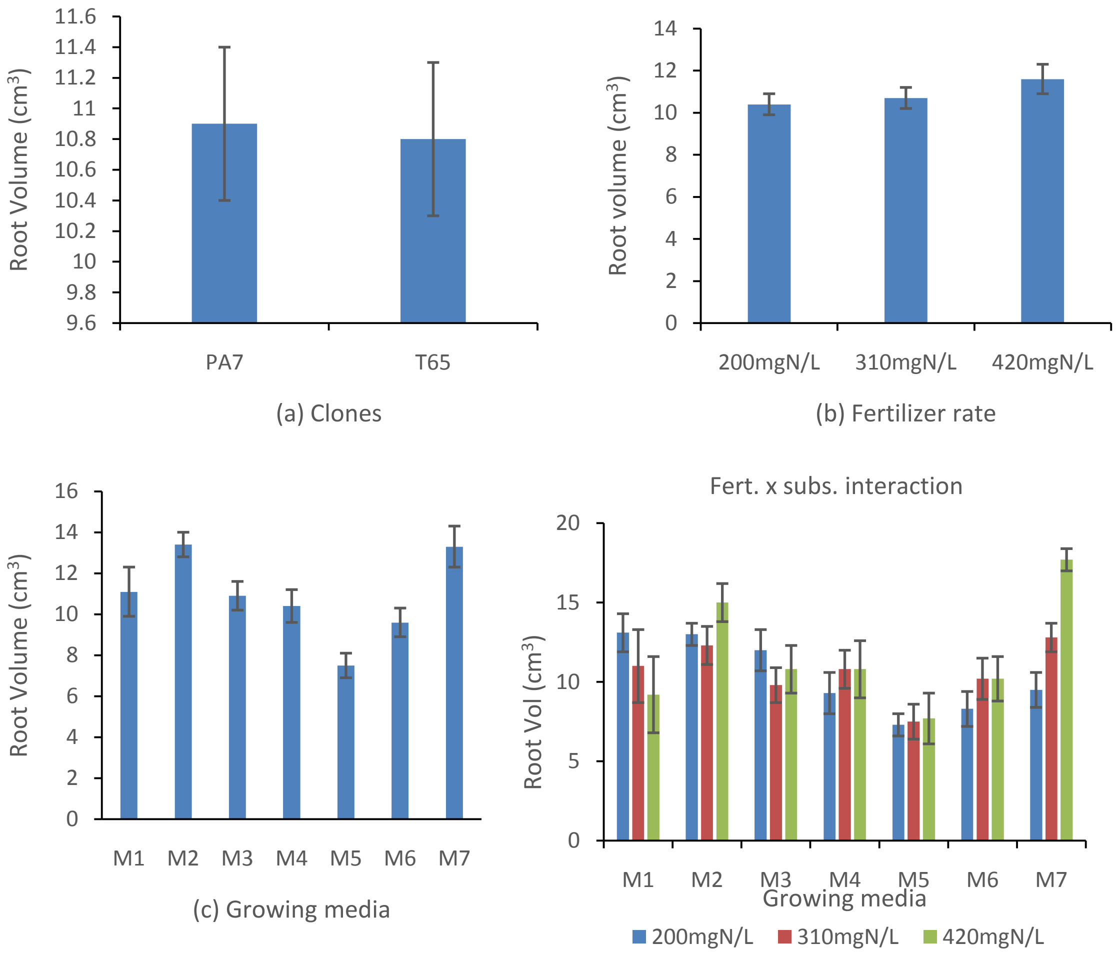


Fig 6: Effect of fertilizer rates and substrates on root volume at 14 WAS

3.9 Dry matter

Leaf dry weight (LDW): The clone T65 produced significantly higher (4.9 g/plant) leaf dry weight than PA7 (4.1 g/plant). The fertilizer rate applied did not significantly affect the leaf dry weight. Among the substrates M2 recorded significantly higher (7.5 g/plant) leaf dry whiles M5 recorded the lowest (2.0 g/plant). The interaction between fertilizer and substrate produced significantly higher leaf dry weightat 310mgN/L x M2(8.7 g/plant) compared to 200mgN/L x M2 (6.8 g/plant) and 420mgN/L x M2 (7.1g/plant). For the M1, higher leaf dry weight was recorded at 420mgN/L(3.7g/plant).

