ENHANCING THE PRODUCTIVITY *OF MORINGA OLEIFERA* LAM. FOR SUSTAINABLE DEVELOPMENT IN AGROFORESTRY

Williams O.A., Bolanle-Ojo O.T., Ogunwande O.A., Yakubu F.B. and Igboanugo A.B.I.

Department of Sustainable Forest Management, Forestry Research Institute of Nigeria, PMB 5054, Jericho Hill, Ibadan

ABSTRACT: *The study evaluated the effectiveness of NPK (15:15:15), poultry manure, cow dung and green manure of Tithonia diversifolia and Chromolaena odorata leaves on the growth of Moringa oleifera. The experiment was laid out in a Completely Randomized Design (CRD) with 11 treatments replicated 5 times. Data were collected for the growth parameters (height, number of leaves and stem diameter) of the M. oleifera seedlings. It was observed that Moringa seedlings grown on soil treated with 20g of T. diversifolia had significantly ($P \leq 0.05$) higher plant growth parameters than those on soil with the other treatments including the control. Those treated with NPK had similar higher growth parameters comparable to those plants treated with 10g of T. diversifolia and both 10 and 20g of C. odorata. There were also significant differences in the quantities of the manure and NPK applied on the M. oleifera seedlings. This study shows the effectiveness of T. diversifolia and C. odorata as organic manure for improving and enhancing the growth of M. oleifera. Utilization of such weed species component as green manure, compost material or in improved fallow system will help the poor resource farmer to create more sustainable and productive crop yield.*

KEYWORDS: Moringa oleifera, Fertilizer, Green manure, NPK, Agroforestry

INTRODUCTION

Moringa oleifera Lam. belongs to the Moringaceae family and is one of the important traditional multipurpose food plants that is produced and used in many African countries (Amaglo, 2007). Although Moringa is essentially not indigenous to Nigeria, it has become part of the traditional diet in general especially in the Northern parts. *M. oleifera* has gained a lot of popularity due to its usefulness to mankind, resulting in great rate of interest in the plant. Studies have been conducted into the medicinal and nutritional benefits as well as its water purification properties (Sutherland *et al*., 1996; Fuglie, 2001; Anwar and Gilani, 2007). Every part of the Moringa tree is edible and has beneficial properties that can serve humanity (Fahey, 2005), thus the status of *Moringa oleifera* has moved to intensively managed medicinal, culinary and agricultural plants due to its obvious valuable attributes to mankind and environment (NRC, 1992; Emmanuel *et al*., 2011; Anekwe and Mbah, 2014).

M. oleifera has a great potential to become one of the most economically important tree crop for the tropics and subtropics considering its use in many fields varying from nutritional to medicinal, food and fodder for animal feeding (Areghore, 2000; Sarwatt *et al*., 2002; Peixoto *et al*., 2011; Pontual *et a*l., 2012; Egwui *et al*., 2013). Recently, there has been increasing attention and awareness to its importance in agriculture; in that it will not only enhance, improve and empower the economy and health status of the individual farmer and community but would also benefit the ecosystem, improve conservation and biodiversity (NRC, 1993; Faizi *et al.*, 1994a; 1994b; Fuglie, 2000; Mehta *et al*., 2003; Suddhuraju and Becker, 2003; Anwar *et al*., 2005; Fahey, 2005; Rollof *et al*., 2009; Sharma *et al*., 2011; Omotesho *et a*l.,

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2013). The cultivation of *Moringa oleifera* therefore, has basically become a developmental programme centered on the concept of productivity and sustainability

The sustainable utilization of Moringa in Nigeria varies among regions and cultures and has been shown to require controlled harvesting and periodic monitoring of its regeneration. It is therefore imperative that in order to sustainably utilize Moringa, the soil has to be enriched with nutrients for its optimum productivity. This enrichment could be in form of fertilizer application which may be organic or inorganic forms, all of which furnish plants with nutrients necessary for their growth (Bumb *et al*, 1996).

