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Research Article

Comparative Effects of Different Fertilizer Sources on the Growth and Nutrient Content of Moringa (*Moringa oleifera*) Seedling in a Greenhouse Trial

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A greenhouse experiment was conducted to investigate the effects of NPK, poultry manure, and organomineral fertilizer on the growth and nutrient concentration of *Moringa oleifera* leaves. The experimental design was completely randomized design (CRD) with four treatments replicated three times. Data collected were analysed using descriptive statistics and ANOVA at $P = 0.05$. Growth parameters measured include number of leaves per plant, plant height (cm), and stem girth (mm). The application of poultry manure increased the height, number of leaves, and stem girth of moringa compared to the application of NPK and organomineral fertilizer while the control had the least growth. Poultry manure, NPK, and organomineral fertilizer were 66%, 62%, and 39% higher in number of leaves than the control at eight weeks after planting. The application of poultry manure significantly ($P \leq 0.05$) increased the nutrient content of moringa leaves compared to other sources of fertilizer applied. The results shows that the application of poultry manure significantly ($P \leq 0.05$) improved the growth and nutrient content of moringa; however, further field trial is suggested.

1. Introduction

Moringa oleifera originated from the foothills of the Himalayas in Northwestern India and is cultivated throughout the tropics [1]. Moringa can be cultivated in a wide range of soil types but grow best in well-drained loam to clay loam soil with slightly acidic to neutral pH however, it cannot withstand prolonged water logging. Moringa is very useful in the following areas; as alley cropping, animal forage, biogas, domestic cleaning agent, green manure, gum, medicine, ornamental plants, and water purification. Moringa leaves, seeds, and roots are also use in treating diseases like lung diseases, hypertension and skin infection [2, 3].

Moringa is nutritional and rich in vitamins and minerals. Moringa leaves are the most nutritious part of the plant, being a significant source of vitamin B_6 vitamin C, and provitamin A as beta carotene, magnesium, and calcium [4]. However, Moringa still remains unpopular in Nigeria despite its acclaimed economic values and importance; very little research has been done on this plant, although it is widely used by the rural poor as a food resource [5].

Land degrading is one of the major impediments to agricultural productivity. This is manifested in the loss of soil fertility, desertification, and destruction of the soil structure [6]. Due to the implication of land degradation on agronomic productivity and the environment, it becomes necessary to proffer means to minimize it effects. Ultisols of tropical and subtropical regions occur in old landscapes that have a monsoon climate and are extremely weathered and leached. They have a red, brown, or yellow argillic B horizon with a base saturation of less than 50%. The soils have a low content of organic matter with ferric and hydromorphic properties. These soils are generally of low fertility and are susceptible to erosion [7]. One way to improve soil fertility is the application of fertilizer which obviously is a means required for optimum crop yield.

The use of poultry dungs has been documented to give a better result on soil amendment in degraded ultisols [8]. It has been reported that organic manure can serve as soil amendment to improve soil nutrient status and the growth of crops [9]. Organic base fertilizer such as organomineral fertilizer improves soil structure, reduces erosion, lowers

the temperature at the soil surface, and increases soil water holding capacity [10]. The use of NPK fertilizer has resulted in the improvement of the growth and yield of crops. Due to increasing demand of moringa for biofuel and medicinal uses, it is therefore necessary to investigate ways to improve its growth in degraded soil. This study aimed at the responses of moringa seedling to soil amendment in degraded ultisols of Edo state under a greenhouse condition.

2. Materials and Methods

2.1. Description of Experimental Site. The experiment was conducted at the Teaching and Research Farm of Ambrose Alli University, Emaudo Annex, Ekpoma, in 2012 under greenhouse condition. The area lies between latitude North 6 degrees, 45 minutes, 34 seconds ($6^\circ\ 45'\ 34''$) and longitude East 6 degrees, 8 minutes, 27 seconds ($6^\circ\ 8'\ 27''$ East) with average amount of rainfall 1750 mm.

2.2. Collection of Soil for Analysis. Top soils (0–15 cm) were collected from the farm site; the soils were sieved with a 2 mm mesh to remove gravel and plant roots. The 5 kg polythene bags used for the experiment were filled with the sieved soil.

2.3. Soil Physical and Chemical Analysis. Particle size analysis was carried out using hydrometer method [11]. The pH was determined in water (ratio 1 : 1, soil : water). Organic carbon was determined by wet dichromate method [12] and available phosphorus by Bray extraction method [13]. Total nitrogen was determined by Kjeldahl method. Exchangeable cations (potassium, calcium, and magnesium) were extracted with ammonium acetate. Potassium was determined by flame photometer while calcium and magnesium were determined by atomic absorption spectrophotometer. Copper, zinc, manganese, and iron were also determined [14].