Stem dry weight (SDW); the least SDW (1.6 g/plant) was recorded for M5 whiles the highest for M2 (4.2 g/plant). The interaction between fertilizer rate and substratetype significantly induced ahigher SDW at 420mgN/L than at 200mgN/L for all the soilless substrateswhiles in the control (M1) significantly higher SDW was recorded at 200mgN/L as compared to 420mgN/L rate.

Total dry weight: M2 and M3 produced significantly higher (14.0 and 12.3 g/plant) TDW than the control M1 (9.6 g/plant) and the substrate containing MSWCie M5-M7 (4.8, 6.8 and 6.6 g/plant). Increasing Biochar and PM decrease the dry matter produced whiles increasing Biochar and MSWC increase the dry matter. The interaction between fertilizer rate applied and type of substrate induced significantly ($P<0.05$) higher TDW at M2 x 310mgN/L(14.4 g/plant) as compared to M1 x 310mgN/L (10.9g/plant) and M7 x 310mgN/L (7.0g/plant).

Table 4: Dry matter production of two cocoa clones as affected by fertilizer rates and substrates

Treatment	Leaf Dry Wt (g/plt)	Stem Dry Wt (g/plt)	Root DW (g/plt)	Total DW (g/plt)	Root: Shoot ratio
Main effect for clones					
PA 7	4.2	2.7	1.7	8.9	2.5
T65	4.9	3.1	1.9	9.9	2.8
Lsd (5%)	**0.6**	**NS**	**NS**	**NS**	**NS**
Main effect for fertilizer					
200mgN/l	3.9	2.7	1.7	8.4	2.2
310mgN/L	5.0	2.7	2.0	9.7	2.7
420mgN/L	4.9	3.2	1.8	9.6	3.0
Lsd (5%)	**1.1**	**NS**	**NS**	**NS**	**NS**
Main effect for substrate					
M1	4.1	3.5	2.1	9.6	2.6
M2	7.5	4.2	2.2	14.0	3.6
M3	6.5	3.6	2.1	12.3	3.3
M4	5.7	3.1	1.9	10.7	3.3
M5	2.0	1.6	1.3	4.8	1.6
M6	3.1	2.0	1.7	6.7	1.8
M7	2.9	2.1	1.7	6.6	2.0
Lsd (5%)	**0.9**	**0.9**	**0.4**	**1.7**	**1.0**
Interaction (Clone x Fertilizer)					
PA7 x 200mgN/L	3.5	2.7	1.6	7.7	2.0
PA7 x 310mgN/L	4.8	2.5	1.9	9.2	2.8
PA7 x 420mgN/L	4.2	2.8	1.7	8.8	2.5
T65 x 200mgN/L	4.3	2.8	1.9	9.0	2.4
T65 x 310mgN/L	5.2	2.9	2.2	10.3	2.5
T65 x 420mgN/L	5.1	3.6	1.8	10.5	3.4
Lsd (5%)	**1.3**	**NS**	**NS**	**NS**	**NS**
Clone x Substrate	**	**NS**	**NS**	**NS**	**NS**
Fert. x Substrate	***	**	**NS**	**	**NS**
Clone x Fert. x Subs.	**NS**	**NS**	**NS**	**NS**	**NS**

NS – Not significant ** * significant at 5% and 1% respectively**

Correlation matrix for factors in fertilizer x growing media interaction

The correlation matrix for factors in fertilizer x growing media interaction are presented in (Table 5). All the parameters had positive correlation with each other. The correlations were strong and highly significant for most of the factors. Again, there was a weak correlation between root volume and the rest of the factors.

