GROWTH AND YIELD RESPONSE OF *MORINGA OLEIFERA (Lam)* TO DIFFERENT RATES, METHODS AND TIMING OF COMPOST APPLICATION

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ABSTRACT

Moringa oleifera* (L)** *production is recently being advocated for its outstanding phytochemical components with high medicinal values. However, its production is being threatened with poor soil fertility most especially in urban areas. Field experiment was carried out to determine the effects of time, rate and method of compost application on the growth and yield of Moringa oleifera. Composts made from Mexican sunflower and poultry manure, applied at 2.5t/ha (C1) and 5.0t/ha (C2), with two methods of application (surface; M1 and drilling; M2) and applied at different times of application (2 weeks before transplanting; T1 and 2 weeks after transplanting; T2) to give nine treatments (C1M1T1, C2M1T1, C1M2T1, C2M2T1, C1M1T2, C2M1T2, C1M2T2, C2M2T2 and Control). The treatments were arranged using Randomized Complete Blocks Design (RCBD) and replicated three times. Data were collected on vegetative development such as number of leaves, number of branches, stem diameter and plant height fortnightly for 12 weeks beginning from four weeks after transplanting (4WAT). At 12 weeks, the plants were uprooted and separated into roots, stems and leaves for fresh and dry weights determination. The post-cropping soil analysis was also carried out following standard procedure. Results indicated that compost treatments significantly enhanced growth parameters($P \leq 0.05$). C2M2T2 was superior to other compost treatments. It gave the highest number of leaves, number of branches, stem diameter and plant height. Fresh weight and dry matter accumulation were also influenced by organic amendment compared to control, Soil analysis result showed that amendment with compost generally increased soil nitrogen, available phosphorus, and organic carbon content of the soil. It could be concluded that 5t/ha of compost, applied after transplanting using drilling method increased the cumulative yield of* ***Moringa oleifera.

Keywords: Drilling, Surface, Mexican sunflowers, Phytochemicals, Compost, Moringa

INTRODUCTION

Moringa oleifera also known as horseradish tree or drumstick is a medium-sized tree of about 10m height. It belongs to the family Moringaceae. Moringa is one of the world's most nutritious crops (Fuglie, 1999). Different parts of this plant contain a profile of important minerals, and are a good source of protein, vitamins, beta-carotene, amino acids and various phenolics. The leaves are outstanding as a source of vitamins A and, when raw, vitamin C (Palada and Chang, 2006).According to Mensah *et al.* (2012), nutritional investigation of moringa revealed the presence of carbohydrates (29.08%), ascorbic acid (140mg/100g),fibre (2.1%), protein (6.88%) as well as iron (70mg/100g), calcium (1530 mg/100g), vitamin C (17.8 mg/100g), potassium (255 mg/100g), magnesium (250 mg/100g) and vitamin A (19.9 mg/100g).

Moringa can be found in the wild or cultivated and sold as a supplement. In India and different parts of Africa, it is cultivated on a large scale in nurseries or orchards (Shindano & Chitundu, 2008). The leaves, seeds, flowers, pods (fruit), bark and roots are all seen as vegetable and each part is uniquely harvested and utilized. For example, fresh leaves are picked, air dried, ground to a powder, and then stored for food flavouring or additive. Dried or fresh leaves are also used in foods such as soups and porridges (Lockett, 2000). Farmers also use the leaves as animal feed (Manh *et al.*, 2005) and water purification (Schwarz 2000). The nutritive value of Moringa is said to be similar to that of soybeans and rapeseed meal (Soliva, 2005).

In South-western Nigeria, *Moringa oleifera* still remains unpopular despite its acclaimed economic and nutritional values (Odeyinka *et al.*, 2007). More research/extension works are therefore required to encourage Moringa cultivation in this part of the country. One of the factors required for optimum yield of crops is adequate nutrients in the soil and their proper management. *Moringa oleifera* needs a steady supply of nutrients to produce leaves, seeds and pods maximally. However, in developing a nutrient regime for moringa production, environmental and health implications of the nutrient source must be put into considerations. Hence, the promotion of the use of organic source of fertilizer instead of conventional fertilizers.

Organic fertilizers are sustainable, relatively cheap materials of plant and animal origin that are usually incorporated into the soil before seeding, to increase its productivity and crop yield. Green manure, compost and sewage sludge are some of the materials used as organic amendments (Akanbi *et al.*, 2000). Among the organic soil amendments, compost has been found to be effective in improving soil nutrient status (Stofella *et al.*, 1997; Chukwuma and Omotayo, 2009). The main objective of composting is to re-cycle nutrients in the plants and animal left over back to the soil in available forms for plant growth (Adediran *et al.*, 2001). It provides a ready source of carbon and nitrogen for microorganisms in the soil, improves soil structure, increases the water holding capacity of the soil and above all, it increases soil organic matter which ultimately improves plant growth and yield (Stoffela and Graetz, 1996; Roe *et al.*, 1997). Compost has other advantages such as availability of materials for its preparation, gradual release of plant nutrients without being wasted through leaching or erosion, destruction of harmful weed and toxic materials during preparation and environmental friendliness (Adediran *et al.*, 2001).