2.4. Experimental Design. The experimental design was a completely randomized design (CRD) with four treatments replicated three times. The treatments were NKP, organomineral fertilizer (OMF), poultry manure, and control.

2.5. Planting Operation. Moringa (*Moringa Oleifera*) seeds were first soaked in water for 24 hours to allow the seeds to absorb the moisture required for sprouting. The seeds were removed from the water, wrapped in a wet towel, and stored in a warm dark place. The towel was kept damp to allow maximum germination and prevent drought. The sprouted seeds were planted two per pot and later thinned to one stand per pot.

2.6. Fertilizer Application. Poultry manure (PM) was applied four weeks before planting at the rate of 100 g per pot; organomineral fertilizer (OMF) was applied two weeks before planting at the rate of 5 g per pot. NPK fertilizer was applied two weeks after planting at the rate of 2 g per pot. Ring application method was used for NPK and OMF while poultry manure was mixed with the soil.

Table 1: Physicochemical properties of soil before planting.

Properties	Results
pH (1 : 1) H_2O	6.20
N (g/kg)	0.40
OC (g/kg)	3.50
P (mg/kg)	14.15
Ca (cmol/kg)	0.88
Mg (cmol/kg)	0.97
K (cmol/kg)	0.17
Na (cmol/kg)	0.73
Mn (mg/g)	63.58
Fe (mg/g)	93.34
Cu (mg/g)	0.57
Zn (mg/g)	4.77
ECEC	3.39
H^+	0.64
Sand	852
Silt	34
Clay	114
Textural class	
Sandy loam.	

2.7. Spacing. The pots were arranged at a distance of 60 cm × 60 cm between and within rows. A total number of 12 pots were used for the experiment.

2.8. Collection of Data. Growth parameters such as plant height, number of leaves, and stem girth were measured at 4, 6, and 8 weeks after planting the sprouted seeds. Moringa leaves were collected for plant nutrient analysis at eight weeks after planting.

3. Results

The soil was moderately acidic with sandy loam texture. The values of the nutrient element were as follows: nitrogen: 0.40 g/kg; phosphorus: 14.15 mg/kg; calcium: 0.88 cmol/kg; magnesium: 0.97 cmol/kg; potassium: 0.17 cmol/kg; sodium: 0.73 cmol/kg. The value of ECEC was 3.39, Mn 63.58 mg/g, Fe 93.34 mg/g, Cu 0.57 mg/g, and Zn 4.77 mg/g (Table 1).

3.1. The Chemical Properties of the Poultry Manure Used for the Experiment. The poultry manure was alkaline with pH of 9.60, high in organic matter and other nutrient elements. The nitrogen (N) value was 3.4 g/kg, available phosphorus (P) was 59.53 mg/kg, calcium was 19.84 cmol/kg., Mg was 1.64 cmol/kg, Na was 14.32 cmol/kg, K was 7.25 cmol/kg, and H^+ which was 0.10 cmol/kg (Table 2).

3.2. Organomineral Fertilizer Analysis. Total nitrogen value was 44.0 g/kg, available phosphorus was 11.0 cmol/kg, and K and Ca were 6.8 cmol/kg and 6.8 cmol/kg, respectively. The value of Na was 0.8 cmol/kg and Mg was 10.8 cmol/kg. Fe value was 8,153.0 mg/kg, Zn was 712.7 mg/kg, Mn was 558.3 mg/kg, and Cu was 247.4 mg/kg (Table 3).

Table 2: Nutrient content of poultry manure.

Parameters	Units	Values
pH		9.60
Organic matter	g/kg	31.2
Total nitrogen	g/kg	3.4
Available phosphorus	mg/kg	59.53
Ca	cmol/kg	19.84
Mg	cmol/kg	1.64
Na	cmol/kg	14.32
K	cmol/kg	7.25
H^+	cmo/kg	0.10

Table 3: Nutrient content of organomineral fertilizer grade A.

Elements	Values
Total nitrogen (g/kg)	44.00
Available phosphorus (mg/kg)	11.00
Exchangeable bases (cmol/kg)	
K	6.80
Na	0.80
Mg	10.80
Ca	6.80
Extractable micronutrients (mg/kg)	
Mn	558.30
Fe	8153.40
Cu	247.40
Zn	712.70

Source: pace setter organomineral fertilizer plant, Ibadan.

Table 4: Responses of moringa height (cm) to different fertilizer applications.