Chromolaena odorata (L.) King & H.E. Robins and *Tithonia diversifolia* (Hemsl.) A. Gray (Common names) are aggressive weeds that are widely spread in Nigeria where they are found growing on abandoned waste/lands, along major roads, water ways and uncultivated farmlands. According to Opeke (1996), *C. odorata* is considered to be a nutrient sink and has potential benefits to the plant/crop as regular source of organic matter and nutrients. *T. diversifolia* has high nitrogen, phosphorous and potassium content with great potential for soil amendment due to its fast rate of decomposition (Jama *et al* 2000).

This study was aimed at evaluating the effects of fertilizer application on *M .oleifera* at early growth stage with a view of maximizing its sustainable productivity and utilization for the medicinal, nutritional, agricultural and industrial purposes.

MATERIALS AND METHODS

Study area

The study was carried out in the green house of the Department of Sustainable Forest Management (SFM), Forestry Research Institute of Nigeria (FRIN), Jericho hill Ibadan, Oyo State, Nigeria. FRIN is located on the latitude $07^0$23'N and longitude $03^0$51'E with the main total rainfall of 1548.9 mm, falling in approximately 90 days. The mean maximum temperature was 31.9^0C, minimum 24.2^0C and the relative humidity was 71.9% (FRIN, 2014).

Soil analysis before planting

Loamy soil used for this experiment was mixed thoroughly and the sample was taken to the laboratory, air-dried and sieved to pass through a 2mm screen for chemical analysis.

Source and preparation of organic fertilizers

Cow and poultry manures were obtained from the livestock unit of Federal College of Forestry, Ibadan, Oyo State while *T. diversifolia* and *C. odorata* leaves were collected from the arboretum of Forestry Research Institute of Nigeria (FRIN), Jericho, Ibadan, Oyo State. The organic materials were processed to allow decomposition. The cow and poultry manure were air-dried and stacked to allow a quick mineralization process. Leaves of *T. diversifolia* and *C. odorata* were also air-dried for two weeks and stacked for mineralization.

Chemical analysis of the organic fertilizers

Two grams from each of the processed forms of the organic materials were analyzed. The nitrogen content was determined by Kjedahl method while the determination of P and K was done using the wet digestion method based on 25-5-5ml of HNO_3-H_2SO_4-$HCIO_4$ acids

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Experimental design and treatments

Fifty-five (55) seedlings (one week old) of uniform heights were used in this experiment. 2 kg of loamy soil was filled inside each polythene pots. The experiment was laid out in a Completely Randomized Design (CRD) in the green house of the Department of Sustainable Forest Management (SFM), FRIN. The experiment was made up of 11 treatments including the control namely; Cow dung (**CD**) 10 g, Cow dung (**CD**) 20 g, Poultry manure (**PO**) 10 g, Poultry manure (**PO**) 20 g, *T. diversifolia* (**TD**) 10 g, *T. diversifolia* (**TD**) 20 g, *C. odorata* (**CO**) 10 g, *C. odorata* (**CO**) 20 g, **N.P.K** 0.5 g, **N.P.K** 1 g and **Control** (loamy soil)

Each treatment was replicated five times. The various fertilizers were thoroughly mixed with the soil (loamy) filled into the polythene bags marked with the different treatments. The polythene bags were then watered daily for three weeks to enhance decomposition. Growth characteristics of *M. oleifera* seedlings under each treatment were monitored and these include total height (cm), collar diameter (mm) and leaves production were taken every two weeks and lasted for the period of 16 weeks.

Data analysis

The data (early growth parameters) collected were then subjected to one-way Analysis of Variance (ANOVA) to compare the effect of the different treatments on the early growth characteristics of *M. oleifera* seedlings. Means found to differ significantly were separated using Duncan Multiple Range Test (DMRT) procedure. Results were summarized in tables and figures.

RESULTS AND DISCUSSION

Table 1: Result of Soil, *T. diversifolia*, *C. odorata*, Cow manure and poultry droppings analysis.

Parameters	Loamy soil	*T. diversifolia*	*C. odorata*	Cow dung	Poultry manure
Nitrogen %	0.1	1.74	1.51	0.9	1.2
K(cmol/g)	16.33	38	30	21	26
P(mg/g)	75.67	441	328.3	273.1	299

Source: Laboratory result (2014)

The results of chemical analysis of organic fertilizers used for the experiment were presented in Table 1. The result shows that *T. diversifolia* has the highest Nitrogen, Potassium and Phosphorus contents followed by *C. odorata* and poultry manure. Cow dung has the lowest content of NPK.

