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Original Paper

Influence of soil texture and compost on the early growth and nutrient uptake of *Moringa oleifera* Lam

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Soil is the main reservoir of water and nutrients, and thus controls the availability of most essential plant nutrients for crop growth and establishment. Therefore, a study was conducted at Ladoke Akintola University of Technology, Ogbomoso, Nigeria to investigate the effects of soil texture and compost on early growth of *Moringa oleifera* (*M. oleifera*). The experiment was a split plot laid out in a randomized complete block design with three replications. The main treatment comprises of three soil texture; sand, loamy sand, and clay while the sub-plot treatment was compost at four rates of 0, 2.5, 5 and 10 t/ha per 10 kg of soil and NPK 15 : 15 : 15 at the rate of 90 kg N/ha. Data on plant height, number of leaves, stem diameter were measured at 2 week interval for 10 weeks. Results showed that Moringa plant produced in loamy sand was superior in plant height, number of leaves and stem girth irrespective of compost applied. At 10 weeks after sowing, fresh shoot weights/pot was 73.3, 31.7, 30.3 g respectively for loamy sand, clay and sand. *M. oleifera* N uptake in loamy sand was significantly ($P < 0.05$) greater by 57 and 50%, respectively, than sand and clay. P uptake was significantly higher at 5 ton per ha than the control and other treatments. The study concluded that, combination of loamy sand and 5 ton per ha of compost was suitable for the early growth of *M. oleifera*.

Keywords: soil texture, compost, *Moringa oleifera*, growth, nutrient uptake

1 Introduction

Moringa oleifera has gained a lot of popularity due to recent discoveries of its usefulness to mankind thus resulting in rapid growth in interest for the plant. Consequent upon this, considerable research has been conducted on the extraction of its seed oil for use in agro forestry systems, water purification property, medicinal and nutritional benefits (Fuglie, 2001). Moringa is rich in health promoting phytochemicals such as carotenoids, phenolic, various vitamins and minerals (Foidl et al., 2001; Becker and Siddhuraju, 2003; Bennett et al., 2003). It leaves are highly nutritious, one serving of the plant contains 125% calcium, 61% magnesium, 41% potassium, 71% iron, 272% vitamin A and 22% vitamin C daily value, 5–10% crude protein and it does not easily turn rancid (Fuglie, 2001). It has more beta carotene, protein, vitamin, calcium, potassium and iron than carrots, peas, oranges, milk, bananas and spinach respectively (Palada and Chang, 2003).

Soil texture can influence growth and yield of crop, as it could have tremendous effect on retention and uptake of water and nutrient by the plant. Generally, most soils in Nigeria have organic carbon content falling below one percent, low phosphorus and slightly acidic medium (pH below 6.5) leading to low plant productivity (Esu, 1991). Furthermore, the rising cost of inorganic fertilizers coupled with their inability to condition the soil has directed attention to organic manures in recent times (Agyenim-Baoteng et al., 2006; Oyedeji et al., 2014). The use of organic manure as fertilizer releases many important nutrients into the soil and also nourishes soil organisms, which in turn slowly and steadily make minerals available to plants (Erin, 2007). Organic materials serve not only as sources of plant nutrients but also as soil conditioners by improving soil physical properties, as evidenced by increased water infiltration, water holding capacity, aeration and permeability, soil aggregation and rooting depth, and by decreased soil crusting, bulk

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density and erosion (Franzluebbers, 2002; Zebarth et al., 1999).

Organic wastes of acceptable quality usually, when returned to agricultural soils on regular basis contribute greatly to the overall maintenance of soil fertility and productivity, and reduce the need for mineral fertilizer (Parr and Colacicco, 1987). Compost is an organic residue that has decomposed and recycled as a fertilizer and for soil amendment. It is a potential source of nutrients and is also useful in soil amelioration especially for communal farmers who cannot afford fertilizers. However, getting the maximum value of the compost requires applying it at the proper rates and frequency in conjunction to a particular soil. Research on the establishment and growth of *Moringa oleifera* seedlings is the realization that production can be adversely affected by soil types and nutrient status of the soil or media. This having received much attention depends on the availability of materials used in composting which varies from different locations. Considering the nutritive value of *M. oleifera* as well as the variability of soils, the present study was carried out with the objective of determining the effects of soil texture and compost rates on the early growth and biomass yield of *M. oleifera*.

