Revista Brasileira de Gestão Ambiental e Sustentabilidade (2019): vol. 6, n. 13, p. 549-555.
ISSN 2359-1412
https://doi.org/10.21438/rbgas.061322

Evaluation of different nutritional and soil sources on the early growth of *Moringa oleifera* (Lam.)

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Abstract. In any plantation establishment programme their must be adequate number of healthy seedlings and these depend on the nutrition and care given to them at the nursery stage. Pot experiment was conducted to assess the response of *Moringa oleifera* (Lam.) seedlings to different soil and nutritional sources at nursery stage. One hundred seeds were obtained from Centre for Environmental Renewable Resources Research and Development (CENRAD), Ibadan, Nigeria, and sown in germination trays. Seed germination was completed between 10-15 days, 36 uniformly growing seedlings were transplanted into polythene pots of size 29 cm × 25 cm and were filled with different soil sources at 500 g (arable) soil, forest reserve soil and natural forest mixed with nutritional sources of the same ratio (10 g) i.e. poultry manure, cow dung and NPK (15:15:15). The experiment was factorial arranged in a completely randomized design. Result showed that pots with natural forest soil mixed with 10 m NPK (s_3f_3) produced seedlings with highest value. In plant height (76.30 cm), stem diameter (3.47 mm) and number of branches (10) which was significantly different ($p < 0.01$) from the other treatments. The least value in plant height (30.70 cm) stem diameter (1.50 mm) and number of branches (3.3) were recorded in pots with forest reserve soil mixed with cow dung (s_2f_2). Interaction effect of soil and nutritional sources were significant for all the growth parameters assessed ($p < 0.01$). Natural forest soils treated with NPK (15:15:15) should be employed in raising *Moringa oleifera* seedlings at nursery stage for optimum performance.

Keywords: Moringa; Growth; Nutritional sources; Soil.

Resumo. ***Avaliação de diferentes fontes nutricionais e do solo no crescimento precoce de* Moringa oleifera *(Lam.)***. Em qualquer programa de estabelecimento de plantações, deve haver um número adequado de mudas saudáveis e isso depende da nutrição e dos cuidados que lhes são prestados no estágio do viveiro. Foi conduzido experimento em vaso para avaliar a resposta de mudas de *Moringa oleifera* (Lam.) a diferentes fontes nutricionais e do solo na fase de viveiro. Foram obtidas 100 sementes no Centre for Environmental Renewable Resources Research and Development (CENRAD), Ibadan, Nigéria, e

Received
August 8, 2019

Accepted
August 30, 2019

Available on line
August 31, 2019

Released
August 31, 2019

Open Access

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semeadas em bandejas de germinação. A germinação das sementes foi concluída entre 10 a 15 dias, 36 mudas de crescimento uniforme foram transplantadas em vasos de polietileno de tamanho 29 cm × 25 cm e foram preenchidas com diferentes fontes de solo a 500 g (arável) de solo, solo de reserva florestal e floresta natural misturada com nutrientes fontes da mesma proporção (10 g), isto é, esterco de aves, esterco de vaca e NPK (15:15:15). O experimento foi fatorial arranjado em delineamento inteiramente casualizado. O resultado mostrou que vasos com solo florestal natural misturado com 10 m NPK (s_3f_3) produziram mudas com maior valor. Na altura da planta (76,30 cm), diâmetro do caule (3,47 mm) e número de ramos (10) os resultados foram significativamente diferentes ($p < 0,01$) em comparação aos demais tratamentos. O menor valor em altura da planta (30,70 cm), no diâmetro do caule (1,50 mm) e número de galhos (3,3) foi registrado em vasos com solo de reserva florestal misturado com esterco de vaca (s_2f_2). O efeito da interação do solo e das fontes nutricionais foi significativo para todos os parâmetros de crescimento avaliados ($p < 0,01$). Os solos florestais naturais tratados com NPK (15:15:15) devem ser empregados na criação de mudas de *M. oleifera* no estágio do berçário, para desempenho ideal.

Palavras-chave: Moringa; Crescimento; Fontes nutricionais; Solo.

