

Effectiveness of *Moringa oleifera* (Lam) as Soil Amendment for the Growth and Yield of *Amaranthus caudatus* L. and *Abelmoschus esculentus* (L.) Moench

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ABSTRACT

Moringa Leaf (ML), Moringa Leaf Petiole (MLP), Gliricidia leaf (GL), Organic Fertiliser and NPK 20:10:10 each at 100 kg N/ha, as well as control (0 kg N/ha) were evaluated on 2 m² field plots for their effects on the growth and yield of *Amaranthus caudatus* and *Abelmoschus esculentus*. The experiment was laid in a randomised complete block design with three replicates. Data on amaranth number of leaves were recorded from 10 plants at 4 weeks after sowing (WAS) while number of leaves of okra were recorded from nine okra plants at 8 WAS. Amaranth Shoot Yield and Okra Pod Yield were recorded per plot. All data were analysed using ANOVA at $\alpha_{0.05}$. The number of leaves of amaranth ranged from nine (control) to 15 (ML) while number of leaves of okra ranged from 21 (control) to 38 (ML). The shoot yield of amaranth from plots treated with ML (9.9 t/ha) and NPK (9.2 t/ha) were similar and significantly higher than production with GL (8.3 t/ha), MLP (7.8 t/ha), organic fertiliser (6.6 t/ha) and control (3.7 t/ha). Similarly, pod yield of okra from plots treated with ML (6.0 t/ha) and NPK (5.9 t/ha) were comparable and significantly higher than for MLP (5.1 t/ha), GL (4.9 t/ha), organic fertiliser (4.5 t/ha) and control (2.6 t/ha). Dry moringa leaf at 100 kg N/ha improved growth and yield performance of amaranth and okra, and could be used as an alternative soil amendment to NPK fertiliser in amaranth and okra production.

Keywords: Moringa leaf , Soil amendment, Amaranth shoot yield, Okra pod yield

Introduction

The major constraint of crop production in sub-Saharan Africa is low soil fertility. Application of mineral fertiliser into the soil leads to soil acidity and underground water pollution while its continuous use leads to soil degradation (Obigbesan, 2015). Akande *et al.* (2010) reported that organic fertiliser sources such as compost, poultry manure and plant residues have been used as alternative to mineral

fertiliser in crop production systems. According to Ojo *et al.* (2008), use of organic fertiliser on tropical soil has several benefits such as addition of new organic matter which reduces surface and underground water pollution, improves soil fertility and increases crop production. Organic fertiliser from plant sources such as moringa leaf extract and seed cake are more friendly to the environment, and sufficient research has not been conducted on

moringa plant parts as sustainable organic fertiliser. *Moringa oleifera* leaves have been reported to have high nitrogen content (Anjorin *et al.*, 2010) and this makes moringa leaves to be a good source of supplementary organic matter in the soil. Earlier, Foidl *et al.* (2001) stated that addition of moringa leaves as manure may correct soil degradation resulting from continuous cultivation and it may also increase efficiency of fertiliser use.

Moringa plant parts have been considered as fertiliser for use in food crop agriculture in few developing countries (Anjorin *et al.*, 2010). Few researchers in Senegal and Kenya have used moringa plant parts as soil amendment and as plant growth enhancer to raise agricultural crops such as black beans, pepper, tomatoes and leafy vegetables. Foidl *et al.* (2001) reported that moringa leaf extract used as plant growth enhancer significantly increased the yield of soya beans, pepper and tomatoes by 39, 48 and 52%, respectively. Also, Fuglie (2001) reported more favourable results in nutrient uptake, growth and yield of leaf and fruit vegetables when moringa seed is applied as soil amendment.

Amaranth and okra are among the best propagated vegetables in terms of their chemical composition and nutritional status (Akanbi and Togun, 2002; Akanbi *et al.*, 2005). Growing of vegetables is a major aspect of horticulture in view of the value of its products, and one of the major constraints to vegetable production is inadequate supply of mineral fertilisers with frequent increase in the price of these fertilisers (Omotosho and Shittu, 2007). As a result of high cost of mineral fertilisers and their adverse effects on tropical soils, there is

need for cheap fertiliser sources that have the ability to provide organic matter and nutrient for tropical soil improvement. However, investigation is needed on moringa leaf blade and leaf petiole as soil amendments to ascertain an effective alternative to expensive mineral fertiliser in amaranth and okra production. The objectives of this study were to:

- (i) Determine the effects of moringa leaf and moringa leaf petiole as soil amendment compared with gliricidia leaf, sunshine organic fertiliser and NPK 20:10:10 in amaranth and okra production, and

Materials and Methods

Experimental location and experimental design

A field experiment was carried out at Parry Road section of the Teaching and Research Farm, University of Ibadan (7° 26'N and 3° 54'E), University of Ibadan in the early cropping season. The experiment involved the cultivation of amaranth and okra as sole crops on separate plots in the same location. The experimental field was laid in a randomised complete block design with test crops as the main plot and treatments as subplots replicated three times. Each plot per treatment was 2 m² while spacing within and between blocks was 1 m.