Though, the advantages of organic amendments application in crop production have long been recognized, certain conditions must be considered to obtain maximum benefit. Effectiveness of compost is said to depend on source, rate, method and time of application (Adediran *et al.*, 2001; Togun *et al.*., 2004). This study was therefore carried out to determine the effectiveness of different rates of compost (made from Mexican sunflower and poultry manure), appropriate method and time of application on vegetative development and yield of *Moringa oleifera*.

MATERIALS AND METHODS

Experimental Location

The field experiment was carried out at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan in 2012. University of Ibadan is located at latitude 7°34'N and longitude 3°54'E at an altitude of 234m. Ibadan is located in humid tropical rainforest zone of South -Western Nigeria with annual rainfall of 1,250mm to 1,500mm, annual average temperature of 21.3°C and relative humidity of 70-80%.

Experimental Procedure

Treatments and field layout

Mexican sunflower (*Tithonia diversifolia)* compost prepared in combination with poultry manure in ratio 3:1 of plant materials to poultry manure (on dry weight basis) was used for the experiment. It contains total N;2.17%, P; 2470mg/kg, Carbon; 6.94%, K; 61.5cmol/kg; Ca ;37100mg/kg, Mg:12900mg/kg. Zn;162mg/kg and Pb: 0.20mg/kg (Table 1). The treatment consisted of compost applied at the rates of 0t/ha (No compost), 2.5 t ha^{-1} (250g) and 5 t ha^{-1} (500g). Times of application of compost were two weeks before planting and two weeks after planting. The methods of application were surface and drilling methods to give nine treatments all together that were replicated three times. These are denoted as C1M1T1, C2M1T1, C1M2T1, C2M2T1, C1M1T2, C2M1T2, C1M2T2, C2M2T2 and CONTROL; where, C1– compost rate (2. 5t/ha), C2– compost rate 2 (5t/ha), M1 -surface application method of compost, M2 - drilling application method of compost, T1- application before planting and T2- application after planting. The surface application method was carried out by mixing the appropriate compost rate thoroughly with the top soil of the plots receiving surface application while the drilling method of application was carried out by digging two horizontal lines of about 0-5cm deep and 0.5m in between the two lines. Compost was applied on these two lines and covered with the soil. The seedlings were then planted close to the two lines. Four seedlings were transplanted to each plot following the recommended spacing of 10–20 cm within rows and 30–50 cm apart. The field layout is as shown in Figure 1. Twenty-seven (27) plots of 1m by 0.5m were mapped out and raised up to demarcate treatments from each other. The experiments were arranged in Randomized Complete Block Design (RCBD). The experiment was made up of nine (9) treatments and three (3) replications.

Table 1: Chemical properties of composts used for amendments

Compost type	(%)		Concentration (mg/kg)					cmol/kg
	C	N	P	Ca	Mg	Pb	Zn	K
MSC	6.94	2.17	2470	37100	12900	0.20	162	61.5

Key: MSC; Mexican Sunflower Compost C: Carbon; N: Nitrogen; P: Phosphorus; Ca: Calcium; Mg: Magnesium; Pb: Lead; Zn: Zinc; K: Potassium

***Source:** Adejumo et al. / Pedologist (2011) 182 -193*

Planting procedure

The seeds of *Moringa oleifera Lam* were obtained from the Deparment of Crop Protection and Environmental Biology (Crop physiology section), University of Ibadan. Due to the oily nature of moringa seeds, the viability of the seeds is always affected. For proper germination and management, these seeds were first raised in the nursery before transplanting into the field two weeks after planting. This was also to ensure homogeneity of the seedlings being transplanted on the field. Pre-planting (two weeks before planting) application of organic fertilizer was done by thoroughly mixing each rate (i.e.250g and 500g) of compost with the soil following the application method and two weeks later, plants were transplanted to the field. Two weeks after transplanting, composts were applied to the plots receiving compost at two weeks after transplanting, excluding the treatment without compost (Control). At four (4) weeks after transplanting, the first data were taken, this was repeated at six (6), eight (8), ten (10) and twelve (12) weeks after transplanting.