The growth parameters of M. oleifera Seedlings under different fertilizers

There were significant differences ($p \leq 0.05$) in the plant height, collar diameter and leaf production of *M. oleifera* seedlings subjected to the different treatments (Table 2).

Table 2: ANOVA result for effects of fertilizers on the growth of *M. oleifera* seedlings

Parameter Assessed	Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F	Sig.

Height	Fertilizer	10	278.01	2645.19	37.75	0.00*
	Error	44	24664.84	70.07		
	Total	54	130268.7			
Collar diameter	Fertilizer	10	654.38	65.54	67.54	0.00*
	Error	44	341.06	0.97		
	Total	54	2225.1			
Leaves production	Fertilizer	10	2497489.8	249748.98	64.32	0.00*
	Error	44	1366805.39	3882.97		
	Total	54	7636994.05			

significant at ($p\leq0.05$)

Plant Height

The height growth development of *M. oleifera* seedlings for the growth period of 16 weeks is presented in Figure 1. The effects and rates of fertilizer application showed significant differences ($p\leq0.05$) in the seedlings height from 6 weeks till the end of the trial (Fig. 1). *M. oleifera* seedlings grown on soil treated with TD 20g had significantly higher heights than those in the other treatments including the Control. With the exception of those seedlings grown on soil treated with TD 10g, CO 10g and CO 20g, seedling heights of *M. oleifera* on soil treated with NPK 0.5g were significantly higher than those from the other treatments. The height of seedlings grown on soil treated with PO 10g were also significantly higher than those seedlings from PO 20g, NPK 1.0g, CD 20g, CD 10g and the Control. However, the shortest plant heights were obtained from the seedlings grown on soil treated with CD 10g. The result obtained indicated a minimal increase in the seedlings height of all plants under all the treatments from the 2nd to 4th week and a steady increase in the height growth after the 4th week. However, the increase in the height of the seedlings under the Control treatment and CD 10g treatments remained minimal throughout the trial (Fig. 1).

Table 3: Mean separation results for effects of fertilizers on height, collar diameter and leave production of *M. oleifera* seedlings.

Fertilizer	Height (cm)	Collar Diameter (mm)	Leaves Production
CD10g	38.48^{a}	4.87^{a}	150.93^{a}
CD20g	41.67^{ab}	5.34^{b}	178.7^{b}
PO10g	48.83^{c}	6.49^{c}	192.7^{bc}
PO20g	44.29^{b}	6.8^{cd}	188.28^{bc}
TD10g	56.24^{de}	7.85^{e}	237.17^{d}
TD20g	62.04^{f}	8.36^{f}	375.6^{f}
CO10g	55.68^{de}	7.72^{e}	290.07^{e}
CO20g	52.6^{d}	6.49^{c}	301.22^{f}
NPK0.5g	57.57^{e}	7.46^{e}	240.35^{d}
NPK1.0g	42.61^{b}	6.95^{d}	207.28^{c}
CONTROL	40.03^{ab}	4.39^{a}	86.98^{g}

Means followed by the same superscripts in column are not significantly difference ($p\leq0.05$)