Introduction

The forest plays an important role in protecting the soil, ameliorating the environment and protecting water resources. Non-timber forest products are very essential in urban and rural life, under which *Moringa oleifera* (Lam.) belong (Leone et al., 2015). *Moringa oleifera* is the most widely cultivated species of the genus *Moringa*, is the only genus in the Family Moringaceae. English common names include moringa, drumstick tree (from the appearance of the long, slender, triangular seed pods), horseradish tree (from the taste of the roots, which resembles horseradish), and ben oil tree, or benzoil tree (from the oil which is derived from the seeds) (Olson, 2010). It is a fast-growing, drought-resistance tree, native to the southern foothills of the Himalayas in the northwestern Indian, and widely cultivated in tropical and subtropical areas where its young seed pods and leaves are used as vegetables. It can also be used for water purification and washing, and is sometimes used in herbal medicine (Torondel et al., 2014).

It has become a clear issue that man cannot sufficiently sustain its existence without adequately improving the level of food and fiber production as raw material for industrial uses. Most tropical soils are deficient in nitrogen and other macronutrients and uptake of these limited quantities of nutrients by plant roots from litters is difficult (Martínez-Sánchez, 2003). Nitrogen allows plants to produce proteins needed to build living tissues for green stems, leaves and strong roots, phosphorus helps move energy throughout the plant while potassium aids plants in adapting sugars needed in growth. Fertilization is the only way to supply nutrients within a short period of time. Adegbidi et al. (2003) reported that the effects of the mixed use of chemical fertilizer and organic matter on the growth of trees and soil fertility vary substantially according to the fertilizer amounts and the organic manure characteristics. The need to investigate the response of

Moringa oleifera to different ratios of inorganic and organic fertilizer application on soil sources is essential as this will determine its optimum growth performance at the nursery stage.

The objective of the study was to investigate the effect of different nutritional and soil sources on early growth of *M. oleifera* so as to find the optimum dose of fertizer for raising quality seedlings.

Materials and method

The experiment was carried out at the West African Hardwood Improvement Project (WAHIP) of the Forestry Research Institute of Nigeria (FRIN), Ibadan (Latitude 7° 3913' and longitude 3° 8628' E. The institute is situated at Jericho Hills, in Ibadan, North West Local Government Area of Oyo State. The climate of the area is tropically dominated by rainfall pattern ranging between 1.400-1.500 mm, average temperature is 30 °C. It has 2 distinct seasons rainy season (April-October) and dry season (November-March) (FRIN, 2015). The black polythene pots were purchased from CENRAD, Ibadan. Cow dung and poultry manure were collected from Federal College of Forestry Teaching and Research Farm Ibadan. NPK (15:15:15) fertilizer was obtained from Centre for Environmental Renewable Resources and Management Development (CENRAD), Jericho, Ibadan. The natural forest soil was collected from FRIN arboretum, forest reserve soil was collected from *Pinus caribea* Morelet plantation FRIN while the cultivated soil used was collected from Federal College of Forestry Ibadan Farm. One hundred *Moringa oleifera* seeds were obtained from CENRAD and sown in germination trays filled with sterilized river sand.

Cow dung and poultry manure were dried, crushed and sieved with 2 mm sieve while the soil samples were also sieved. The same ratio of cow dung, poultry manure and fertilizer (NPK 15:15:15) were measured in grams (10 g) and mixed with the soil samples, each treatment contained the same level of organic and inorganic fertilizers. 10 g of organic fertilizer (cow dung and poultry manure of same ratio), and 10 g of NPK (15:15:15) were weighed in the soil laboratory of Forestry Research Institute of Nigeria. 10 g of cow dung and poultry manure were applied on 36 seedlings, i.e. 18 seedlings contained 10 g of cow dung and 18 seedlings contained 10 g of poultry manure, while 18 seedlings contained 10 g of NPK (15:15:15). Eighteen seedlings were used as control. A total of 72 seedlings were transplanted after four weeks into polythene pots of 29 cm × 25 cm size filled with the different potting mixtures. Watering of the seedlings was done once daily. Seedling height (cm), stem diameter (mm) and number of branches were assessed after 4 weeks for 12 weeks.

Table 1. Laboratory analysis of organic and inorganic fertilizer.