C1M1T1R1	C2M1T1 R1	C1M2T1 R1	C2M2T1 R1	C1M1T2 R1	C2M1T2 R1	C1M2T2 R1	C2M2T2 R1	CONTROLR1
CONTROL R2	C2M2T2 R2	C1M2T2 R2	C2M1T2 R2	C1M1T2 R2	C2M2T1 R2	C1M2T1 R2	C2M1T1 R2	C1M1T1R2
C2M2T2R3	C1M2T2 R3	C2M1T2 R3	C1M1T2 R3	CONTR OLR3	C2M2T1 R3	C1M2T1 R3	C2M1T1 R3	C1M1T1R3

Figure1: Experimental Layout

R1-Replicate one, R2-Replicate two, R3-Replicate three

Data collection on vegetative parameters

The growth characters on which data were taken include; number of leaves, number of branches, number of nodes, plant height (cm) and stem diameter (cm). Number of leaves, plant nodes and branches were counted by visual method. Plant height was measured using ruler and the measurement was from the soil level to the tip of the plant. Stem diameter was carried out by placing vernier callipers round the stem of the plant.

Fresh and dry weight determination

At 12 weeks after transplanting, the experiment was terminated and the plants were uprooted by carefully separating the roots from the soil, washed and air-dried to remove the water. The plants were then partitioned into leaves, stems and roots before weighing using top loading metler balance. For dry matter accumulation, the partitioned parts were placed in envelopes and then put in an oven at 80°C for 48 hours, after which they were removed and re-weighed.

Post-cropping soil analysis

Soil samples were taken from each plot for chemical analysis. Samples were collected from five equidistant points at 0-15cm depth to ensure even representation of the plot. The soil was air dried, mixed thoroughly and sieved. Composite sample was then taken for analysis. Organic Carbon (%) was determined by dichromic oxidation. Total N (g/kg) by kjeldahl method, Available P (mg/kg) and Exchangeable cations were determined using standard method by IITA (1979).

Statistical Analysis

Statistical analysis involved analysis of variance (ANOVA) and means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

RESULTS

EFFECTSOF COMPOST RATE, TIME AND METHOD OF APPLICATION ON VEGETATIVE CHARACTERS OF *MORINGA OLEIFERA LAM.*

Effects of Rate, Time and Method of compost application on the Number of Leaves of Moringa oleifera

Moringa leaf production was enhanced in all the compost treatments compared with control (without compost) which had the lowest number of leaves throughout the period of data collection. There was a progressive increase in the number of leaves in all the treatments, including control. At four (4) weeks after transplanting (4WAT), moringa plants grown on the plot that received higher compost rate (5t/ha) drilled into the soil and applied after transplanting (i.e. C2M2T2) produced the highest number of leaves though, not significantly higher than other compost treatments, it was significantly higher than control. The trend was the same at eight weeks after transplanting (8WAT), the number of leaves in this treatment was the highest compared with other treatments. Conversely, the number of leaves of the plant grown in the plot with lower rate of compost applied before transplanting following surface application method (C1M1T1) was not significantly different from control plant at 8WAT. However, at twelve (12) weeks after transplanting (12WAT), lower compost rate applied before transplanting of moringa using drilling method had the highest number of leaves which again was not significantly different from other compost treatments. Control also had the lowest number of leaves at this period which were significantly lower than the number of leaves from other treatments (Table 2). Comparatively, among the two methods of application, drilling method appeared to have increased the number of leaves more than surface application method (Table 3).

Table 2. Effects of different types of compost rate, time and method of application on the number of leaves of *Moringa oleifera (Lam)* planted at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

TREATMENTS	4WAT	8WAT	12WAT
C1M1T1	352.50c	903.00bc	2645.00a
C2M1T1	423.00b	1115.00ab	2659.33a
C1M2T1	574.00a	1412.50ab	3150.17a
C2M2T1	563.67a	1398.00ab	2550.00a
C1M1T2	395.50bc	1072.67ab	2189.00a
C2M1T2	508.50ab	1283.17ab	2749.50a
C1M2T2	475.17ab	1223.50ab	2604.67a
C2M2T2	597.50a	1469.00a	2545.33a
CONTROL	343.83c	791.83c	1254.83b

Means followed by the same letter in a column are not significantly different at P≤ 0.05 by Duncan Multiple Range Test (DMRT)

WAT = Week after planting
C1MIT1- 2.5t/ha Compost, Surface application and Before transplanting
C2M1T1- 5t/ha Compost, Surface application and Before transplanting
C1M2T1- 2.5t/ha Compost, Drilling application and Before transplanting
C2M2T1- 5t/ha Compost, Drilling application and Before transplanting
C1M1T2- 2.5t/ha Compost, Surface application and After transplanting
C2M1T2- 5t/ha Compost, Surface application and After transplanting
C1M2T2- 2.5t/ha Compost, Drilling application and After transplanting
C2M2T2- 5t/h Compost, Drilling application and After transplanting