2 Material and methods

2.1 Study site, soil sampling, and laboratory analyses

The study was carried out at the screen house of the Department of Agronomy, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.

Soil samples used for the experiment were collected from three different locations. Surface soils sample (0–15 cm depth) taken from the three sites were air-dried and pass through 2 mm sieve and then stored for the pot experiment. Sub-samples of the composite soil samples were analyzed for selected physical and chemical properties (Table 1). The compost used for the study was also analysed for some chemical properties as shown in Table 2. The routine analysis of the soil for the experiment was carried out at IITA (International Institute for Tropical Agriculture) Ibadan. Particle size analysis was done by hydrometer method (Gee and Or, 2002). Soil pH was determined with the pH meter using glass electrode in a soil: water ratio of 1 : 1. Organic carbon was determined by the Walkley-Black procedure described by (Nelson and Sommers, 1986). Exchangeable cations were determined according to the procedure described by (Tel and Roa, 1982). Available phosphorus

Table 1 Physico-chemical properties of soils at different location (0–15 cm) used in filing the pot for sowing *Moringa oleifera* seeds in a screen house

Soil properties	Soil texture		
	Sand	Loamy sand	Clay
Physical properties (g/kg)			
Sand	930	790	370
Silt	10	90	160
Clay	60	120	470
Chemical properties			
pH (H_20) (1 : 1)	5.70	7.8	7.5
N (g/kg)	0.16	2.75	0.28
OM (g/kg)	0.49	7.48	0.76
Avail P (mg/kg)	3.10	3.49	2.26
Exchangeable bases (cmol/kg)			
Ca	0.54	0.82	3.97
Mg	4.13	1.38	2.82
K	0.60	0.32	0.20
Na	0.08	0.08	0.09
Micro-elements (mg/kg)			
Mn	29.12	7.03	26.11
Fe	296.12	61.90	26.11
Cu	4.05	2.33	0.52
Zn	48.18	34.70	4.46

was determined using Bray II method (Bray and Kurtz, 1945) while Total nitrogen was determined by Macro-Kjeldahl method (Bremner, 1965).

Table 2 Chemical composition of compost used for the screen house experiment

Parameter	Values
pH	8.1
OC (%)	61.8
TN (%)	1.73
C : N ratio	36 : 1
P (%)	2.52
K (%)	1.48
Ca (%)	3.74
Mg (%)	0.16
Mn (mg/kg)	350.0
Fe (mg/kg)	315.0
Cu (mg/kg)	25.4
Zn (mg/kg)	42.5

2.2 Screen house experiment

The experiment was a split plot laid out in a Randomized Complete Block Design with three replications giving a total of 45 experimental units. The main treatments consisted of three soil types; sand, loamy sand, and clay and four rates of compost (prepared from sawdust and poultry manure mix) at 0, 1.5, 5.0,10 ton/ha represented by C0, C1, C2, C3 respectively, and NPK 15 : 15 : 15 fertilizer (F4) at recommended rate of 90 N kg/ha. The compost was applied per 10 kg of soil weighed into a 10 litres capacity plastic pots perforated at the bottom for drainage outlets. Moringa seeds were sourced from Department of Agronomy, University of Ibadan, Nigeria. The pots were watered to field capacity and left for two weeks before sowing the seed while the recommended rate for NPK 15 : 15 : 15 (90 kg N/ha) equivalent to 0.03 g was applied at sowing. Three seeds of *Moringa oleifera* were sown per pot and later thinned to one vigorous plant 2 weeks after sowing. Data on seedling height, stem girth, number of leaves were collected at 2 week interval for 10 weeks. Fresh and dry shoot (g) and root (g) weights were determined at harvesting (10 weeks after sowing) using weighing balance. Proximate analysis of total dry matter was used to determine the percentage of Nitrogen, Phosphorus and Potassium which was used to calculate the nutrient uptake of *Moringa oleifera* seedlings.

Data were subjected to analysis of variance (ANOVA) using the SAS package 2002.Treatment means were separated using the Fisher's Least Significant Differences at 5% level of probability.

3 Results and disscussion

The physical and chemical status of the soils used for the experiment is shown in (Table 1).

