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Effect of Growth Media Composition on Early Growth and Development of Moringa (*Moringa oleifera* L.) Seedlings

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ABSTRACT

In spite of huge economic and medicinal importance of moringa, its cultivation in Nigeria is still very low. This is largely due to the fact that sound agronomic practices have not been established. To do this, pot experiments were carried out at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria in 2015 to determine the effect of growth media composition on early growth and development of moringa seedlings. The growth media tested were 100% top soil, 100% compost, 100% sawdust, 75% soil + 25% compost, 50% soil + 50 % compost , 25% soil + 75% compost, 75% compost + 25% sawdust, 5% soil + 50% sawdust, 25% soil + 75% sawdust, 75% compost + 25% sawdust, 50% compost + 50% sawdust, 25% compost + 75% sawdust and 33.3% soil + 33.3% sawdust + 33.3% compost. The experiment was laid out in a Completely Randomized Design (CRD) replicated five times. Data collected, which included growth parameters such as seed germination (%), seedling vigour (scaled between 1 and 5), shoot weight, dry matter yield, stem height, stem girth and number of leaves and nutrient uptake, were subjected to analysis of variance and their means were compared using Duncan's Multiple Range Test (MRT) ($p<0.05$). Variation of growth media had significant effects on most of the parameter assessed. The result showed that 25% sawdust + 75% compost has the highest % seed germination 9 seedling/pot (92.6 %) and seedling vigour (4.5). Other growth media tested had less effect on the parameter studied. In addition, plants grown in 100% compost significantly outperformed others with regards to growth parameters' such as the stem height (91.66 cm), stem girth (1.95 cm), number of leaves/plant (14.53), fresh shoot (13.80 g), fresh root

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(28.36 g), dry shoot (5.90 g), dry root (7.50 g) and total dry matter yield (13.40 g). This superior performance is attributed to leaf nutrient uptake of 4.10, 0.56, 4.50, 1.40, 4.63, 87.47, 4.03 and 60.10 g/kg N, P, K, Ca, Mg, Fe, Cu, and Zn, respectively. Result showed that the use of 100% compost gave the best seedlings with the highest nutrient uptake. It is therefore concluded that the use of 100% compost produced high quality moringa seedling with optimum leaf nutrient uptake, hence it can be considered as an effective medium.

Keywords: Compost, growth media, nutrient uptake, sawdust, soil

INTRODUCTION

Moringa (*Moringa oleifera* L.), a member of Moringaceae family, is grown in the tropical and subtropical regions of the world. *Moringa oleifera* is a soft wood and native to India with great potential for its economical and medicinal (Adebayo et al., 2011; Sharma et al., 2011). It is commonly called drumstick tree and well known for its multi-purpose uses. It is widely adapted and regarded as the world most nutritious plant for human (Farooq et al., 2012) and for its culinary properties (Stevens et al., 2013). Moringa plants are known to have high amount of essential nutrients, vitamins, minerals and beta carotene (Gopalakrishnan et al., 2016). Apart from its medicinal uses, the plant leaves are good sources of amino acid (Okiki et al., 2015) and could be used as immune booster. All parts of moringa tree are useful and have long been used by human (Abdull et al., 2014). Moringa is a fast-growing, deep-rooted dicotyledonous plant with tuberous taproot system. It is drought-resistant and can thrive well in poor soils with little or no fertilization (Ndubuaku et al., 2014). Moringa plants are established either by cuttings or seeds (Mathenge, 2015). The seeds are either sown directly in the field or planted in nurseries (Ede et al., 2015) which subsequently influences their establishment and productivity in the field.

The juice extracted from the leaves can be used to make foliar nutrient capable of increasing crop yield (Matthew, 2016; Merwad, 2017). The leaves also provide excellent materials for the production of biogas (Kivevele et al., 2011). It is rich in health promoting photochemical such as carronades, phenolics (chlorogenic acid), flavonoids (quercelin and kaempherol glycoside), various vitamins and minerals (Okiki et al., 2015; Udikala et al., 2017). *Moringa oleifera* is often grown as fence plant (Amaglo et al., 2007).

Growth media play an important role in seed germination, seedling growth and vigour. Potting media assist in the regulation of growth and the development of seedlings produced (Bhardwaj, 2014; Popescu & Popescu, 2015) which subsequently influence their establishment and productivity in the field. In Nigeria, the traditional method of potting medium is topsoil dug from farmland and amended with manure. This could render the land unproductive for cropping which could also be prone to erosion and degradation (Baumhardt et al., 2015; Pimentel & Burgess, 2013). The quality of media composition used could influence the seedling obtained (Bhardwaj, 2014; Desai et al., 2017; Tian et al., 2017).

Baiyeri and Mbah (2006) reported the relative importance of soilless media for growing potted ornamental plants in Nigeria. Percentage germination, seedling emergence and growth in different sowing media were affected by the physical and chemical compositions of the growing media. The use of coarse materials as growth media ensured greater aeration and drainage of the media and also enhanced germination and seedling emergence (Baiyeri & Aba, 2007).

Despite the economic and medicinal importance of this crop, its cultivation still remains low. In order to encourage its large scale cultivation, there is a need to develop sound agronomic practices, hence the need for the present study. Therefore, this paper reports the effects of growth media composition on early growth and development of moringa (*Moringa oleifera*) seedlings.

MATERIALS AND METHODS

The Experimental Site

The experiments were carried out in February-May and August-November 2015 at Teaching and Research farm of Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Ogbomoso, is located on latitude 8°10'N of the equator and longitude 4°16'E. It is located in the Guinea Savanna Zone of Southwest Nigeria. The temperature of the area ranges from 28°C to 33°C with humidity of about 75 % all year except in January when the dry wind blows from the North. Rainfall distribution is bimodal and extends for eight to nine months of the year. On the average, the total annual rainfall is about 128 mm. The soil of the site belongs to the USDA classification of Alfisol, which is moderately drain, ferruginous tropical soil with a sandy loamy texture. The vegetation covers of the site are characterized by scattered trees and shrubs and by cynodon species.