Table 3. Effect of different methods of compost application on the number of leaves of *Moringa oleifera* (Lam) planted at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

Time of application	Compost rate	Method of application	Number of leaves		
			4WAT	8WAT	12WAT
T1	C1	M1	352.50b	903.00b	2645.00b
		M2	574.00a	1412.50a	3150.17a
	C2	M1	423.00ab	1115.00b	2659.33a
		M2	563.00a	1398.00a	2550.00a
T2	C1	M1	395.50ab	1072.67b	2189.00b
		M2	475.17a	1223.50a	2604.67a
	C2	M1	508.50b	1283.17b	2749.50a
		M2	597.50a	1469.00a	2545.33a

Means followed by the same letter in a column for M1 and M2 under different time and rate of compost application are not significantly different from each other at P≤0.05 by Duncan Multiple Range Test (DMRT)

WAT = Week after planting
T1- Application before transplanting
C1- 2.5t/ha Compost rate
C2- 5t/ha Compost rate
M1- Surface application
T2- Application after transplanting
M2-Drilling application method

Effects of rate, time and method of compost application on number of branches of Moringa oleifera

As with number of leaves, number of branches also increased progressively in all the treatments for the period of data collection but the lowest number was recorded for the control plants. The mean number of branches at four (4) weeks after transplanting for the plants grown on the plots that received higher compost rate was generally higher than lower compost rate irrespective of time and method of application. At 6WAT, there was an increase in the number of branches of moringa plants from all the compost treatments but lower rate of compost which was applied by drilling method and before transplanting (C1M2T1) gave the highest number of branches. This was followed by higher compost treatment applied after transplanting and by drilling method whereas surface application of lower compost rate at both times of application produced lower number of branches. At 8WAT, the highest number of branches were recorded in the plants grown on the plots that received higher compost rate (5t/ha) by drilling method after transplanting (C2M2T2). Similarly, as observed for the number of leaves, using the same compost rate, drilling method of application performed better than surface application method at different times of application. The same trend was observed at ten (10) and twelve (12) WAT.C2M2T2 also produced the number of branches that was significantly higher than other treatments while control was the lowest (Table 4).

Table 4. Effects of different types of compost rate, time and method of application on the number of branches of *Moringa oleifera* (Lam) planted at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

TREATMENTS	4WAT	6WAT	8WAT	10WAT	12WAT
C1M1T1	46.00b	75.17bc	83.83ab	117.17a	153.67a
C2M1T1	51.50ab	82.33ab	87.50ab	97.17a	151.67a
C1M2T1	62.83a	98.83a	95.00ab	115.67a	177.00a
C2M2T1	64.17a	88.00ab	87.67ab	109.17a	144.67a
C1M1T2	53.83ab	73.17bc	77.17ab	105.67a	122.83a
C2M1T2	61.83a	82.17ab	87.17ab	113.33a	142.33a
C1M2T2	52.33ab	79.83ab	90.00ab	111.00a	149.83a
C2M2T2	64.83a	90.50ab	102.67a	133.67a	175.17a
CONTROL	49.67ab	68.00c	71.83b	103.00a	137.67a

Means followed by the same letter in a column are not significantly different from each other at $P \leq 0.05$ by Duncan Multiple Range Test (DMRT)

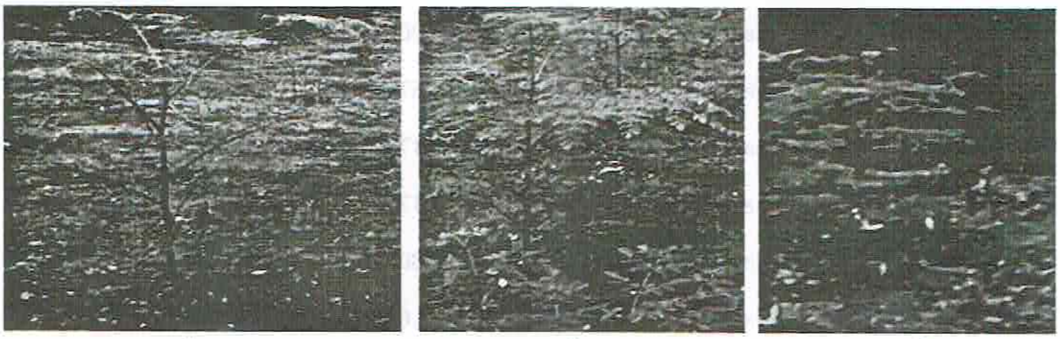
WAT = Week after planting
C1MIT1- 2.5t/ha Compost, Surface application and Before transplanting
C2M1T1- 5t/ha Compost, Surface application and Before transplanting
C1M2T1- 2.5t/ha Compost, Drilling application and Before transplanting
C2M2T1- 5t/ha Compost, Drilling application and Before transplanting
C1M1T2- 2.5t/ha Compost, Surface application and After transplanting
C2M1T2- 5t/ha Compost, Surface application and After transplanting
C1M2T2- 2.5t/ha Compost, Drilling application and After transplanting
C2M2T2- 5t/h Compost, Drilling application and After transplanting