Analysis of soil texture revealed that soils from the three locations 1, 2 and 3 were clay, sand and loamy sand, respectively. Soil pH was acidic in coarse textured soil than medium and fine textured soil which tends towards neutral. Soil organic matter, Total N and available P were in the order of loamy sand > clay > sand which is a reflection of the nutrient potential of the soil. The chemical properties of the compost used for the study is present in Table 2.

The effects of soil texture and compost on Moringa plant height are represented in Figure 1. Moringa plant height was not affected by soil texture at 2 weeks after sowing (WAS). However, at 4, 6, 8, and 10 WAS loamy sand recorded significantly higher plant height than sand and clay soils. At early growth stage of Moringa, fertilizer treatment did not significantly influenced plant up to 4 WAS. Thereafter, fertilizer application significantly influenced the heights at 6, 8, and 10 WAS. At 6 WAS, treatments were in the order of C2 > F > C1 > C3 which were significantly higher height than the control (C0). At 8 WAS, the order was C2 > C1 > C3 > F4.Whereas at 10 WAS, C2 recorded significantly higher height than all the treatments, while the lower plant height was observed in C0, but there was no difference between F4 and C0.

Soil texture had significant effect on stem girth of Moringa throughout the growing stage except at 2 WAS (Figure 2). Stem girth from loamy sand was consistently significantly higher than sand and clay starting from 4 WAS to 10 WAS. The higher stem girth values obtained from loamy sand could be attributed to higher nutrients status of loamy sand compared with other textural classes as reflected in Table 1. At 4WAS fertilizer treatments revealed that C2 significantly produced higher stem girth than F4 and C0 while C1 and C3 are not different from C2 and C0. At 6 WAS, the order was C2 > C3 > C1 > F4 which were significantly higher than C0. At 8 WAS, and 10 WAS, C3, C1, F4 significantly contributed to the improvement of the stem. The lowest stem girth was found in C0.

Soil texture significantly affected number of leaves of Moringa at 4 WAS up to 10 WAS excluding 2 WAS (Figure 3). At 4 WAS loamy sand had higher number of leaves when compared to clay, while number of leaves in sand was not different from loamy sand and clay. However, at 6 WAS, number of leaves was in the order of loamy sand > clay > sand. Also, at 8 and 10 WAS, number of