Soil Analysis

Soil samples analyses was done for physical and chemical properties. Soil samples were collected at the depth of 0 – 15 cm. The sample was air-dried, crushed and sieved for the determination of pH, bulk density, total nitrogen (N), available phosphorus (P), exchangeable potassium (K) , calcium (Ca), magnesium (Mg), ferrum (Fe), copper (Cu), zinc (Zn) and manganese (Mn) and carbon (C).

Experimental Materials

The growing media and the dosage rate used for this study were: 100% soil (S), 100% Sawdust (SD), 100% compost (C), 75% soil + 25% compost, 50% soil + 50% compost, 25% soil + 75% compost, 75% soil + 25% Sawdust, 50% soil + 50% sawdust, 25% soil + 75% sawdust, 75% compost and 25% sawdust, 50% compost + 50% sawdust, 25% compost + 75% sawdust, 33.3% soil + 33.3% sawdust + 33.3% compost and PK 1 moringa seeds.

Experimental Design and Management

The pot experiment consisted of 65 pots. Each treatment had 5 pots considered as a replication laid out in complete randomized design. The potting media were perforated at the base to enhance aeration and drainage. Each pot was filled with 5 kg of its respective treatment combination and dosage. At planting, ten moringa seeds (PK 1 variety from India) were sown in the potted media at depth of 1.5 cm. The pots were watered heavily immediately after sowing and subsequently once on alternative days. Weeding was done by hand roughing of the weeds as they emerged. Physical and chemical properties of the sowing media were determined through laboratory analyses before sowing the seeds.

Data Collection

Percentage seeding germination, that is, seedling emergence was recorded when the first foliage leaf appeared using the method described by Ede et al. (2015):

$$\% \ SG = \frac{N_{gs}}{T_{nsp}} \times 100 \quad (1)$$

where SG - Seeds Germination; N_{gs} -Number of germinated seeds; T_{nsp} -Total number of seeds planted. The plant height was measured from the root level to the tip of the shoot using tape rule. The stem girth was determined by taken the circumference of the stem and multiplying the value by $\frac{22}{7}(\pi)$ (Ede et al., 2015):

$$\text{Stem girth} = \text{Stem diameter} \times \frac{22}{7}(\pi) \quad (2)$$

The number of leaves was obtained by counting the number of fully expanded leaves per seedlings. Dry matter yield: Three plants per plot were uprooted (destructive sampling) at harvesting, the plants were separated into different parts (stem, root, and leaf), cut into pieces, bagged in separate brown envelope and oven dried to constant weight at 80^{o}C. From these, dry weights of each plant parts were obtained.

Plant tissue nutrient contents and uptake: For determination of the leaf N, P, K, Ca, Mg, Fe, Cu, and Zn contents, three fully expanded leaves were selected per plant. Sampled leaves were oven dried at 80°C for 72 h to the constant weight and grounded in a Willey mill to reduce the material to a fineness suitable size. The grounded samples were stored in airtight plastic containers for chemical analysis. Total nitrogen was determined by digesting 0.5 g dry leaf samples with 68% H_2SO_4 in Kjeldahl digestion unit until sample colorless and titrated with 0.1 N of H_2SO_4 using selenium and sodium as catalyst. Total N was determined from the digest by stem distillation with excess NaOH. The P, K, Ca, Mg, Fe, Cu and Zn plant tissue contents was determined by ashing 0.2 g of the plant samples in muffle furnace at 600^{o}C for 3 hours. The ash was cooled and dissolved in 1N hydrochloric acid and the solution passed through filter paper into 50 ml volumetric flask and was made up to the mark with distilled water. From the digest, P concentration was determined by the vanadomolybdate yellow colorimetry method using spectrophotometer. The K was determined by using flame photometer (Cornin Model 400) while micronutrient (Fe, Cu, Zn) were estimated with atomic absorption spectrophotoneter (Perken Elmer AAS-300). Nutrient accumulation in plant was evaluated using the method used by Akanbi et al. (2002) as:

$$\text{Nutrient uptake} = \% \text{ Tissue nutrient content} \times \text{sample dry weight} \quad (3)$$

Data Analysis

Data collected over the two trials were pooled before subjected to statistical analysis using standard analysis of variance (SAS 2000) for complete randomized design. The significance of the treatment effect was determined using the F-test and mean separation was done with Duncan's Multiple Range Test (MRT) at 5% probability level.

RESULTS

The physical and nutrient analysis of the growing media was determined and the result is presented in Table 1. The highest pH (7.6) and least bulk density (0.09) were obtained in 100% compost while the least pH (6.3) and highest bulk density (1.4) were obtained from 100% soil. Among the growth media, 25% S + 75% C had highest total Nitrogen (1.11) while the least was 100% SD (0.60) and 25% S + 75% SD (0.60) (Table1). The 100% compost had the highest P and K (0.97 and 3.90, respectively) while the least were from 100% soil (0.00) followed by 75% C+ 25% SD (0.30). The 25% C + 75% SD had the highest Ca (5.70) while the least was from 100% SD (0.93). Highest Mg was recorded from 25% S + 75% SD and 33% S + 33% C + 33% SD (0.51) while the least came from 100% soil (0.07). The growth media 50% C and 50% SD had the highest Fe (0.71) while least Fe (0.09) was obtained from 100% SD. The 100% SD had the highest Cu (64.00) while least Cu (21.00) came from 100% soil. The 25% S + 75% SD had the highest Zn, C, C: N, (340.33, 40.70 and 68.33) while the least Zn (78.33), C (14.20) and C: N (13.00) from 100% soil and 100 % SD.

Effect of Growth Media on Seed Germination (%)

Figure 1 shows that the effects of growth media composition on germination (%) and seedling vigour are significant at ($p<0.05$). The treatment 25% S + 75% C has the highest germination rate (92.6) while 100% SD has the least (51) (Figure 1a). There was no significant difference in seedling vigour of growth media of 100% compost and 25% S + 75% C (Figure 1b). These two growth media have the same seedling vigour rating of (4.5) while treatment of 25% C + 75% SD had the least (2.80).

Effects of Growth Media Composition on Growth Parameters of Moringa Seedlings

Response of moringa seedlings to different growth media composition are presented in Figures 2 and 3. Growth media compositions had significant ($p<0.05$) effect on stem height, stem girth and number of leaves at different growth stages.