Effects of rate, time and method of compost application on the height of Moringa oleifera

Plant height was enhanced in all the compost treatments compared to control. On plant height, C1M2T1 (2.5t/ha compost applied by drilling before transplanting) and C2M2T2 (5t/ha compost applied by drilling after transplanting) treatments increased plant height at 4WAT more than other compost treatments and control plants were the shortest (Table 5). At 6WAT, there was an increase in plant height in all the treatments, including control but the plants from C1M2T1 were the tallest, followed by those of C2M1T1 (5t/ha, surface application before transplanting) and C2M2T2. Control plants were still the shortest. Similarly, at 8WAT, the plants treated with C1M2T1 were significantly taller than other treatments. However, at 10WAT and 12WAT, plants from C2M2T2 treatment, were the tallest and control plants remained the shortest compared to other treatments (Plate 1).

Effects of rate, time and method of compost application on stem diameter of Moringa oleifera

The stem diameter of moringa plants from C1M2T1, C2M2T1, C1M2T2 and C2M2T treatments were not different from each other at 4WAT (P< 0.05) but at 6WAT, C1M2T1 was significantly different from other treatments while control had the lowest.. At 8WAT, C2M2T2 treatment significantly increased the diameter than other treatments. This was followed by C1M2T1 while others and control were not significantly different from each other. The stem diameter was the same in all the treatments at 10WAT. At 12WAT, C2M2T2 was significantly different from other treatments and had the highest value of stem diameter while the stem diameter of the moringa plants from C1M1T2 and control treatments were the lowest and was not significantly different from each other (Table 6).



A B C

Plate 1. Picture showing the plant height on the plots treated with 5t/ha compost (A), 2.5t/ha compost (B) and Control. (C)

Table 5. Effect of different types of compost, rate, time and method of application on the height (cm) of *Moringa oleifera* (Lam) planted at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

TREATMENTS	4WAT	6WAT	8WAT	10WAT	12WAT
C1M1T1	24.73ab	34.23bc	41.67ab	58.33b	84.80b
C2M1T1	24.93ab	44.03ab	48.53ab	55.30b	83.23b
C1M2T1	29.00a	54.70a	58.93a	63.38b	68.37b
C2M2T1	25.87ab	35.17bc	40.17ab	55.53b	77.30b
C1M1T2	22.43ab	29.70bc	34.03ab	48.35b	71.37b
C2M1T2	26.86ab	35.87bc	41.10ab	59.02b	85.80b
C1M2T2	26.20ab	36.67bc	44.70ab	58.28b	82.53b
C2M2T2	28.86a	40.60ab	47.37ab	70.47a	103.43a
CONTROL	20.27b	27.23c	29.03b	37.77c	63.17a

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by Duncan Multiple Range Test (DMRT)

WAT = Week after planting
C1MIT1- 2.5t/ha Compost, Surface application and Before transplanting
C2M1T1- 5t/ha Compost, Surface application and Before transplanting
C1M2T1- 2.5t/ha Compost, Drilling application and Before transplanting
C2M2T1- 5t/ha Compost, Drilling application and Before transplanting
C1M1T2- 2.5t/ha Compost, Surface application and After transplanting
C2M1T2- 5t/ha Compost, Surface application and After transplanting
C1M2T2- 2.5t/ha Compost, Drilling application and After transplanting
C2M2T2- 5t/h Compost, Drilling application and After transplanting

Table 6. Effect of different types of compost rate, time and method of application on the stem diameter (cm) of *Moringa oleifera* (Lam) planted at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

TREATMENTS	4WAT	6WAT	8WAT	10WAT	12WAT
C1M1T1	0.62ab	0.86ab	0.94b	1.20a	1.51ab
C2M1T1	0.58ab	0.86ab	0.98b	1.21a	1.52ab
C1M2T1	0.69a	0.99a	1.12ab	1.84a	1.64ab
C2M2T1	0.67a	0.89ab	0.97b	1.22a	1.36ab
C1M1T2	0.56ab	0.73bc	0.80b	2.40a	1.23bc
C2M1T2	0.62ab	0.82ab	0.94b	1.18a	1.55ab
C1M2T2	0.63a	0.92ab	0.96b	1.17a	1.49ab
C2M2T2	0.63a	0.92ab	1.43a	1.35a	1.73a
CONTROL	0.49b	0.68c	0.76b	0.98a	1.21c