Sample code	N (%)	P (%)	K (%)
Poultry manure	3.47	1.18	1.38
Cow dung	4.06	0.33	0.77
NPK (15:15:15)	15.00	15.00	15.00

Treatment combination

Where (1)	(i)	S_1f_0	-	Arable soil without fertilizer (control)
	(ii)	S_1f_1	-	Arable soil with poultry manure
	(iii)	S_1f_2	-	Arable soil with cowdung
	(iv)	S_1f_3	-	Arable soil with N.P.K (15.15.15)
(2)	(i)	S_2f_0	-	Forest reserve soil without fertilizer (control)
	(ii)	S_2f1	-	Forest reserve soil with poultry manure
	(iii)	S_2f_2	-	Forest reserve soil with cowdung
	(iv)	S_2f_3	-	Forest reserve soil with N.P.K. (15.15.15)
(3)	(i)	S_3f_0	-	Natural Forest soil without fertilizer (control)
	(ii)	S_3f_1	-	Natural Forest soil with poultry manure
	(iii)	S_3f_2	-	Natural Forest soil with cowdung
	(iv)	S_3f_3	-	Natural forest soil with N.P.K (15.15.15)

Data analysis

Analysis of variance was used to analyze the data obtained while least significant difference (LSD) was used to separate the means where significant.

Results and discussion

Table 2 shows that there was no significant difference in stem diameter of the seedlings subjected to various treatments at $P < 0.001$ while NPK (15:15:15) in natural forest soil (S_3F_3) had the highest stem diameter of 4.53 mm. There was a continuous increase in stem diameter across the weeks. This was followed by NPK (15:15:15) in arable soil that had value of 4.28 mm against cowdung in forest reserve soil which had the lowest stem diameter of 1.5 mm across the weeks. This confirms the findings of Waheed et al. (2001) for *Camelia sinensis* that nitrogen containing fertilizers such as NPK had a significant effect on seedling growth parameters. Almeida (1997) had earlier reported that NPK fertilizer gave a positive response in seedling growth of cashew. This also supports the findings of Larcheveque et al. (2011) that chemical fertilizers promote higher growth and root development compared to livestock organic manure in a poplar plantation.

Table 3 revealed that there was no significant difference in the height of Moringa seedlings among the treatments at $P < 0.001$. NPK (15:15:15) in natural forest soil had a height of 89.67 cm ($P < 0.001$), this was achieved due to the increase in the growth rate (height) of *Moringa* across the weeks. This was followed by NPK (15:15:15) in arable soil that had a value of 74.55 cm, the trend was also maintained across the weeks while cowdung in forest reserve soil had the lowest height of 35.74 cm. Similar positive results has been reported by (Hoque et al., 2004) seedling growth was enhanced significantly with the application of NPK fertilizer. Tree seedlings need nutrients to grow, nitrogen for lots of green leaves, phosphorus for new tissues particularly the roots and potassium for seedling vigour.

Table 2. Effect of treatment on stem diameter (mm) of *Moringa oleifera* seedlings*.*

Treatment	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
S_1F_0	1.90	2.06	2.00	2.03	2.17	3.19
S_1F_1	1.93	2.07	1.97	1.97	2.17	3.20
S_1F_2	2.03	2.10	2.00	2.03	2.20	2.84
S_1F_3	2.07	2.20	2.40	2.63	3.17	4.28
S_2F_0	1.97	2.03	0.63	0.63	0.63	1.45
S_2F_1	2.10	2.13	1.97	1.93	2.00	3.17
S_2F_2	2.07	1.40	1.40	1.43	1.50	2.42
S_2F_3	2.03	2.03	0.00	0.00	0.00	0.00
S_3F_0	1.90	2.03	1.40	3.80	1.77	2.85
S_3F_1	2.03	2.07	2.13	2.17	2.60	3.00
S_3F_2	1.90	2.03	2.17	2.22	2.60	3.00
S_3F_3	1.93	2.00	2.07	2.47	3.47	4.53
Mean	1.99	2.01	1.68	1.94	2.02	2.83
Significance	< 0.001***	< 0.001***	< 0.001***	< 0.001***	< 0.001***	< 0.001***
Se±	0.1023	0.1023	0.1023	0.1023	0.1023	0.1023
LSD	0.9105	0.9105	0.9105	0.9105	0.9105	0.9105
C.V. (%)	5.3	5.3	5.3	5.3	5.3	5.3

Where: - WAT= Week after transplanting*** significantly difference ($p < 0.001$).