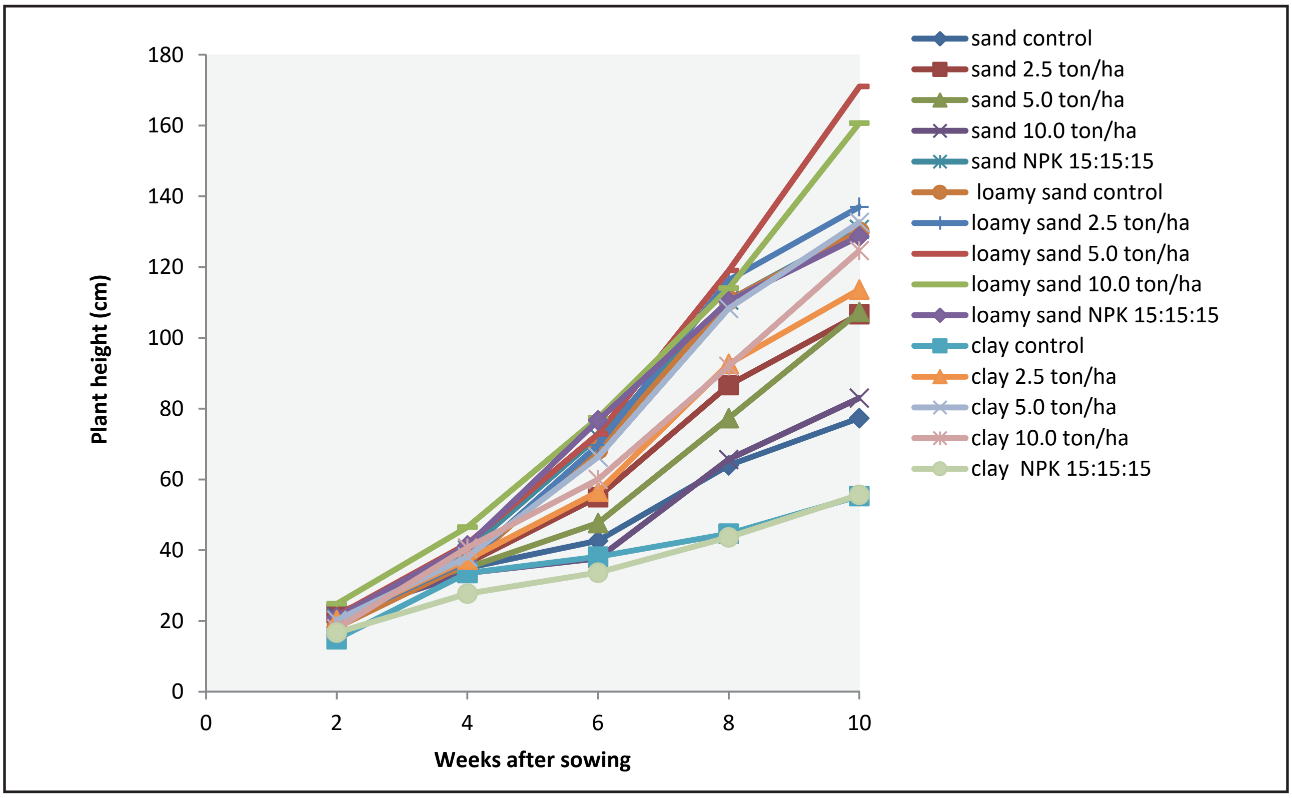

Figure 1 The interaction effects of soil texture by compost effects on *M. oleifera* plant height