Table 5. Correlation matrix for factors in fertilizer x substrate interaction

	Total DW	Leaf DW	Stem DW	Root DW	Leaf Number	Leaf Area	Stem girth	Height	Root Vol	Chloro-phyll
Total DW	1.00									
Leaf DW	0.97***	1.00								
Stem DW	0.89***	0.77**	1.00							
Root DW	0.86***	0.81***	0.72***	1.00						
Leaf NO.	0.90***	0.80***	0.76***	0.67**	1.00					
Leaf Area	0.96***	0.90***	0.74***	0.66**	0.97***	1.00				
Stem girth	0.88***	0.93***	0.86***	0.76**	0.92***	0.93***	1.00			
Height	0.94***	0.90***	0.69**	0.73**	0.78**	0.86***	0.88***	1.00		
Root Vol	0.54	0.49	0.52	0.53	0.45	0.53	0.56**	0.51	1.00	
Chlorophyll	0.88***	0.88***	0.80***	0.77**	0.81***	0.82***	0.90***	0.83***	0.55	1.00

Significantly correlated at p = 0.05**, 0.01***, values without * are not significant

IV. Discussions

4.1 Influence of substrate mixtures on emergence and seedling growth of two cocoa clones

All the soilless growing media have a higher rate of emergence (number of seedlings appearing every 3 days) and took shorter days to reach 50% emergence. This might be due to their higher WHC and low BD as compared to the soil medium, high WHC might have reduced the imbibition period and allowed seedlings to emerge at a faster rate but low WHC may increase the imbibition period and therefore increasing the days to reaching the 50% emergence. High bulk density affects seedling emergence, Bhardwaj & Kendra, (2014) reported that pawpaw seeds nursed in vermicompost medium with 2cm cocopeat supported increased germination parameters, whiles sand + pond soil (1:1) without cocopeat showed lowest germination parameters. With epigeal germination in cocoa, the high BD might have prevented the emergence of the cotyledons, it was observed at the nursery that the stem appeared, but the cotyledons were embedded in the soil for a longer period before being able to emerge, yet some never emerged at all until they died out. The high BD might have also led to compaction in the soil medium during watering creating resistance to seedling emergence and also causing some seeds to suffocate and die. This observation is in line with (Tariq et al., 2012) who stated that if plants are grown in containers with soil, the frequent watering required by the plants causes soil compaction. Baiyeri (2012) also reported a similar finding of poor seedling emergence of African breadfruit in hundred percent soil medium than medium composed of 1:2:3 Rice hull: PM: River sand.

The clone T65 displayed vigorous growth habit than the hybrid PA7. The T65 was the tallest, produced more leaf area and bigger stem girth than the PA7, this may be due to the varietal differences. The hybrid varieties require optimum weather and agronomic practices for vigorous growth (Kolavalli & Vigneri, 2011). The significant performance of the substrates containing PM over those containing MSWC might be due to the fact that PM contained vital nutrient linked with high photosynthesis and as result advanced root and vegetative growth (Havlin et al., 2005).

However, the quantity of MSWC used might not contain enough N and other elements which could beef up the medium for vigorous seedling growth. Cooperband, Bollero, & Coale (2002) found out that MSWC releases 3 to 4 times less nitrite N compared to poultry litter. Not all, the highC:N ratios recorded by substrate mixtures with MSWC as component might results in nitrogen immobilization as microorganisms are highly active in such environments making use of the mineral N for their protein synthesis (Verdonck, 1988).

The enhanced taproot development observed for substrate M2 might be due to the low bulk density, which encourages root development. Again the development of larger leaf area might lead to the production of high assimilates which were partitioned to the root. This finding agrees with (Argo, 1998) who stated that the type of media used in potting seedlings determines rate of shoot and root development.

The higher leaf dry weight recorded for clone T65 might be due to the production of high leaf area compared to PA7. Different genotypes of crop plants have different partitioning factor, the T65 might have partitioned more assimilates into production of larger leaf area which has resulted in higher leaf dry matter. Acheampong et al., (2013), observed that differential partitioning of assimilates to leaf components was paramount to varietal difference in biomass. The higher leaf dry weight displayed by the growing media containing PM over those MSWC might be due to their relatively high N and OM content including low C:N ratio that led to the production of more leaves and larger LA by these substrates.Awolun (2007) reported that application PM at the rate of 6t/ha contributed to the production of more leaf number, leaf area and stem girth which resulted in higher fresh and dry weight of Telfaria. Production of higher vegetative growth and large biomass of seedlings depends on the availability of nutrients in the growing medium (Zhang et al., 2014). Seedlings grown in substrates containing Biochar and PM displayed better quality and suitability for transplanting than the mixtures containing Biochar and MSWC.