Treatment	Week after sprouting		
	4	6	8
Control	14.50^b	25.00^b	27.50^b
OMF	22.40^a	22.70^b	27.95^b
NPK	22.53^a	48.47^a	59.00^a
Poultry manure	28.10^a	52.80^a	65.47^a

Values followed by different letters under the same column are significantly different using Duncan's multiple range test ($P < 0.05$).

3.3. Growth Parameter of Moringa

3.3.1. Plant Height (cm). Poultry manure consistently and significantly increased the height of moringa compared to other treatments. At six weeks after planting, the height of moringa was significantly ($P < 0.05$) increased with the application of poultry manure (52.8 cm) compared to the application of NPK, organomineral fertilizer. Also at eight weeks after planting, application of poultry manure significantly ($P < 0.05$) increased the height of moringa (65.47 cm) compared to other treatments (Table 4).

3.3.2. Stem Girth (mm). The stem girth of moringa was not significantly different among treatments at four weeks after planting. However, the application of poultry manure and NPK significantly ($P < 0.05$) increased the stem girth of moringa (7.22 mm and 6.90 mm) compared to the application of OMF and control. At eight weeks after planting, the stem girth of moringa was significantly ($P < 0.05$) higher when poultry manure and NPK were applied (8.83 mm and 8.16 mm) compared to OMF application and control (Table 5).

Table 5: Responses of moringa stem girth (mm) to different fertilizer applications.

Treatment	Week after sprouting		
	4	6	8
Control	2.93^a	4.76^b	5.04^b
OMF	3.20^a	3.88^b	4.62^b
NPK	3.16^a	6.90^a	8.16^a
Poultry manure	3.46^a	7.22^a	8.83^a

Values followed by different letters under the same column are significantly different using Duncan's multiple range test ($P < 0.05$).

Table 6: Responses of number of leaves of moringa to different fertilizer applications.

Treatment	Week after sprouting		
	4	6	8
Control	81.00^a	119.00^b	127.00^c
OMF	64.50^a	135.00^b	209.50^b
NPK	99.00^a	307.00^a	336.00^b
Poultry manure	102.66^a	334.33^a	378.33^a

Values followed by different letters under the same column are significantly different using Duncan's multiple range test ($P < 0.05$).

3.3.3. Number of Leaves. Application of fertilizer did not significantly ($P < 0.05$) increase the number of leaves of moringa at four weeks after planting. However, at six weeks after planting, the application of poultry manure and NPK significantly ($P < 0.05$) increased the number of leaves of moringa (334.33 and 307.007) compared to OMF and the control. It was observed that, at eight weeks after planting, poultry manure significantly ($P < 0.05$) increased the number of leaves of moringa (378.33) compared to other treatments (Table 6).

3.3.4. Nutrient Content of Moringa Oleifera Leaves. Nutrient content of *Moringa oleifera* leaves was significantly ($P < 0.05$) influenced by fertilizer application. Poultry manure and NPK significantly ($P < 0.05$) increased the nitrogen content of moringa leaves. Phosphorus, potassium, sodium, and manganese content in moringa leaves were significantly ($P < 0.05$) higher with the application of poultry manure compared to other treatments. OMF application had the highest calcium content with value 2.46 cmol/kg. NPK application increased the values of Cu and Fe content in the leaves of moringa while the control has higher magnesium and zinc (Zn) content compared to other treatments (Table 7).

3.3.5. Correlation Analysis. Positive correlation exists between phosphorus and potassium content at 0.07% and

Table 7: Comparative effect of PM, OMF, and NPK on the nutrient content of moringa.

Treatments	%N (g/kg)	P (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (mg/g)	Mn (mg/g)	Fe (mg/g)	Cu (mg/g)	Zn (mg/g)
Control	2.11^{b}	0.15^{b}	0.87^{b}	0.70^{a}	2.28^{c}	401.08^{c}	100.20^{c}	189.02^{a}	6.61^{b}	36.14^{a}
OMF	2.01^{b}	0.19^{b}	2.46^{a}	0.42^{a}	3.21^{b}	492.14^{b}	115.43^{c}	158.43^{a}	6.04^{b}	10.43^{b}
NPK	3.28^{a}	0.12^{b}	0.94^{b}	0.46^{a}	2.66^{c}	392.18^{c}	392.34^{b}	198.08^{a}	8.31^{a}	17.23^{b}
PM	4.13^{a}	0.26^{a}	0.94^{b}	0.53^{a}	4.78^{a}	563.05^{a}	563.00^{a}	142.17^{a}	8.22^{a}	19.78^{b}
SE	1.70	0.42	1.14	0.73	1.80	21.50	17.11	13.11	2.70	4.57

Values with different letters (a, b, c) are significantly ($P < 0.05$) different using Duncan's multiple range test.