Table 1
Chemical composition of different growth media used for the experiment

Media Growth Composition	**pH**	**Bulk Density**	**N**	**P**	**K**	**Ca**	**Mg**	**Fe**	**Cu**	**Zn**	**C**	**C: N**
		g/cm	---------- g/kg ----------					---------- mg/kg ----------				
100% Soil (S)	6.3	1.4	0.63^{e}	0.25^{h}	0.54^{i}	1.20^{g}	0.07	0.12	21.00^{j}	78.33	14.20^{m}	22.33^{i}
100% Compost (C)	7.6	0.09	0.60^{ef}	0.97^{a}	3.90^{a}	0.93^{g}	0.46	0.32	64.00^{a}	332.33	21.43^{i}	13.00^{k}
100% Sawdust (SD)	6.6	0.9	0.62^{e}	0.72^{b}	1.12^{h}	5.30^{ab}	0.41	0.09	34.63^{e}	316.00	39.33^{b}	62.00^{b}
75% S + 25% C	6.7	1.26	0.72^{c}	0.55^{e}	1.65^{ed}	3.20^{e}	0.21	0.31	27.10^{i}	148.33	16.13^{l}	22.33^{i}
50% S + 50% C	6.9	1.22	0.78^{bc}	0.64^{d}	1.62^{e}	3.00^{e}	0.24	0.37	32.03^{gh}	162.66	18.10^{k}	22.66^{i}
25% S + 75% C	7.1	0.19	1.11^{a}	0.72^{b}	1.71^{d}	3.80^{d}	0.22	0.30	47.10^{c}	171.33	20.13^{j}	41.00^{f}
75% S + 25% SD	6.7	1.35	0.80^{b}	0.31^{g}	1.31^{g}	3.96^{d}	0.42	0.20	30.13^{h}	310.33	30.53^{e}	38.00^{g}
50% S + 50% SD	6.8	1.31	0.82^{b}	0.41^{f}	1.42^{f}	4.80^{bc}	0.45	0.20	41.06^{e}	302.33	33.56^{c}	45.33^{e}
25% S + 75% SD	7.0	1.08	0.60^{ef}	0.69^{bc}	1.60^{e}	5.03^{bc}	0.51	0.22	33.63^{fg}	340.33	40.70^{a}	68.33^{a}
75% C + 25% SD	7.2	0.15	0.62^{e}	0.71^{b}	0.30^{j}	4.80^{bc}	0.42	0.62	60.10^{a}	280.33	29.30^{f}	55.33^{c}
50% C + 50% SD	7.1	0.18	0.62^{e}	0.41^{e}	0.31^{j}	4.^{70c}	0.41	0.71	54.33^{d}	314	28.03^{g}	45.33^{e}
25% C + 75% SD	7.1	0.21	0.64^{de}	0.65^{cd}	1.60^{e}	5.70^{a}	0.50	0.62	60.10^{a}	278.33	31.43^{d}	48.33^{d}
33% S + 33% C + 33% SD	7.0	0.23	0.71^{cd}	0.73^{b}	2.64^{b}	2.40^{f}	0.51	0.55	33.20^{fg}	270.33	25.56^{h}	35.33^{h}

Note. Means along the column with the same letter are not significant at $p \leq 0.05$

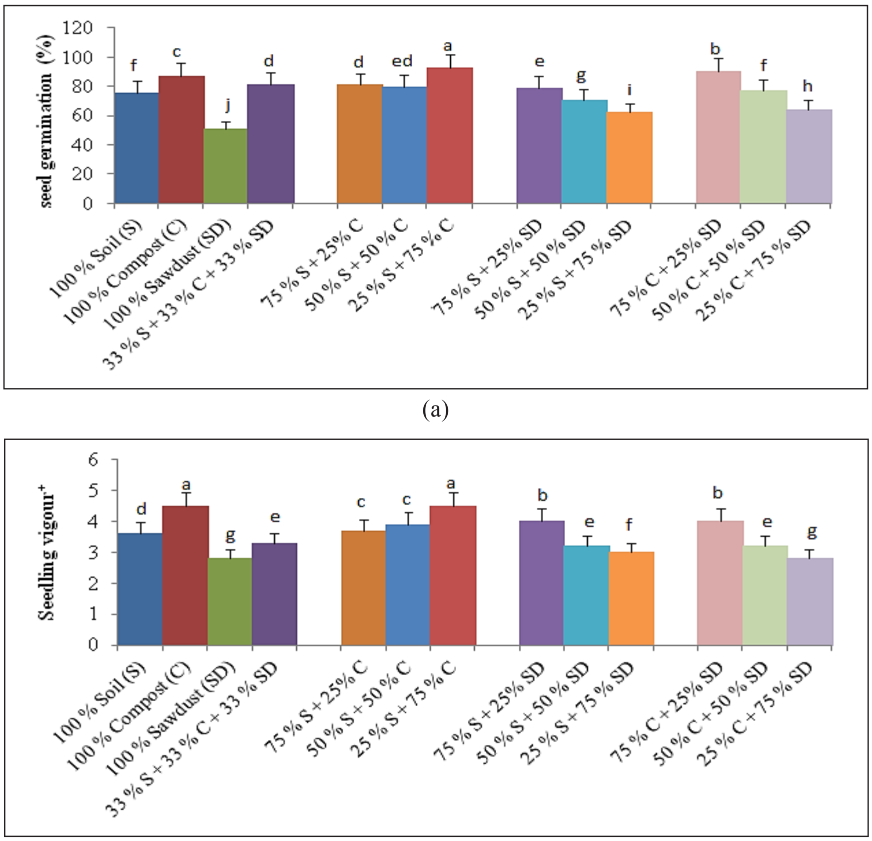
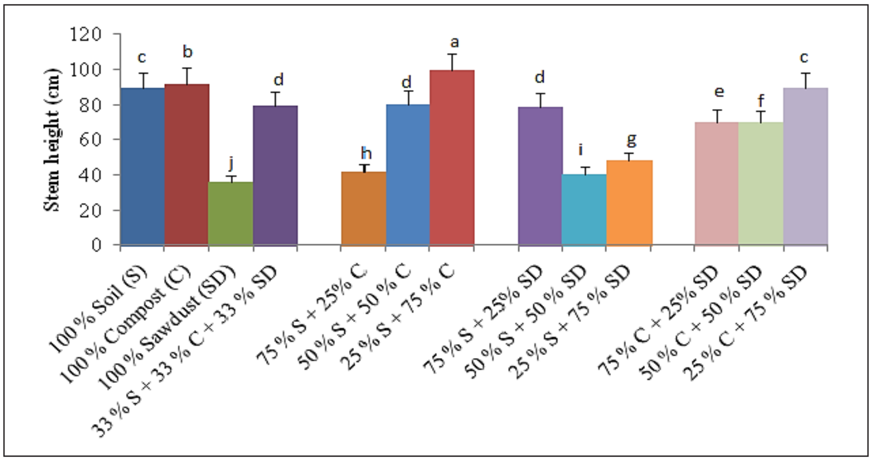