Table 3: Effect of soil mixture on the height (cm) of *Moringa oleifera* seedlings.

Treatment	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
S_1F_0	32.40	34.50	36.40	37.40	40.00	43.04
S_1F_1	28.40	37.33	41.33	42.33	46.00	54.25
S_1F_2	32.00	36.67	39.50	34.17	46.67	55.80
S_1F_3	40.17	41.33	46.00	54.33	66.67	74.55
S_2F_0	32.33	31.67	11.00	11.67	12.33	15.61
S_2F_1	34.73	33.73	35.17	37.83	42.50	48.72
S_2F_2	24.83	20.67	28.77	30.00	30.67	35.74
S_2F_3	26.33	34.33	0.00	0.00	0.00	0.00
S_3F_0	28.50	31.50	32.17	35.00	36.00	39.50
S_3F_1	34.83	35.57	46.50	50.33	52.33	60.28
S_3F_2	34.50	34.17	42.33	49.33	54.67	64.45
S_3F_3	30.90	32.33	43.33	58.00	73.33	89.67
Mean	31.66	33.81	3.38	37.45	41.74	48.47
significance	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***
Se±	3.638	3.638	3.638	3.638	3.638	3.638
LSD	0.9105	0.9105	0.9105	0.9105	0.9105	0.9105
C.V%	5.3	5.3	5.3	5.3	5.3	5.3

Where: WAT = Week after transplanting***. Significantly difference (< 0.001).

Table 4 shows that there were significant differences in number of branches of *Moringa* seedlings among the treatments at $P < 0.001$. NPK (15:15:15) in natural forest soil (S_3F_3) had the highest value of 10.0. This was achieved due to continuous production in number of branches across the weeks. This was followed by NPK (15:15:15) in arable soil that had the value of 9.7 which was also maintained across the weeks while cowdung in forest reserve soil (S_2F_2) had the lowest value of 3.33 across the weeks. This supports the findings of

Jaenicke (1999) who stated that cowdung contains 0.3% Nitrogen, 0.2% phosphoric acid and 0.1%-0.5% while Ajay (2017) also reported that cowdung is not as rich in nitrogen as many other types of fertilizers. He reported that it has about 8% nitrogen, 2% phosphorus and 1% potassium. These nutrients are also slowly infused into the soil.

Table 4. Effect of soil mixture on number of branches of *Moringa oleifera* seedlings

Treatment	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
S_1F_0	6.00	6.00	5.67	6.33	6.67	6.67
S_1F_1	7.00	6.00	6.33	6.00	6.00	6.00
S_1F_2	5.67	4.67	6.00	7.33	6.67	7.52
S_1F_3	4.00	6.00	8.67	9.67	9.67	10.23
S_2F_0	5.00	2.00	1.33	1.33	1.33	1.33
S_2F_1	6.33	3.67	4.00	5.00	5.33	6.50
S_2F_2	5.67	3.00	3.00	3.67	3.33	3.33
S_2F_3	5.67	4.33	0.00	0.00	0.00	4.33
S_3F_0	5.00	3.67	4.67	4.67	4.00	4.00
S_3F_1	6.67	6.33	7.33	6.67	6.67	6.67
S_3F_2	6.33	7.00	7.00	8.67	8.00	8.00
S_3F_3	6.33	6.33	8.67	10.33	10.00	11.00
Mean	5.81	4.91	5.58	6.17	6.00	6.33
significance	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***
Se±	0.570	0.570	0.570	0.570	0.570	0.570
LSD	2.830	2.830	2.830	2.830	2.830	2.830
C.V%	10.3	10.3	10.3	10.3	10.3	10.3

Where: WAT = week after transplanting*** significantly different ($P < 0.001$).

Conclusion

Based on the findings of these studies, seedlings raised with NPK (15:15:15) mixed with natural forest soil had the highest stem diameter, height and number of branches. Also, there were significant differences in seedlings height, stem diameter and branches at $P < 0.001$, interaction effect among soil and nutritional sources was also significant.

Natural forest soil mixed with NPK (15:15:15) should be used in raising seedlings of *Moringa oleifera* for optimum growth performance since the seedlings presented most noticeable positive influence on seedling growth in the nursery.

Conflicts of interest

Author declares that they have no conflict of interests.

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