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by Duncan Multiple Range Test (DMRT)

WAT = Week after planting
C1MIT1- 2.5t/ha Compost, Surface application and Before transplanting
C2M1T1- 5t/ha Compost, Surface application and Before transplanting
C1M2T1- 2.5t/ha Compost, Drilling application and Before transplanting
C2M2T1- 5t/ha Compost, Drilling application and Before transplanting
C1M1T2- 2.5t/ha Compost, Surface application and After transplanting
C2M1T2- 5t/ha Compost, Surface application and After transplanting
C1M2T2- 2.5t/ha Compost, Drilling application and After transplanting
C2M2T2- 5t/h Compost, Drilling application and After transplanting

EFFECTS OF COMPOST RATE, TIME AND METHOD OF APPLICATION ON THE YIELD OF *MORINGA OLEIFERA* LAM.

Effects of rate, time and method of compost on fresh weight of Moringa oleifera

On the fresh weight, soil amendment with compost enhanced fresh weight in moringa production compared to control. Application of 5t/ha after transplanting of moringa seedling using drilling method produced more leaf fresh weight than other treatments while control had the lowest. Similarly, fresh stem weights of moringa plants treated with C2M2T2 was the highest followed by that of C1M2T2 but were not significantly different from each other. The plants from control and C1M1T2 had the lowest fresh weight. The fresh root weight was however, increased in plants treated with C2M1T2 more than the plants from other treatments. In the root, compost addition generally enhanced the formation of branched/adventitious roots compared to control (Plate 2). This was followed by that of C2M2T2. Plants from control and C1M1T2 had the lowest fresh root weight. Overall, total fresh weight was highest in plants treated with C2M2T2 (Table 7).

Table 7. Effects of different types of compost rate, time and method of application on the fresh weight (g) of *Moringa oleifera* (Lam) planted at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

Treatments	Leaf fresh weight(g)	Stem fresh weight (g)	Root fresh weight (g)	Total fresh weight (g)
C1M1T1	100.46ab	104.60ab	223.16ab	428.22b
C2M1T1	85.17b	101.74ab	178.35ab	365.22c
C1M2T1	133.57ab	127.15a	226.00ab	486.72b
C2M2T1	82.13b	72.87b	194.79ab	349.79c
C1M1T2	82.99b	57.29c	148.80c	289.08d
C2M1T2	129.66ab	112.66ab	283.65a	529.97b
C1M2T2	110.82ab	95.33ab	154.59c	360.74c
C2M2T2	142.75a	129.21a	270.69ab	542.65a
CONTROL	77.49b	52.87c	152.31c	287.67d

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by Duncan Multiple Range Test (DMRT)

C1MIT1- 2.5t/ha Compost, Surface application and Before transplanting
C2M1T1- 5t/ha Compost, Surface application and Before transplanting
C1M2T1- 2.5t/ha Compost, Drilling application and Before transplanting
C2M2T1- 5t/ha Compost, Drilling application and Before transplanting
C1M1T2- 2.5t/ha Compost, Surface application and After transplanting
C2M1T2- 5t/ha Compost, Surface application and After transplanting
C1M2T2- 2.5t/ha Compost, Drilling application and After transplanting
C2M2T2- 5t/h Compost, Drilling application and After transplanting

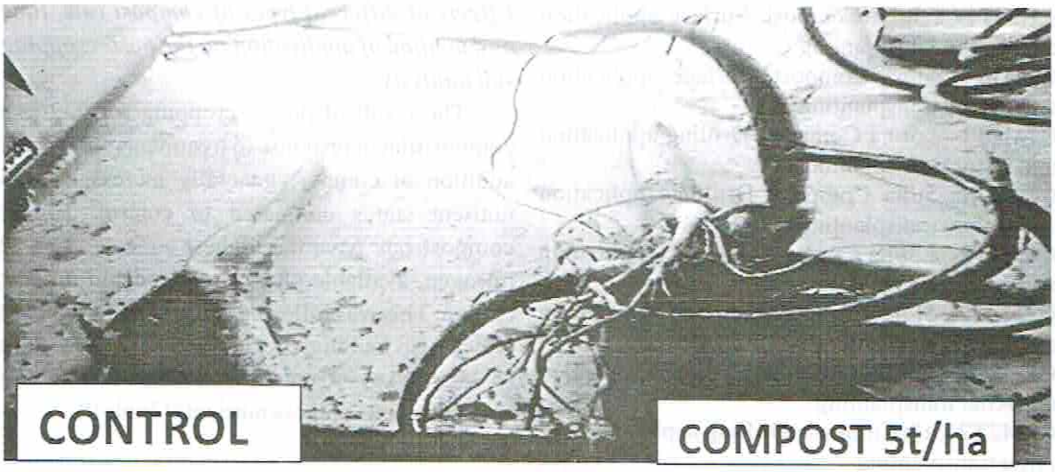


Plate 2. Root of Moringa oleifera from control and compost treatment

Effects of rate, time and method of compost on dry weight of *Moringa oleifera* Lam.