Figure 1. (a) Effects of growth media composition on percentage seed germination; and (b) seed vigour of moringa seedling
Note: + Scaling rating 1-5, where 1=Very poor and 5= Excellent

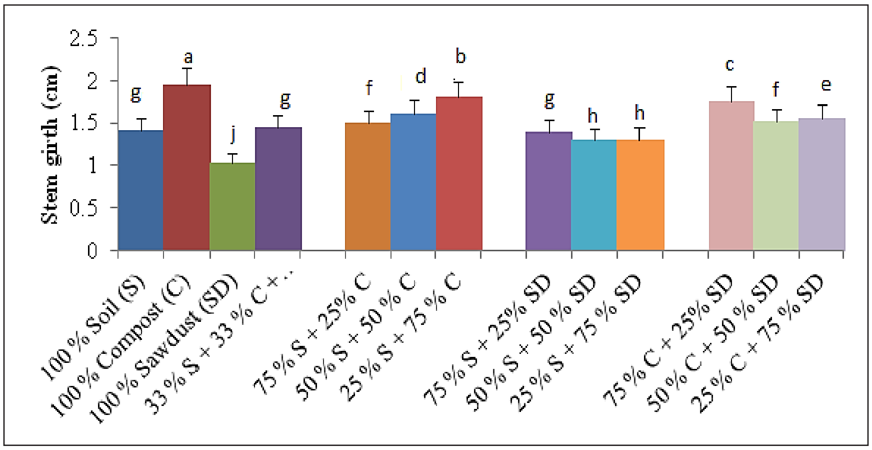
Figure 2a showed the effects of growth media on stem height. At 12 WAS, application of 25% S + 75% C growth media composition had the tallest plant (99.33 cm/plant) while 100% sawdust had the shortest plant. Among the pure substrates and their combination, 100% compost had the tallest plant (91.66 cm/plant) while 100% sawdust had the shortest plant (36.33 cm/plant). In addition, for different combination level of soil and compost, as the level of soil decreases and increases in compost (25% S + 75% C) performed better (99.33 cm). Again, when different levels of soil were mixed with sawdust, the higher the level of soil and lower the sawdust (75% S + 25% SD) gave better stem height (79.00 cm). From the combination of different level of compost and sawdust, 25% C + 75% SD had the longest stem (89.33 cm/plant). For stem girt (Figure 2b), the moringa seedling grown in 100% compost had the robust stem girth at 12 WAS with the values of 1.95 cm/plant followed by mixture of 25% S + 75% C (1.8

cm/plant) while the least was recorded with the growth media composition of 100% SD (1.04 cm/plant).

For number of leaves at these stages (Figure 3), the value of 14.53 cm were recorded for seedling grown with 100 % compost at 12 WAS while 25% C + 75% SD had the least number of leaves (10.00/plant). Among the pure substrates and their combination, 100% compost had the highest number of leaves/plant (14.53). In addition, for different combination level of soil and compost, as the level of soil decreases and increases in compost (25% S + 75% C) gave better number of leaves/plant (12.40). Again, when different levels of soil were mixed with sawdust, combination of 50% S + 50% SD and 25% S + 75% SD gave the same number of leaves/plant (11.2). From the combination of different level of compost and sawdust, 50% C + 50% SD had the highest number of leaves/plant (12.73).



(a)



(b)

Figure 2. (a) Effects of growth media composition on stem height; and (b) and stem girt of moringa seedling

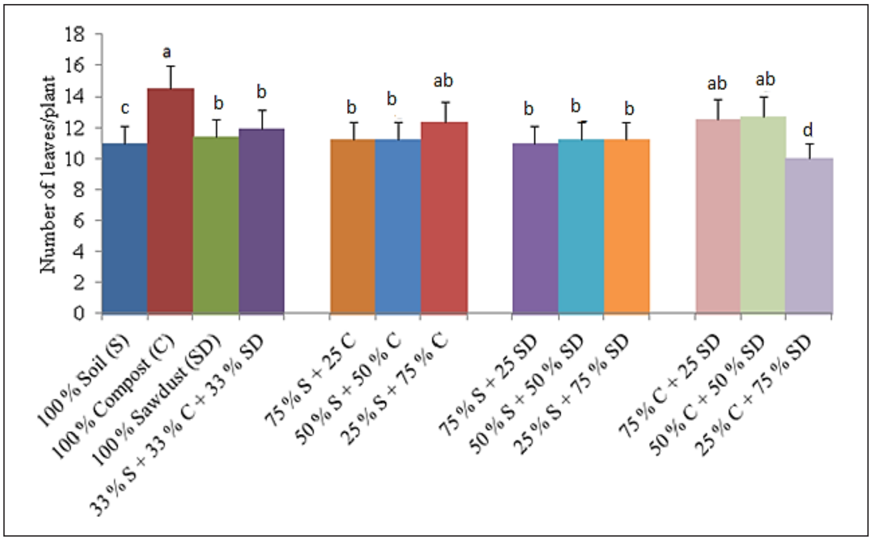


Figure 3. Effects of growth media composition on number of leaves/plant of moringa seedlings