Fertilizer application rates and growing media interaction effect on seedling growth of cocoa.

Increasing fertilizer application rate increased growth parameters in the soilless substrate. This might be due to the fact that these media require more nutrients for optimum seedling This corroborates with (De Almeida et al., 2016) who studied the effect of N fertigation on the growth of cocoa and reported that increasing nitrogen levels led to a significant increase in growth traits of cocoa.

The result of the significance of fertilizer application rate x growing media interaction for most of the growth traits again confirm those of (Gruda, 2010; Gruda & Schnitzler, 1999; Sharman, 1996) whose pointed out that plants grown in different substrate mixes would require adequate supplementary nutrient to overcome nitrogen draw down in order to promote vigorous seedlings growth. In this study, however, taller cocoa seedlings with thicker stems were produced by the growing media containing PM at fertilizer rate of 310mgN/L whiles those containing MSWC produced similar sized seedlings at higher fertilizer rate of 420mgN/L indicating the high nutrient requirement of the later. This gives an implication for high productioncost.Zulfiqar et al., (2019) concluded that Biochar and PM amelioration could increase nitrogen content of potting media thus taking out cost of fertilization and at the same time boosting growth of plants.

Strikingly, larger root volume displayed by the M7 might be due to increased MSWC+Biochar, which supported root development but increased PM+Biochar reduced root volume. Maust & Williamson (1994) studied the effect of nitrogen nutrition on containerized citrus nursery and reported that dry weight of various citrus seedling parts increased with increased N concentrations.

Significantly, the strong correlation observed for the total dry weight-leaf area, total dry weight-seeding height and seedling height-stem girth for the interactions was an indication of good seedling growth. This finding agrees with (Herrera et al., 2008) who stated that a strong correlation between leaf area and the seedling dry matter is an implication of profound and active photosynthesis which result in the production of high assimilates and dry matter accumulation. This quality the authors were of the view that growth media for seedling production must exhibit, in order to be recommended for nursery plant production. The significance of the correlation between the factors of fertilizer x growing media interactions was an essential indicator for additional fertilizer requirement for the various growing medium for good seedling growth.

V. Conclusion

Results showed that soilless growing media have higher WHC and with a low bulk density that resulted in enhanced cocoa seed germination than the control (topsoil) which recorded very poor germination. Clone PA7 took shorter days to emerge than T65 and all the soilless growing media took shorter days to reach 50% emergence and recorded higher germination indices than the control. Increasing PM+Biochar reduced seedling growth parameters thus decreased total dry matter produced. In contrast, increased MSWC+Biochar increased seedling growth and dry matter accumulation. Growing medium M2 comprising of SD+PM+RHB in the ratio of 70:25:5 was found to be superior in cocoa seedling production as it recorded taller seedling height, thicker stem girth, larger root system, larger leaf area and produced the highest total dry matter.

Growth and dry matter production were enhanced at the lower fertilizer rate of 200mgN/L than at the higher rate of 420mgN/L for the control (soil only) whiles increasing fertilizer rate increase growth and dry matter accumulation in the soilless growth media. An indication of the importance of supplementary nutrient requirements of seedlings grown in soilless growth media.

VI. Recommendations

Soilless media composed of sawdust, poultry manure and rice husk Biochar including Municipal solid waste when well composted could be used as an additional medium to the top soil for cocoa seedling production at the nursey. However, further research is needed to look at the rate of MSWC in the mixes for quality seedling production.

A nutrient solution containing NPK plus calcium nitrate in a concentration of 310mgN/L applied three times a week in combination with growth media containing PM would produce good quality cocoa seedling for transplanting. Additional research is required to look at the fertilizer rate in combination with the growth media prepared with MSWC.

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