Higher compost rate applied at two weeks after transplanting using drilling method (C2M2T2) increased total dry matter yield of moringa compared to other treatments. This was followed by the same compost rate applied after transplanting but by surface broadcast (C2M1T2). Control had the lowest dry matter yield. On dry matter partitioning, the distribution followed the same trend in all the treatments. It was more in the root than stem and leaf. However, C2M2T2 treatment also gave the highest dry matter yield in the root followed by those of C2M1T2 and C1M2T1. C2M2T2 also had significant effect on the leaves dry weight compared to other treatments. Control reduced the dry matter accumulation in all the plant parts compared to compost treatments (Table 8).

Table 8. Effects of different types of compost rate, time and method of application on the dry matter yield and partitioning in *Moringa oleifera* (Lam) planted at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

Treatments	Leaf dry weight (g)	Stem dry weight (g)	Root dry weight (g)	Total dry weight (g)
C1M1T1	28.88ab	22.78b	54.07b	105.73bc
C2M1T1	23.28b	24.52b	50.88b	98.68bc
C1M2T1	28.39ab	31.03ab	67.29b	126.71b
C2M2T1	20.79b	39.27a	62.15b	122.21b
C1M1T2	22.58b	31.91ab	39.67bc	94.16c
C2M1T2	33.69ab	30.88ab	67.49b	132.06b
C1M2T2	29.38ab	20.19b	49.97b	99.54bc
C2M2T2	38.63a	36.53a	79.09a	154.25a
CONTROL	23.23b	12.84c	24.54c	60.31d

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by Duncan Multiple Range Test (DMRT).

C1MIT1- 2.5t/ha Compost, Surface application and Before transplanting
C2M1T1- 5t/ha Compost, Surface application and Before transplanting
C1M2T1- 2.5t/ha Compost, Drilling application and Before transplanting
C2M2T1- 5t/ha Compost, Drilling application and Before transplanting
C1M1T2- 2.5t/ha Compost, Surface application and After transplanting
C2M1T2- 5t/ha Compost, Surface application and After transplanting
C1M2T2- 2.5t/ha Compost, Drilling application and After transplanting
C2M2T2- 5t/h Compost, Drilling application and After transplanting

Effects of different types of compost rate, time and method of application on the post- cropping soil analysis:

The result of post – cropping soil nutrient composition in response to treatments shows that addition of compost generally increased soil nutrient status compared to control. Higher compost rate gave the highest concentration of nitrogen, available phosphorus and soil organic carbon. This was followed by C1M2T1 treatment which also had high concentration of kotassium (0.33cmol/kg). Control soil had the lowest concentrations of these nutrients (Table 9).

Table 9. Effects of different types of compost rate, time and method of application on the post-cropping soil analysis at the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (2012)

Treatments	Total Nitrogen (%)	Available Phosphorus (mg/kg)	Exchangeable Potassium (cmol/kg)	Organic Carbon (%)
C1M1T1	0.15ab	43.64a	0.15b	1.51ab
C2M1T1	0.18a	38.48ab	0.27a	2.26a
C1M2T1	0.18a	40.74ab	0.33a	2.11a
C2M2T1	0.19a	38.48ab	0.31a	2.09a
C1M1T2	0.18a	34.23b	0.17b	1.74ab
C2M1T2	0.24a	34.62b	0.18b	2.51a
C1M2T2	0.27a	38.63ab	0.26a	2.25a
C2M2T2	0.25a	47.94a	0.26a	2.68a
CONTROL	0.11b	23.81c	0.26a	0.63b

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by Duncan Multiple Range Test (DMRT).