Effects of Growth Media Composition on Fresh and Dry Matter Weight

Growth media composition has significant ($p<0.05$) effect on fresh and dry matter weights of moringa seedling at 12 weeks after sowing (Table 2). Grow media of 100% SD has the highest fresh shoot weight (34.63 g) followed by 25% S + 75% SD and 25% C + 75% SD with the values of 33.63 g and 33.20 g, respectively while the least (11.40 g) was recorded with growth media composition of 75% C + 25% SD. Dry shoot weight, dry root weight and total dry matter weight of seedlings differ significantly ($p<0.05$) at 12 WAS with different growth media composition. High fresh root, dry shoot weight and root weight and total dry matter weight were the highest with growth media composition of 100% compost (28.36 g, 5.90 g, 7.50 g, and 13.40 g respectively) while 100 % sawdust has the least fresh root weight, dry shoot weight and dry root weight with the values of 19.00 g, 3.96 g, 2.96 g and 6.29 g, respectively. Figures S1 – S2 reveal the correlations between total dry matter yield and nutrient uptake while the correlations between the total dry matter and media available nutrients were presented in Figures S3 – S4. The R^2 values of the nutrient uptakes ranged from 0.0158 to 0.827 while 37.5% had the positive strong correlation on nutrients uptake. For the media available nutrients, the R^2 values ranged from 0.0001 to 0.3239. Generally, there is week correlation between the dry matter yield and media available nutrients.

Table 3 showed the effects of media composition on nutrient uptake moringa plant. The leaf N, P, K, Ca, Mg, Fe, Cu and Zn uptake were significantly affected by media composition. For N, P, K, Ca, Mg, Fe, Cu and Zn, the uptakes were highest with 100% compost while the least for all the elemental composition varies among the other media composition.

Table 2
Effects of growth media composition on fresh and dry weights of different parts of moringa seedlings at 12 WAS

Growth Media Composition	Fresh Shoot Weight (g)	Fresh Root Weight (g)	Dry Shoot Weight (g)	Dry Root Weight (g)	Total Dry Matter Weight (g)
100% Soil (S)	21.00j	24.06c	4.02c	5.03d	9.05^{h}
100% Compost (C)	13.80^{a}	28.36^{a}	5.90^{a}	7.50^{a}	13.40^{a}
100% Sawdust (SD)	34.63^{f}	19.00^{g}	3.96^{c}	2.96^{c}	6.92^{j}
75% S + 25% C	12.00^{bc}	24.56^{c}	4.03^{c}	6.90^{c}	10.93^{e}
50% S + 50% C	32.03^{gh}	24.63c	4.03^{c}	7.03^{a}	11.06^{c}
25% S + 75% C	12.40^{b}	26.06^{b}	5.80^{a}	7.00^{ab}	12.80^{b}
75% S + 25% SD	30.13^{h}	24.60^{c}	4.20^{c}	4.90^{d}	9.10^{g}
50% S + 50% SD	12.40^{d}	21.63^{e}	3.96^{c}	5.00^{d}	8.96^{i}
25% S + 75% SD	33.63f^{g}	20.03^{f}	5.00^{b}	4.93^{d}	9.93^{f}
75% C + 25% SD	11.40^{c}	24.60^{c}	5.00^{b}	6.00^{c}	11.00^{d}
50% C + 50% SD	12.40^{b}	24.53^{c}	4.93^{b}	6.20^{bc}	11.13^{c}
25% C + 75% SD	33.63^{fg}	24.10^{c}	5.00^{b}	6.00^{c}	11.00^{d}
33% S + 33% C + 33% SD	33.20^{fg}	24.70^{c}	4.96^{b}	5.96^{c}	10.92^{e}

Note: Means along the column with the same letter(s) are not significantly different at $p \leq 0.05$

Table 3
Effects of growth media composition on nutrient uptake of moringa seedlings

Growth Media Composition	N	P	K	Ca	Mg	Fe	Cu	Zn
	------------------------ g/kg -----------------------					---------- mg/kg ------------		
100% Soil (S)	2.47^{c}	0.36^{c}	3.10^{d}	0.72^{e}	0.31^{h}	52.47^{j}	3.67^{ab}	24.53^{i}
100% Compost (C)	4.10^{a}	0.56^{a}	4.50^{a}	1.40^{a}	4.63^{a}	87.47^{a}	4.03^{a}	60.10^{a}
100% Sawdust (SD)	2.40^{c}	0.50^{ab}	2.20^{e}	0.84^{de}	0.63^{b}	60.47^{g}	2.86^{d}	38.13^{h}
75% S + 25% C	2.97^{b}	0.40^{c}	3.23^{d}	1.17^{bc}	0.33^{gh}	50.57^{l}	3.90^{ab}	51.33^{c}
50% S + 50% C	3.00^{b}	0.31^{c}	3.96^{bc}	1.00^{cd}	0.51^{c}	53.33^{h}	3.67^{ab}	49.33^{e}
25% S + 75% C	3.28^{b}	0.43^{bc}	4.20^{ab}	1.32^{ab}	0.57^{b}	7.37^{b}	3.60^{ab}	58.20^{b}
75% S + 25% SD	1.99^{c}	0.38^{c}	3.30^{d}	0.70^{e}	0.37^{fg}	51.47^{k}	3.40^{bc}	38.16^{h}
50% S + 50% SD	2.97^{b}	0.30^{c}	3.00^{d}	0.81d^{e}	0.41^{ef}	53.97^{i}	3.00^{cd}	50.23^{d}
25% S + 75% SD	2.40^{c}	0.32^{c}	3.20^{d}	0.74^{e}	0.49^{c}	50.47^{l}	2.97^{cd}	51.57^{c}
75% C + 25% SD	3.00^{b}	0.39^{c}	4.00^{ab}	1.20^{abc}	0.40^{ef}	72.10^{d}	3.93^{a}	57.47^{b}
50% C + 50% SD	2.97^{b}	0.37^{c}	3.93^{bc}	1.10^{bc}	0.41^{ef}	68.03^{f}	3.40^{bc}	42.57^{g}
25% C + 75% SD	3.20^{b}	0.32^{c}	3.20^{d}	1.12^{bc}	0.43^{e}	71.10^{e}	3.60^{ab}	44.00^{f}
33% S + 33% C + 33% SD	3.21^{b}	0.37^{c}	3.40^{cd}	1.13^{bc}	0.44d^{e}	73.47^{c}	3.63^{ab}	43.97^{f}

Note: Means along the column with the same letter are not significant at $p \leq 0.05$

DISCUSSION

Majority of the parameters for moringa such as seedling germination, seedling vigour, stem height, stem girth, number of leaves, fresh shoot weight, fresh root weight, dry shoot weight, dry root weight and total dry matter yield distinctively differ with the growth media composition. Growth media with adequate aeration and moisture content improve seedling germination (Atiyeh et al., 2000; Cáceres et al., 2015; Noorhosseini et al., 2018).The differences in the organic components in the different growth media composition could be the possible cause of differential growth performance. Better vegetative growth was recorded with seedlings treated with compost. This could be due to the fact that compost has the highest pH, lower bulk density, N, P and K which could enhance vegetative growth of the moringa seedlings. Higher nutrient uptake in compost is responsible for promoting better seedling vegetative growth and provides high water-holding capacity, good aeration and stimulates warmth which facilitates germination. This is supported by the reports of Baloch et al. (2014) and Castellanos et al. (2011).