Experimental treatments and fertiliser application

Composite soil samples were obtained from the field plots at 0-15 cm depth. The soil was analysed for chemical properties using the

method of Udo and Ogunwale (1986). Each plot with the test crops separately received 0.72 kg Moringa Leaf Blade (MLB), 0.95 kg Moringa Leaf Petiole (MLP), 0.75 kg Gliricidia Leaf (GL), 1.42 kg “Sunshine” Organic Fertiliser, 0.1 kg NPK 20:10:10 and control (no fertiliser amendment). The quantity of each fertiliser materials applied was based on 100 kg N/ha (N rate of the test crops). All the organic fertiliser materials were applied in powdered hybrid and local variety were sown at 50 x 50 cm (Akande *et al.*, 2010), and later thinned to one plant per stand at 2 WAS, giving 50 and 15 plants per plot respectively. Weeding of the plots was conducted regularly.

Data on plant height (cm), number of leaves, stem-girth (cm) and leaf area (cm²) were taken from 10 tagged amaranths per plot at 4 WAS. Amaranth fresh shoot yield was determined on 34 tagged amaranths per plot by repeatedly cutting their shoot at 10 cm above soil level at 4, 8 and 12 WAS. However, total amaranth shoot yield was determined by the addition of the three harvests. Furthermore, plant height (cm), number of leaves and stem-girth (cm) were taken from nine tagged okra per plot at 4, 6 and 8 WAS. Okra leaf area (cm²) was determined from four leaves detached from each tagged okra per plot at 8 WAS and then measured with a leaf area meter (model CI-202 portable leaf area meter). Harvesting of fresh okra pods started at 10 WAS and was obtained from nine tagged okra. At five-day intervals, fresh pods were harvested per plot for seven weeks. All the seven harvests were added up to be the total okra pod yield, and calculating the yield in grams per plot to its equivalent in tonnes per hectare. After the harvest, composite

form and then applied a week before sowing of seeds while NPK 20:10:10 was applied using side placement method at two weeks after sowing (WAS) (Akanbi and Togun, 2002).

Planting and Data Collection

Amaranth seeds (local variety) were drilled in 20 x 20 cm (Akanbi and Togun, 2002) while four okra seeds (finger nose variety- cross between

soil samples were collected from amaranth plots at 12 WAS and okra plots at 16 WAS for each treatment within 0 – 15 depth. Thereafter, the soils were analysed for pH in water, N, P, K, Ca and Mg using standard methods reported by Udo and Ogunwale (1986). Soil pH was determined in 1 to 1 soil – water ratio using a glass electrode pH meter. Total soil nitrogen was determined by Kjeldahl digestion method, and available phosphorus was determined by the Bray-1-method. Exchangeable Mg and Ca were determined using ethylene diamine tetra acetic acid (EDTA) while exchangeable K was determined using 1 Normal ammonium acetate.

Statistical analysis

Data collected on amaranth and okra growth and yield parameters were analysed using ANOVA, and Duncan’s Multiple Range Test (DMRT) was used for treatment means separation at 5% probability. However, data on post-planting chemical properties were subjected to least significant difference (LSD) at 5% probability.

Results

Nutrient contents of organic fertiliser materials and experimental soil

In Table 1, Moringa Leaf (ML) had over twice as much N (2.79%) and P (0.42%), four times as much K (1.85%) than commercial organic fertiliser () which had 1.41% N, 0.19% P and 0.44% K. However, the highest K and Ca contents were found in Moringa Leaf Petiole (MLP) and it was higher than ML, organic fertiliser and Gliricidia Leaf (GL). Table 2 shows the nutrient status of soil used for the experiment. Soil pH in water indicated that the soil is slightly acidic. The values of N, P, Ca, Mg, K and Na determined were low when compared with their respective critical levels.

Growth and yield performance of amaranth amended with different fertiliser treatments

At 4 weeks after sowing (WAS), the highest plant height (32.8 cm) and number of leaves (15) obtained from Moringa Leaf (ML) were

respectively comparable with 29.1 cm obtained from Gliricidia Leaf (GL) and 14 leaves obtained from NPK 20:10:10 (Table 3). However, plant height (29.1 cm) and number of leaves (14) obtained from Moringa Leaf Petiole (MLP) were comparable with those from GL (26.6 cm, 14) and NPK 20:10:10 (27 cm, 14). However, stem girth obtained with ML and NPK were highest, and they were significantly higher than organic fertiliser and control. The amaranth leaf area obtained from ML was significantly higher than from other fertiliser treatments (Table 3). Amaranth shoot yield (ASY) obtained from ML and NPK 20:10:10 at 4, 8 and 12 WAS were comparable, and were significantly higher than for the other fertiliser treatments (Table 4). However, total ASY obtained from ML and NPK 20:10:10 were significantly higher than those from MLP, GL, organic fertiliser and control.