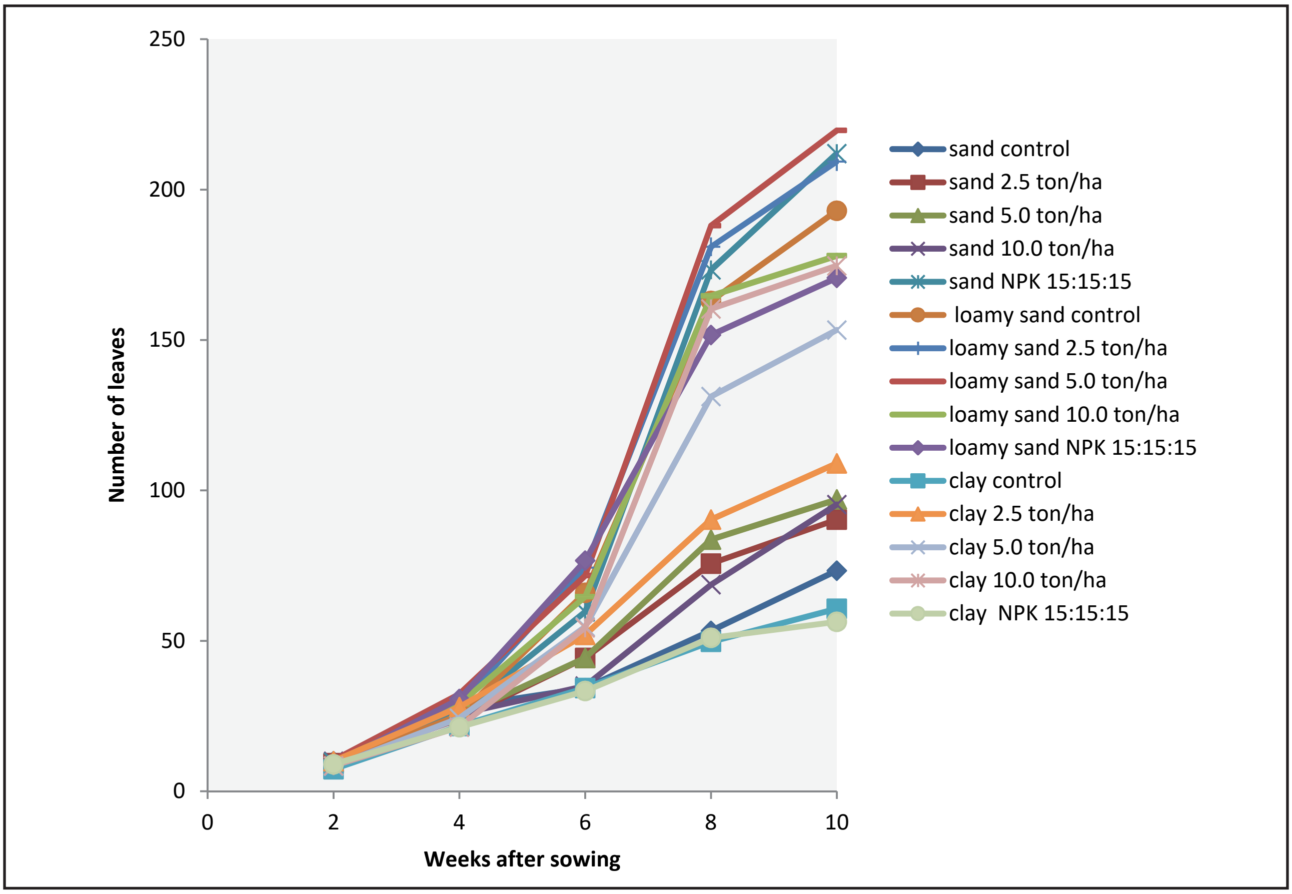

Figure 2 The interaction effects of soil texture by compost effects on *M. oleifera* number of leaves

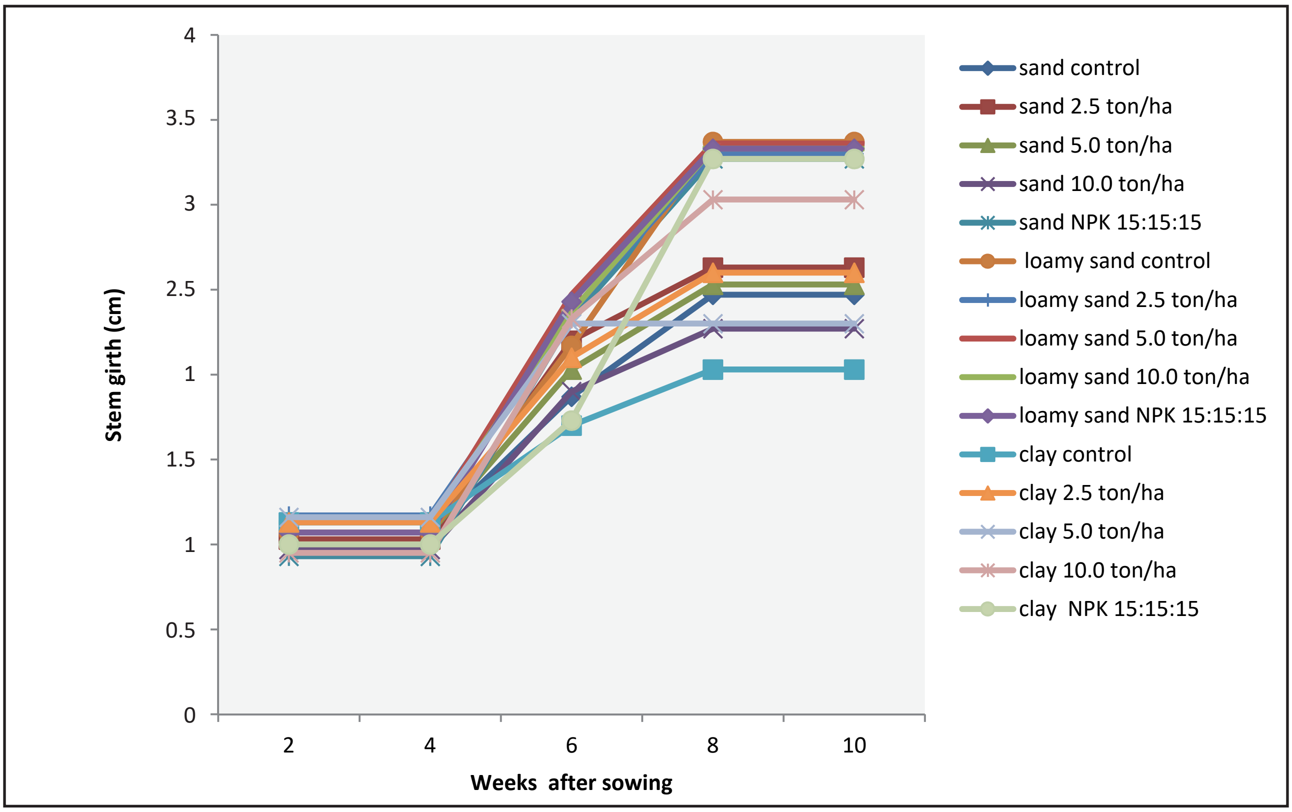

Figure 3 The interaction effects of soil texture by compost effects on *M. oleifera* seedlings stem girth