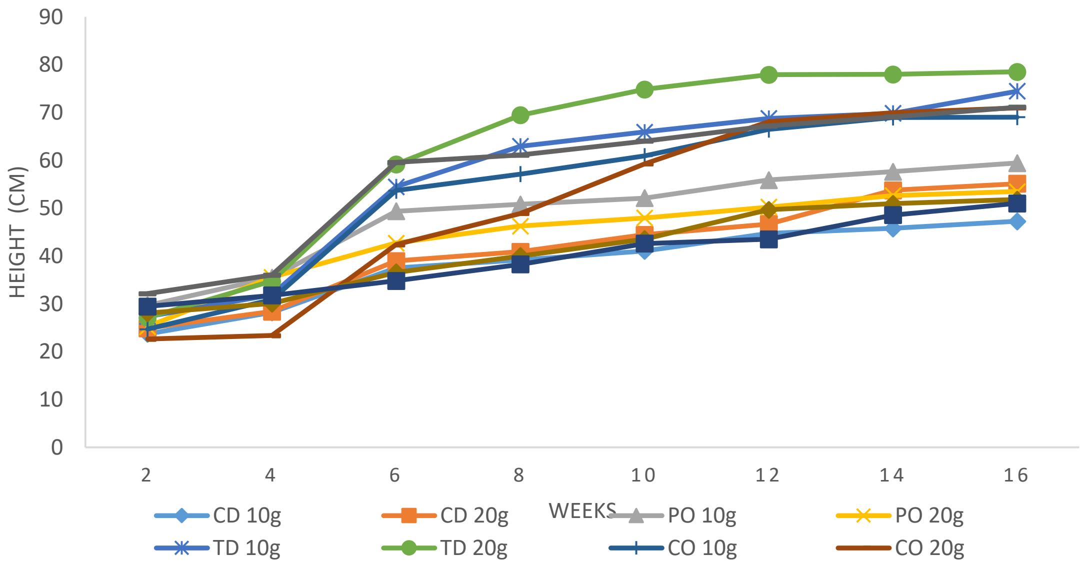

Figure 1: Effects of different fertilizers on height growth of *M. oleifera* seedlings

Higher seedling height values of *M. oleifera* observed on soil treated with by *T. diversifolia*, N.P.K. 0.5g and *C. odorata* (62.04, 57.57 and 56.24) respectively could partly be due to the fact that they contain more appreciable available quantities of nitrogen, responsible for promoting vegetative growth (Swiader *et al.*, 1992 and Panda, 2005).

Lower seedling height values obtained from seedling grown on soil treated with N.P.K 1.0g (42.61) might however, be due to the fact that the nutrient elements were not in mineralized forms hence, not readily available for the plants use. The mean plant growth values of the seedlings treated with TD 20g, N.P.K. 0.5g, TD 10g, CO 10g and CO 20g were 62.04, 57.57, 56.24, 55.68 and 52.60 cm respectively (Table 3) and they showed appreciable growth rates as observed even with the Control (40.03). This generally implies that, the plant is a fast growing species and this confirms the earlier findings of Odee (1998), that *M. oleifera* is a fast growing plant and grows between 6 to 7m per annum even in areas receiving less than 400 mm of rainfall. *M. oleifera* seedlings grown on CO 10g and Control were found not to be significantly different from each other while those on *T. diversifolia* 20g treated soil were significantly different from all the other fertilizers (Table 3).

Plant Collar Diameter

Figure 2 shows the growth development in collar diameter for *M. oleifera* seedlings subjected to different fertilizers for the period of 16 weeks. There was a steady increase in collar diameter of the seedlings grown with the different fertilizers except for seedlings under the Control treatment that had slow development throughout the period of trial (Fig. 2).

The effect of fertilizers showed a significant difference ($p \leq 0.05$) in stem collar diameter of the *M. oleifera* seedlings (Table 2). The collar diameter of *M. oleifera* seedlings grown on soil treated with TD 20g was significantly different from those from the other treatments. However, the collar diameter of seedlings grown on TD 10g were not significantly different from those grown on soil treated with CO 10g and NPK 0.5g but significantly higher than those from the other treatments including the Control.