The highest fresh shoot weight and total dry matter yield was recorded by 100 % compost could be due to high uptake of N, P, and K and Ca by the plant which is responsible for holding together the cell walls of plants as new tissue such as root tips, young leaves and sloop tips often exhibit distorted growth from improper cell wall formation when they are nutrient deficient (Hao & Papadopoulos, 2004). The texture or particle size distribution of nursery soils and that of potting medium for containerized planting stock is an important soil physical property influencing root and shoot growth (Dolor, 2011). This result is also in line with the findings of Goss et al. (2013) that high calcium content increases total biomass yield, fruit dry matter and fruit yield of tomato plants. The result of Domingues et al. (2016) also shows that high calcium concentrations in the growth media lead to higher dry mass of the shoot and root, high grain yield and high calcium concentration in the leaves and grains.

Better stem girth value was recorded with 100 % compost growth media was due to fact that the amount of nutrient uptake and availability by the seedlings in this growth medium is higher than other growth media. As a result of this, the nutrients were readily made available and used. This result is similar to the findings of Asante et al. (2012) which posited that compost had the highest stem height and stem girth. This indicates that stem height growth goes with the growth in stem girth.

Different growth media compositions have significant effect on number of leaves/plant. The use of 100% compost gave the highest number of leaves/plant over other growth media. This result confirms the findings by Peter-Onoh et al. (2014). The best soil for growing vegetables is one that is well drained, and has high amount of nutrient and organic matter content. Similar trends were observed with the uptake of the nutrients by the seedlings. And in most cases seedlings performance were similar where

100% compost or 75% compost + 25% soil were used. This is also in line with the findings that sand and compost combination gave best result for growth and survival of seedlings in the nursery (Bali et al., 2013; Heidari & Mohammad, 2012; Radin et al., 2017).

CONCLUSION

The use of different growth media had significant effects on most of the parameters assessed on moringa seedlings. Generally, percentage germination rate is high for all the growth media. The use of compost only (100% compost) or compost in combination with soil (75% compost + 25% soil) gave the best moringa seedling with the highest number of leaves/plant, fresh root weight, dry shoot weight, dry root weight, % seed germination and nutrient uptake. It was concluded that the use of 100 % compost as growth medium could be the best for production of high quality moringa seedlings.

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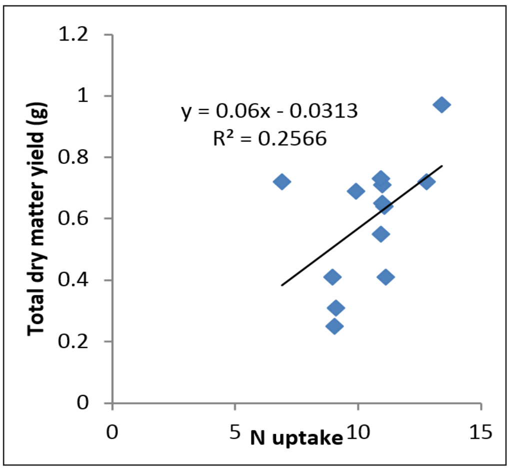
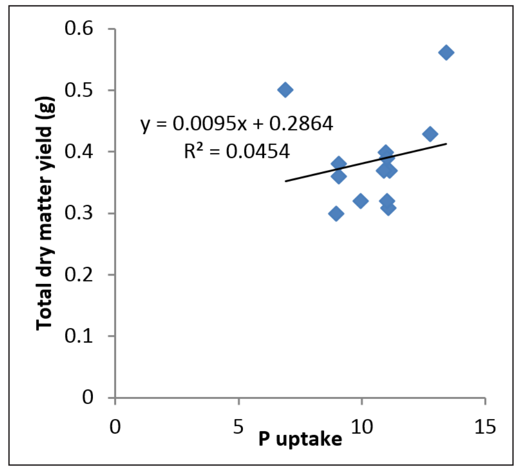
APPENDIX

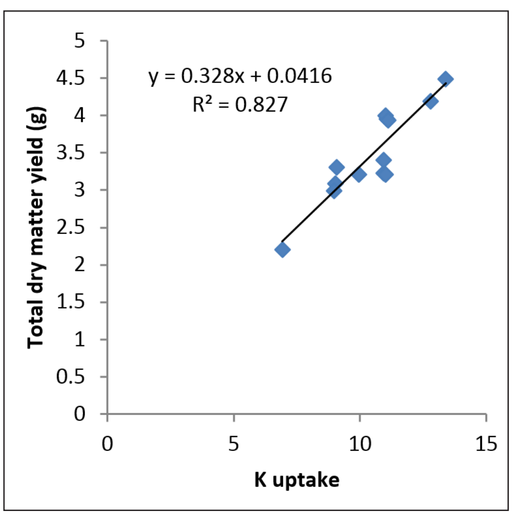
Figures 1 and 2 showed correlation between total dry matter yield and nutrient uptake. There is positive correction between total biomass yield and nutrient uptake.