Table 8: Correlation Analysis.

	Nitrogen	Phos	Ca	Mg	K	Na	Mn	Fe	Cu	Zn
Nitrogen	1.00000									
Phos	0.46888 0.5311	1.00000								
Ca	−0.54252 0.4575	0.14043 0.8596	1.00000							
Mg	−0.16828 0.8317	−0.08404 0.9160	−0.61241 0.3876	1.00000						
K	0.73612 0.2639	0.92446 0.0755	0.01274 0.9873	−0.29252 0.7075	1.00000					
Na	0.38993 0.6101	0.98775 0.0123	0.28985 0.7101	−0.20127 0.7987	0.90684 0.0932	1.00000				
Mn	0.99709 0.0029	0.45822 0.5418	−0.49191 0.5081	−0.24219 0.7578	−0.73970 0.2603	0.38919 0.6108	1.00000			
Fe	0.91941 0.0806	0.52196 0.4780	−0.72280 0.0772	0.21886 0.7811	0.68080 0.3192	0.40206 0.5979	0.88698 0.1130	1.00000		
Cu	0.9560 0.0844	0.07557 0.9244	−0.70120 0.2988	−0.11646 0.8835	0.40534 0.5947	−0.01268 0.9873	0.91445 0.0856	0.81420 0.1858	1.00000	
Zn	−0.16598 0.8340	−0.21472 0.7853	−0.67190 0.3281	0.98880 0.0112	−0.38668 0.6133	−0.33474 0.6653	−0.23744 0.7626	0.20113 0.7989	−0.05504 0.9450	1.00000

Significant at 0.001, 0.01, and 0.05.

phosphorus and sodium at 0.01%. The result showed that as phosphorus increases potassium and sodium increases as well. It was also observed that there was positive correlation between the following nutrient elements: nitrogen and iron, calcium and iron, and nitrogen and copper, and between magnesium and zinc at 0.01%. The result shows that as nitrogen and calcium increased, iron content increased correspondingly (Table 8).

4. Discussion

The major limiting factor of crop production in the tropics is the deficiency of soil nutrient resulting from land degradation which affects the growth, nutrient content, and uptake of the plant. Low levels of nitrogen, phosphorus, and organic carbon were observed in the soil used for the experiment and the finding corroborates with the earlier results [15]; they reported that most of Nigerian soil is deficient in nitrogen, phosphorus, and potassium even organic matter. Therefore, a sustainable method of improving the nutritional status of the soil should be employed to enhance the growth and nutrient content of the plant.

The application of NPK (15 : 15 : 15) fertilizer significantly increased the vegetative growth of moringa plant and this finding agreed with earlier work done [16]. It was reported that the application of NPK fertilizer significantly ($P < 0.05$) increased the vegetative growth of moringa which was also observed from the experiment [17].

The application of poultry manure significantly ($P < 0.05$) increased the height, stem girth, and number of leaves (vegetative growth) of moringa. This result corresponded to the earlier finding [18]. It was reported that the application of poultry manure significantly ($P < 0.05$) increased vegetative growth of moringa. This could result from the nutritional benefits of poultry manure which include improvement of soil fertility, structure, water holding capacity, and organic matter. This will reduce the amount of inorganic fertilizers needed for the growth of moringa plant [19]. The effect of compost and other organic amendment on the growth of moringa plant may be the result of the interaction between the nutrient present and growth of moringa, as organic manure has been found to contain auxins, gibberellins, and cytokines [20].

The application of fertilizer significantly ($P < 0.05$) increased the nutrient content of moringa. Poultry manure application increased the P, K, Na, and Mn content of moringa and this result corresponded to earlier work done [21]. It has been reported that the application of organic manure increased the nutrient concentration of arable and other crops [22]. Similarly, NPK application also improved the nutrient content of moringa which has earlier been reported [23]. The improvement of calcium, potassium, and sodium content of moringa by the application of OMF agreed with the work earlier done [24]. It was reported that organic base fertilizer (OMF) improved the nutrient content of arable crops.

5. Conclusion

The comparative effects of NPK, poultry manure, and OMF on growth of moringa seedling and nutrient concentration was investigated. The results of this study show that the application of poultry manure significantly increased the vegetative growth of moringa. Also the nutrient concentration on the leaves of moringa was significantly improved by

amending degraded soil with poultry manure. These results can be investigated further on a field trial.

Conflict of Interests

The authors declared no conflicting interests regarding the publication of this paper.

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