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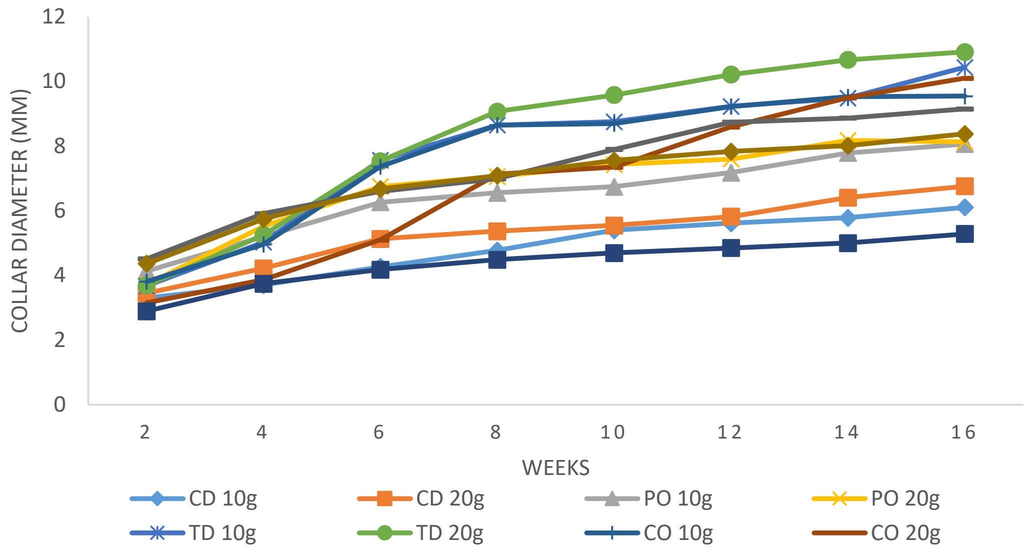

Figure 2: Effect of different fertilizers on the collar diameter growth of *M. oleifera* seedlings

At the 16th week, the stem collar diameter of *M. oleifera* seedlings grown on soil treated with TD 20g recorded the highest value of 8.36 mm followed by those of TD 10g, CO 10g, N.P.K 0.5g, N.P.K. 1.0g, PO 20g, PO 10g, CO 20g, CD 20g, CD 10g and Control (7.85, 7.72, 7.46, 6.95, 6.80, 6.49, 6.49, 5.34, 4.87 and 4.39) respectively (Table 3). The collar stem diameter of seedlings grown on soil treated with NPK 1.0g were similar to those from soil treated with Poultry droppings and CO 20g but significantly different from those from Cow dung and Control. The collar stem diameter of *M. oleifera* seedlings grown on soil treated with CD 20g were also significantly different from those grown on soil treated with CD 10g and Control.

Plant Leaves production

Figure 3 shows the growth in the development of leave production for the period of 16 weeks. Leave production dropped in seedlings grown with TD 20g after 14th week and after 12th week for seedlings grown on soil treated with CD 10 and 20g, PO 10 and 20g, TD 10g, CO 20g and NPK 0.5g. The drop in leave production was observed after 10 weeks with CO 10g and NPK1.0g. However, leave production dropped in seedlings grown under Control treatment after the 6th week (Fig. 3).

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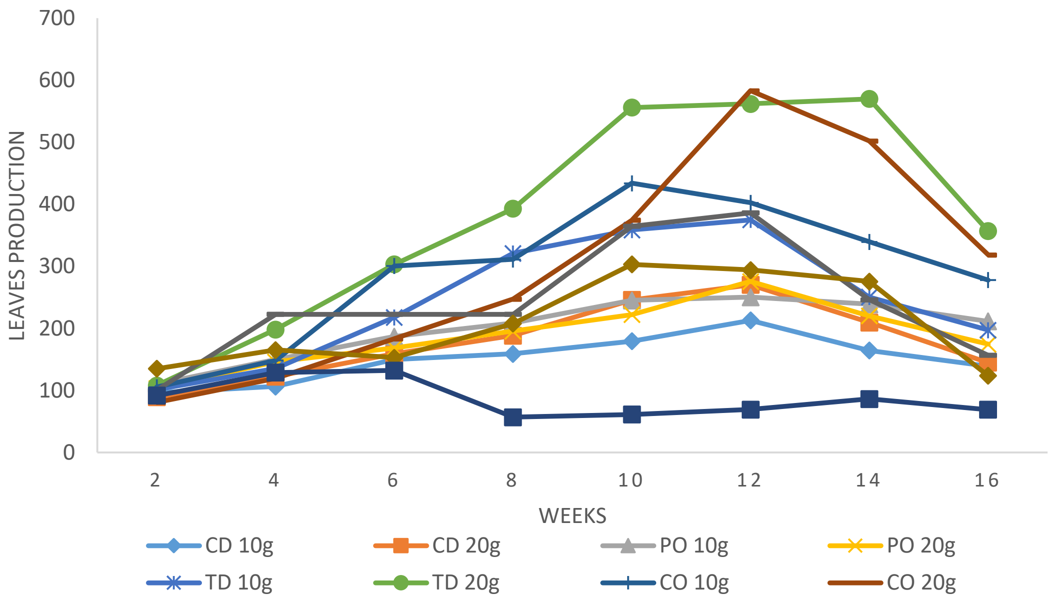