leaves recorded were significantly higher in loamy sand than sand and clay. Fertilizer treatment had no significant effect on number of leaves at 2 and 4 WAS. Conversely, at 6 to 10 WAS, there were significant effects of fertilizer treatment on number of leaves. At 6 WAS, C2, C1 and F4 had significant higher number of leaves than C0 while C3 was not different from the control and other treatments. At 8 WAS, number of leaves was in the order of C2 > C3 > F4 > C1 which were significantly higher than C0. Furthermore at 10 WAS, treatment C2, C3 and F4 were higher in number of leaves than C0.

The effects of soil texture and compost rates on fresh and dry weights of Shoot and Root of *M. oleifera* seedlings is presented in Table 3. Soil texture significantly increased fresh and dry shoot weight of Moringa. Loamy sand produced significantly higher fresh and dry shoot compared with sand and clay. Compost applied at the rate of C2, C3 and NPK fertilizer increased Moringa fresh shoot weight than C0 while C2 was not different from C0 and other treatments.

The influence of soil texture and compost on Moringa is presented in Table 3. Nutrient uptake of *M. oleifera* seedlings was significantly influenced by soil texture. Loamy sand significantly increased N, P, and K uptake by 43, 51 and 61%, respectively than sand, while there was no significant difference between sand and clay.

Compost and NPK 15 : 15 : 15 had significant influence on uptake of N and K. All compost treatments and NPK significantly increased N and P uptake when compare with the control. However, P uptake was significantly greater on C2 (5 ton/ha) than C0, C1, and F4, while C3 did not differ from C2.

The pre-planting soil analysis revealed that major nutrients of the soil (clay and sand) except for loamy sand (Table 1) was below the critical level where the minimum reported for growth was to be 0.6–1.0 gk/g for N, 3–7 mg/kg for P and 0.21–0.3 cmol/kg for K. Also, the low levels of N, available P, and organic carbon observed in the soils used for the experiment corroborate with the findings of (Aduayi et al., 2002); they reported that most of Nigerians soil is deficient in the major nutrients. Therefore, there is need for sustainable amendment to increase soil productivity in order to enhance the optimum growth and nutrient concentration of the crop.

All growth parameters (plant height, stem girth, and number of leaves) had significant performance in loamy sand than sand and clay. The inherent nutrient status of loamy sand could be attributed to the higher performance than all other textural classes. Also, loamy sand producing higher growth and biomass is an indication of sharing the properties of sand and clay which provided a good drainage and nutrient retention. The increasing effects of loamy sand on *M. oleifera*

Table 3 Effects of soil texture and compost rates on yield component of *Moringa oleifera* seedlings at 10 weeks after sowing

Treatment	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight
	g/plant			
Soil Texture (ST)				
Sand	30.31	5.82	7.49	1.01
Loamy sand	73.27	10.74	9.46	0.99
Clay	31.67	5.93	9.61	1.07
$LSD_{(0.05)}$	15.65	4.43	2.77	0.14
Compost (C)				
Control	37.00	6.53	8.39	1.12
2.5 ton/ha(C1)	45.08	6.20	7.96	1.01
5 ton/ha (C2)	50.28	8.28	9.41	0.99
10 ton/ha (C3)	46.16	8.50	8.30	0.92
NPK 15 : 15 : 15 (F4)	46.91	7.97	10.20	1.08
$LSD_{(0.05)}$	8.23	3.61	1.55	0.23
$LSD_{(0.05)}$ ST * F	19.97	Ns	3.63	Ns

LSD = Least significant difference; ST*F = Interaction of soil texture by composts

early growth in this study is in line with the findings of (Oshunsanya et al., 2015) that loamy sand supplied more nutrients for Moringa development which other textural class could not met. He also observed that Moringa plant height was significantly higher in a loose texture than a well a packed fine texture throughout the study period.