C1MIT1- 2.5t/ha Compost, Surface application and Before transplanting
C2M1T1- 5t/ha Compost, Surface application and Before transplanting
C1M2T1- 2.5t/ha Compost, Drilling application and Before transplanting
C2M2T1- 5t/ha Compost, Drilling application and Before transplanting
C1M1T2- 2.5t/ha Compost, Surface application and After transplanting
C2M1T2- 5t/ha Compost, Surface application and After transplanting
C1M2T2- 2.5t/ha Compost, Drilling application and After transplanting
C2M2T2- 5t/h Compost, Drilling application and After transplanting

DISCUSSION

The differences observed between compost treatments and control could be attributed to the previous findings about the potential benefits of compost in improving soil fertility, water holding capacity of the soil and soil organic matter contents (Akanbi,2002; Phan *et al*., 2002; Blay *et al.*, 2002; Adejumo *et al.*, 2010). The organic matter in the compost according to Stewart *et al,* (2000) acts as a nutrient pool, and enhances nutrient cycling, soil cation exchange capacity (CEC) as well as buffer capacityof the amended soil. Organic matter also contains humic acid (HA) and FA which are nutrient reservoir and have positive and stimulatory effects on crop growth (Serenella *et al*., 2002; Adediran *et al.,* 2006). Plants grown in nutrient-enriched soils have also been reported to accumulate more nutrients than those in nutrient-deficient soils like control plants. Accumulation of essential elements by the Moringa plants from compost treatments probably enhanced the building up of cell constituents which could have contributed to increased dry matter production. Nutrient availability as a result of compost treatments could also have enhanced the formation of photosynthetic pigments, thereby increasing the photosynthetic ability of the compost-treated moringa plants (Hay and Walker, 1989; Murty *et al*., 2005).

The effect of compost amendment on *Moringa oleifera* growth and development, most especially, the development of adventitious roots might also be due to the presence of plant growth hormones, as compost has been reported to contain auxins, gibberellins and cytokinins (Miezah *et al.,* 2008). Auxin is known for its effect on rooting. More importantly, compost has been reported to be the main source of nitrogen (N) and other nutrients supply in organic plant production (Adediran *et al*., 2001). Poor performance of Moringa plant from control treatment corroborates the reports of Aduayi *et al.,* (2002) that most Nigerian soils are deficient in essential nutrients and that for sustainable and improved crop production, soil nutrient status must be improved upon or augmented through the use of organic amendments such as poultry droppings, cow dung, plant residues, municipal wastes and compost. In this study also, low levels of nitrogen, phosphorus and organic contents were observed in the soil used.

Increased number of leaves, number of branches, plant height and stem diameter, as well as fresh and dry matter yield of *Moringa oleifera* in the higher compost rate at 5t/ha and applied by drilling method two weeks after transplanting (C2M2T2) supported the fact that higher compost rate increased soil nutrients more than lower rate (Togun *et al,* 2004; Adejumo *et al*., 2010; Onwudike, 2010). Thus, when nutrients are available at an adequate amount, plants tend to grow at their optimum potential. The poor performance of control plants and those of lower compost rate confirms the findings of Bittenbender *et al*., (1998) that significant reduction in plant growth parameters occurs when soil is low or deficient in nutrients. The increase in dry matter accumulation from higher rate of compost amendments also confirmed the fact that nutrient availability in this soil greatly affects the physiological activities of the plant in terms of increased photosynthetic efficiency of the plants which in turn results in storage and accumulation of dry matter (Eghball *et al., 2002*). By burying the compost in the soil using drilling method either before or after transplanting probably prevented the applied compost from being washed away and so was retained in the soil more than the one applied on the surface. This also contributed to the efficiency of the compost applied using this method over that of the surface method in terms of soil nutrient improvement, plant growth and development. This correlated with the report of Marchesini *et al.*(2008) on the long term effect of quality compost treatments on soil and crop. Application of compost after transplanting which was comparatively better than application before transplanting could be attributed to the fact that part of the released nutrients from compost would have been leached out of the reach of the transplanted moringa root whereas the one applied 2WAT was probably better made available to moringa roots. For example, organic soil matter has no specific binding sites for K, and therefore it is said to be prone to leaching (Mengel, 2007).

Highest dry matter accumulation in the roots from all the treatments confirms the report that during the first year of growth, moringa concentrates more on root development and vegetative growth in preparation for pod formation in the following year. Flowers and pods are said to be produced during the second year of growth (Palada and Chang, 2003). Moreover, moringa plant has also been reported to store most of its food reserve in the root.

CONCLUSION

The total number of leaves, total number of nodes, total number of branches, plant height (cm) and total dry weight (g) are some of the components of growth and yield of *Moringa oleifera*; hence, the higher the values of these components in a harvest, the higher the productivity of the plant. In this experiment, compost amendment enhanced the development of all these yield components in *Moringa oleifera*. It increased both vegetative and dry matter yields of Moringa. The effectiveness of the organic amendment used for the experiment varied with the rate of compost application. Compost rate at 5t/ha^{-1}, using the drilling method and applied two weeks after transplanting significantly increased the vegetative growth and dry matter accumulation of *Moringa oleifera*, and is therefore recommended.

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