The type and rates of fertilizers applied showed significant differences ($p \leq 0.05$) in leave production (Table 2). With the exception of seedlings from soil treated with CD 20g, leave production by *M. oleifera* seedlings gown on soil treated with TD 20g had significantly higher number of leaves than those from the other treatments. At 12 weeks, TD 20g recorded the highest value (375.6) for leave production followed by CO 20g, CO 10g, N.P.K 0.5g, TD 10g, N.P.K 1.0g, PO 10g, PO 20g, CD 20g, CD 10g and Control (301.2, 29.07 240.35, 237.17, 207.78,192.7, 188.28, 178.76,150.93, 86.9) respectively. *M. oleifera* seedlings grown on soil treated with CD 20g, PO 10g and PO 20g produced leave numbers that were not significantly different from each other. Seedlings grown on soil treated with CO 10g and CO 20g were also found not to be significantly different from each other. Higher number of leaves production recorded in seedlings grown on soil treated with 20g of *T. diversifolia* and *C. odorata* might be due to the higher content of mineral elements present in the organic manure (Table 1)

Fertilizer requirements of species differ, as such, efforts must be made to identify the appropriate fertilizer preference of any species. According to Oni (2001), the inherent characteristics of species and genotypes within species play an important role in restricting efficiency of plants in the uptake, use and tolerance to mineral elements. The different rates of *T. diversifolia* and other fertilizers as manure significantly affected some important morphological traits of *M. oleifera* examined in this study. This could be attributed to the variations in the content of the three essential minerals (NPK) required for optimum plant growth and development. Donahue *et al.*, (1990) reported that nitrogen, phosphorus and potassium are essential for plant growth, particularly at the nursery stage. Aluko and Aduayi (1983), also reported that NPK application increased seedlings height of *Terminalia ivorensis*. Stem diameter and leaves production were equally enhanced by the combination of organic and inorganic fertilizers as reported by (Adebagbo 1981; Aluko, 1989). The application of inorganic fertilizer also affected major morphological characteristics of *M. oleifera*, however, higher rates had lower effect on the seedlings compared to the lower rates. This agrees with the report of Okeke and Omeliko (1997) on the depressive effects of 150 Kg N/ha on the growth of *Dialium guinensis* Wild. seedlings. The result from this study corroborates those of

Aduradola (1998) who reported that application of organic fertilizers had influence on the production of quality tree seedlings.

CONCLUSION AND RECOMMENDATION

This study revealed that the type and rates of fertilizer application influenced the growth and development of *Moringa oleifera* Lam. seedlings in the nursery. Despite the fact that it has been reported that *M. oleifera* does not necessarily require much nutrient or additional fertilizer, it is very obvious from this study that there is the need for soil amendment for maximum production of this species due to its high demand for nutritional and medicinal purposes. It has therefore been observed from the study that *M. oleifera* seedlings may be successfully raised with organic and inorganic fertilizers. Generally in all cases, TD 20g enhanced the growth and development of the plant height, collar diameter and leaf production better than all the other treatments. This study therefore shows the potentials of *T.diversifolia* and *C. odorata* (both weed components) in enhancing the growth and development of *M. oleifera* seedlings.

Further studies are however, required on the use of *T. diversifolia and C. odorata on M. oleifera* plantation either as improved fallow, green manure or as compost material for higher productivity of *M. oleifera* especially in Agroforestry practices. This would help enhance the availability and economical productivity of *M. oleifera* for industrial purposes. The use of such weed components as green manure, compost material or in improved fallow system would reduce dependence on inorganic fertilizers which are not always available and affordable by the poor resource farmers and also reduce the negative effects of inorganic fertilizers thus, improving environmental sustainability. However, quantitative and qualitative analysis of the nutrients composition of the *M. oleifera* leaves harvested from the different fertilizer sources should also be carried out for the effect of fertilizer source on the nutrient composition of such Moringa leaves.

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