Fresh shoot and root weight followed the same trend as other growth parameters. Loamy sand producing the highest fresh shoot and root weight could be explained to a large extent, the soil potential nutrient capacity to sustain crops which is in the order of loamy sand > sand > clay. This confirms the report of Imoro et al. (2012) that increased nutrient status favoured the growth performance of *M. oleifera* seedlings. Furthermore, Swaider et al. (1992) had similar report that the best soil for growing vegetables is one that is well drained, fairly deep and has a relatively high amount of organic matter (3 to 5%). Nutrient uptake of Moringa seedlings consistently follow the same trend with growth and fresh shoot and root weight of Moringa. Loamy sand aided uptake of N, P and K of Moringa seedlings compared to sand and clay. This could be explained from the perspective that nutrient status of the soil could influence nutrient concentration of *M. oleifera* seedlings.

In terms of compost applied with NPK 15 : 15 : 15, *M. oleifera* seedlings growth parameters was consistently superior in compost applied at the rate of 5 ton per ha compared with the control, NPK and other treatments. The result revealed that 5 ton per ha gave the optimum plant growth beyond which application at higher rate than this retarded growth and might be due to toxicity effect of the compost. Furthermore, the higher response to compost application of 5 ton per/ha could be ascribed to the ameliorative effect of compost on the soil which increased Moringa growth. Asante et al. (2012) reported higher stem height values on compost treated plot and they attributed this in part to the fact that compost treated plot contained an appreciable amount of N which is responsible for promoting vegetative growth. The

Table 4 Influence of soil texture on nutrient uptake of *Moringa oleifera* seedlings

Treatments	N	P	K
	(%)		
Soil Texture (ST)			
Sand	8.78	1.69	2.42
Loamy sand	20.46	3.44	6.18
Clay	10.14	2.45	3.05
$LSD_{(0.05)}$	2.56	1.38	0.97
Compost (C) control	8.29	1.94	2.58
2.5 ton/ha compost	13.49	1.30	4.10
5 ton/ha compost	12.91	4.23	3.93
10 ton/ha compost	15.63	2.81	4.93
NPK 15 : 15 : 15	15.33	2.36	3.88
$LSD_{(0.05)}$	3.30	1.78	1.25
ST*F	5.71	NS	NS

result is in line with Palm et al. (2012) who reported that maintaining soil organic matter through use of organic materials has potential to increase crop yields.

The better production of fresh shoot and root weight with application rate of compost at 5 ton/ha suggested that it was appropriate for the vegetative growth of *M. oleifera* seedlings. Application of 5 ton per ha that was optimum for *M. oleifera* seedlings early growth beyond which retardation sets in contradicts the findings of Pahla et al., 2013; they reported that Moringa growth increased with increase application of manure. The increasing of compost on Moringa development in this study also corroborates the observation of Akanbi et al. (2005) that compost releases considerable soil organic matter, available P and exchangeable cations when applied to soil.

The increase in N, K uptake of *M. oleifera* seedlings from compost applied was comparable to NPK fertilizer, but lesser than the control. However, 5 ton per ha increased P uptake than the control, NPK 15 : 15 : 15 and other treatments. The result revealed that N and K uptake of Moringa could be increased by any application rate of compost which is comparable to NPK 15 : 15 : 15 while P uptake is best with 5 ton per ha. Consequently, application of compost contains beneficial microbes that can promote more effective root growth which aided the uptake of nutrients. This can be corroborated by the report of (Murwira and Mugwira, 2012) that application of manure promotes sustainability of soil fertility through the recycling of nutrients.

Also, the observation agreed with Adebayo et al. (2011) that application of different organic amendment significantly influenced the accumulation of N, P, and K in Moringa seedlings. Chukwuka and Omotayo (2009) also supported that, there was improvement in chemical properties of soil and nutrient uptake in plants due to application of organic amendments.

4 Conclusions

Loamy sand with moderate macro and micro nutrients had a remarkable performance in terms of plant height, number of leaves, stem girth and biomass yield. This implies that Moringa could thrive very well in a medium textured soil than either very loosed or a compacted fine textured soil due to fragile nature of the roots which may find it difficult to penetrate. Also, for optimum growth of the seedlings application rate of compost should not exceed 5 ton per ha beyond which may pose a threat to seedling growth. The results also demonstrated that nutrient concentration could be increased with the application of compost specifically P uptake which was optimum at 5 ton per ha. Therefore, loamy sand in combination with 5 ton per ha is recommended for optimum early growth of *Moringa oleifera*.

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