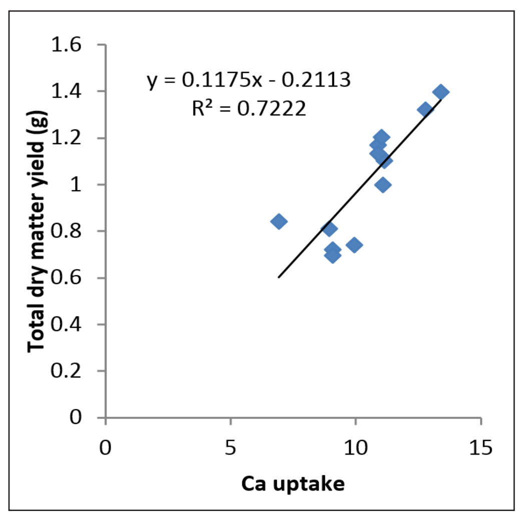
(a)



(b)



(c)



(d)

Figure S1. Correlation between total dry matter yield and nutrient uptake of (a) N ; (b) P; (c) K; and (d) Ca

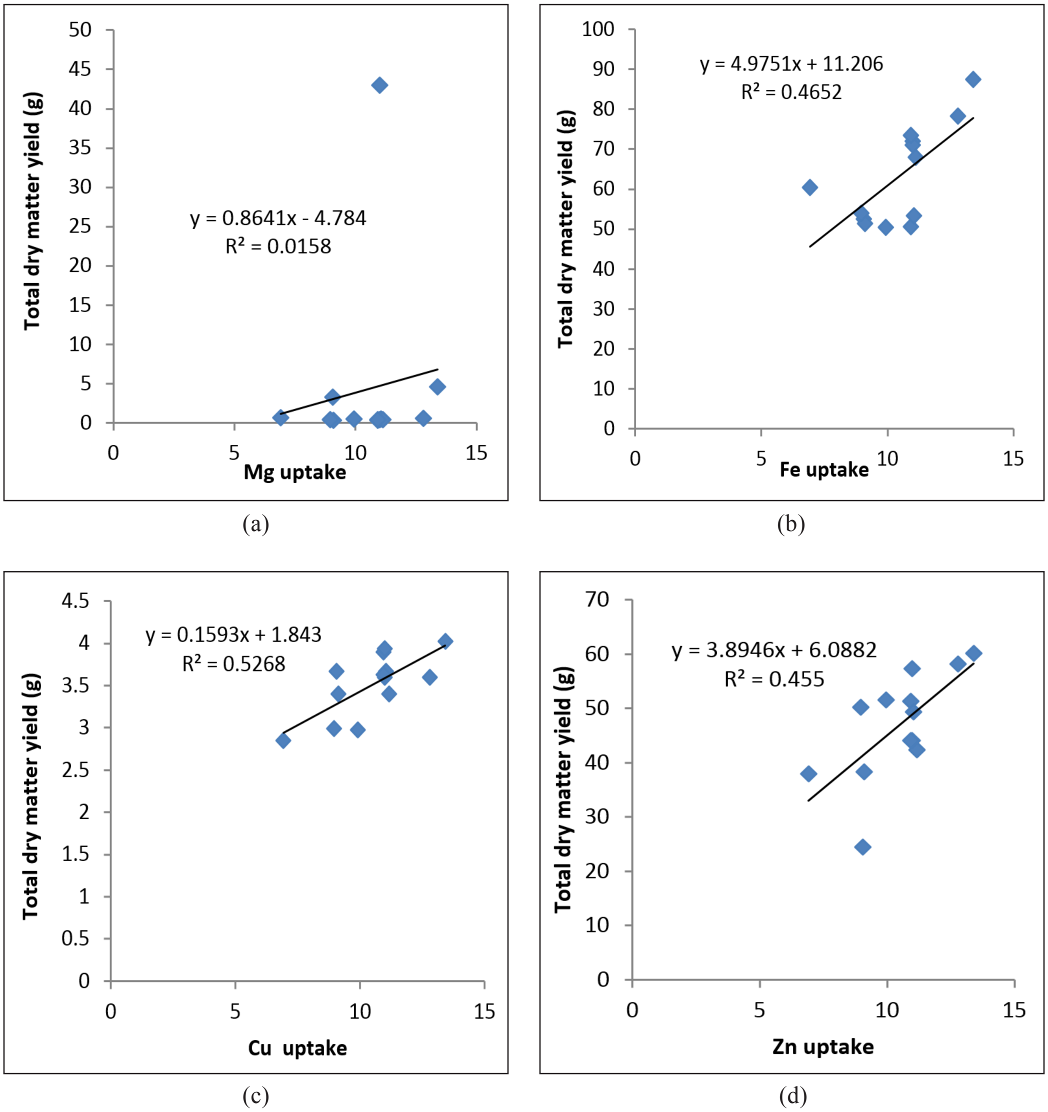


Figure S2. Correlation between total dry matter yield and nutrient uptake of (a) Mg; (b) Fe; (c) Cu; and (d) Zn

Figures 3 and 4 showed correlation between on total dry matter yield and available growth media nutrients There is a positive correction between the total biomass yield and the available growth media nutrients.

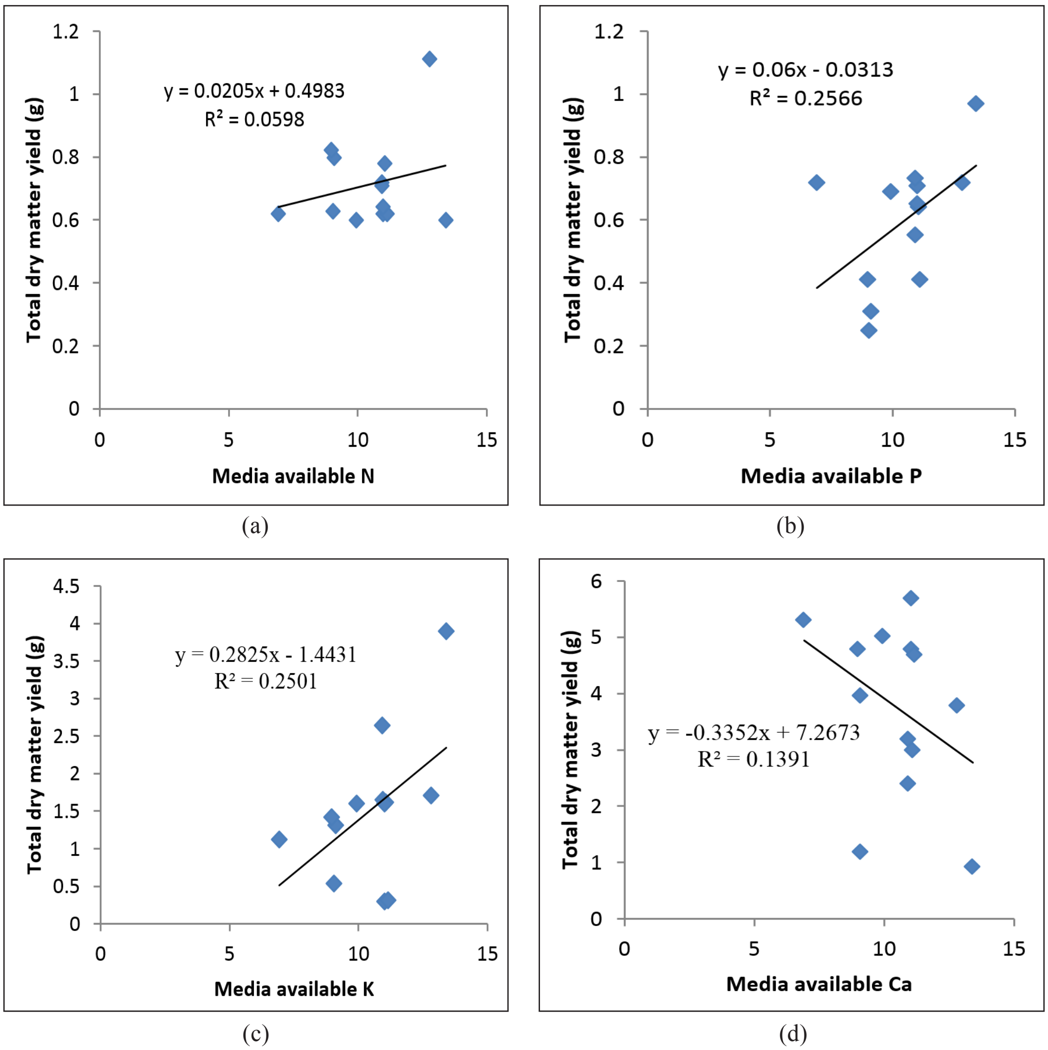


Figure S3. Correlation between total dry matter yield and available soil nutrient of (a) N: (b) P; (c) K; and (d) Ca

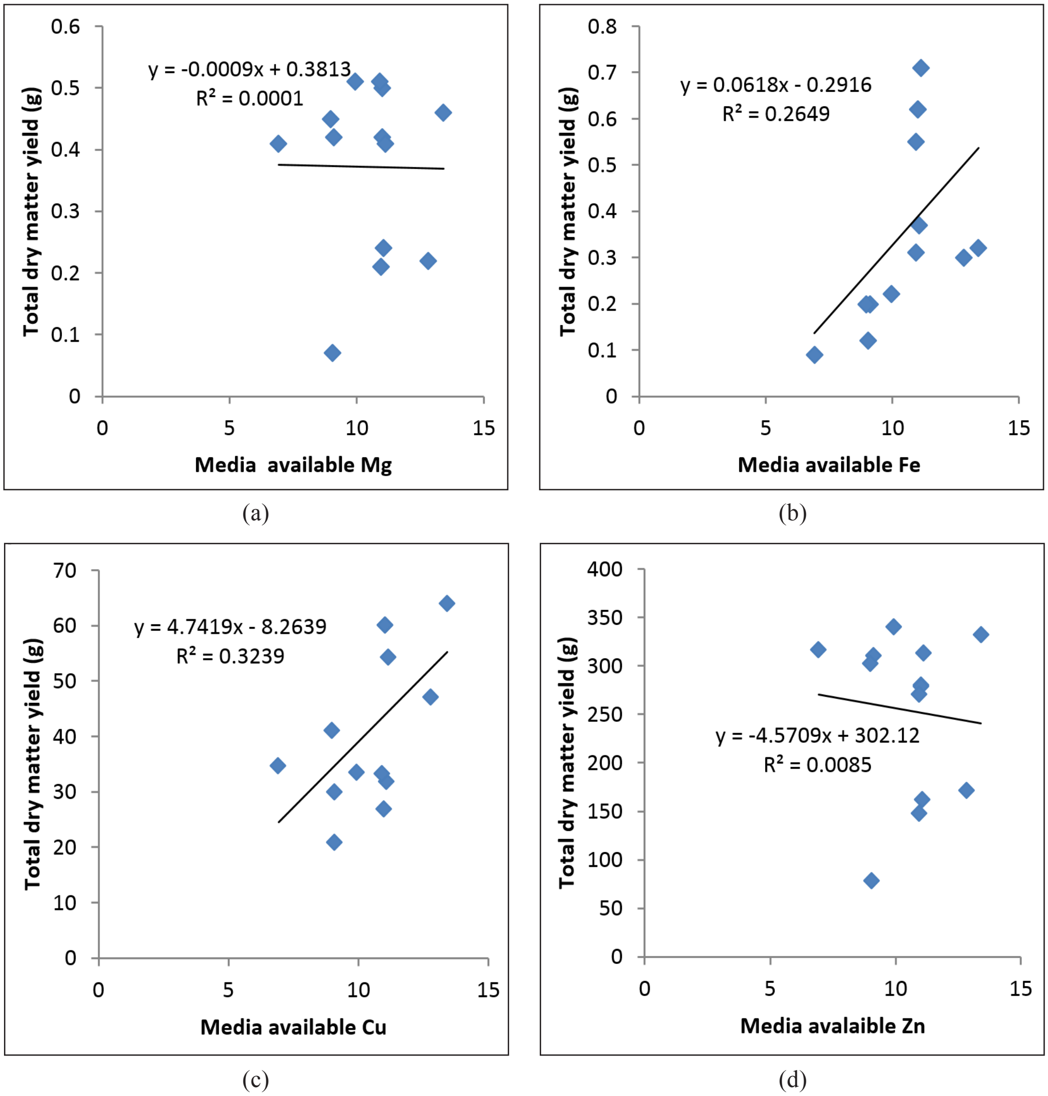


Figure S4. Correlation between total dry matter yield and available media nutrient content of (a) Mg; (b) Fe; (c) Cu; and Zn