Table 1: Nutrient composition of the organic fertiliser materials used in this study

Fertiliser sources	Nutrient Composition (%)				
	N	P	K	Ca	Mg
Moringa Leaf	2.79	0.42	1.85	1.92	0.19
Moringa Petiole	2.10	0.28	2.06	2.23	0.15
Gliricidia Leaf	2.74	0.36	0.72	1.15	0.17
Organic Feritliser	1.41	0.19	0.44	1.08	0.11

Table 2: Pre-trial Soil chemical properties

Soil properties	Values
pH (1:1H ₂ O)	5.2
Total N (g/kg)	0.21
Available P (mg/kg) Bray-P1	2.0
Exchangeable cations (cmol/kg)	
Ca	0.7
Mg	0.2
K	0.05
Na	0.1

Critical level of N = 1.5 – 2.0 g/kg, P = 10 – 15 mg/kg, Ca = 2 – 2.6 cmol/kg, Mg = 0.2 – 0.5 cmol/kg and K = 0.3 – 0.5 cmol/kg.

Growth and yield performance of okra amended with different fertiliser treatments

Okra plants grown with NPK 20:10:10 had the highest plant height at 4, 6 and 8 WAS and they were significantly taller than those obtained for other treatments. At 4 and 6 WAS, the height of okra was comparable among ML, MLP and GL. At 8 WAS, okra height was comparable between ML and MLP as well as MLP and GL (Table 5).

The highest number of leaves was obtained from ML with mean values of approximately 14, 25 and 38 at 4, 6 and 8 WAS, respectively, and the values were significantly higher than for other treatments, except at 4 WAS when MLB and NPK were comparable. At 8 WAS, the leaf area of okra was highest in ML and it was significantly higher than for other treatments. At 4 WAS, there was no significant difference between okra stem girth of ML and NPK while at 6 and 8 WAS, stem girth with ML was significantly higher than for the other treatments (Table 5).

At 12 WAS, fresh pod yield harvested from ML were comparable with that of NPK 20:10:10, and they were significantly higher than other treatments (Table 6). Total pod yield harvested from okra grown with ML and NPK 20:10:10 were comparable and significantly higher than for other treatments. However, total pod yield obtained from okra grown with MLP and GL as well as GL and ORGANIC FERTILISER were comparable (Table 6).

Post-planting chemical analysis

The pH values recorded on amaranth and okra plots under organic fertiliser treatments showed that the pH was slightly acidic while control and NPK were acidic in water and strongly acidic in potassium chloride (Table 7). All the values observed in all the treatment plots for Ca and Mg showed that all the nutrient elements were low compared with their respective critical level. However, K values obtained at ML and MLP plots were within the critical level of 0.3 – 0.5 cmol/kg K. Nitrogen and Phosphorus contents under control and NPK 20:10:10 plot were very low while moringa leaf petiole and organic fertiliser plots contain N and P that were moderately low when compared with N and P critical levels. Under ML plots, N, P, Ca, Mg and K contents were significantly ($P < 0.05$) higher than N, P, Ca, Mg and K contents recorded in NPK 20:10:10, organic fertiliser and control plots (Table 7).

Table 3: Effects of fertiliser treatments on amaranth growth parameters at 4 weeks after sowing (WAS)

Treatment	Plant height (cm)	Stem-girth (cm)	Number of leaves	Leaf-area/plant (cm ²)
Control	19.3d	0.3c	8.9d	14.9e
Moringa Leaf	32.8a	1.2a	14.9a	53.4a
Moringa Leaf Petiole	26.6bc	1.1a	13.9b	35.0d
Gliricidia Leaf	29.1ab	1.1a	14.3ab	42.3c
Organic Fertiliser	24.0c	0.7b	12.8c	30.8d
NPK 20:10:10	27.0bc	1.2a	14.4ab	46.9b

Means with the same letter(s) in the column are not significantly different using DMRT.

Table 4: Amaranth shoot yield harvested at successive weeks after sowing (WAS)

Treatment	4 WAS	8WAS	12WAS	Total shoot yield (g/plot)	Total shoot yield (t/ha)
Control	198.2d	285.8d	256.5d	740.5d	3.7d
Moringa Leaf	584.9a	759.2a	646.1a	1,980.2a	9.9a
Moringa Leaf Petiole	440.5b	591.7b	527.8b	1,560b	7.8b
Gliricidia Leaf	767.9b	636.4b	555.7b	1,660b	8.3b
Organic Fertiliser	354.8c	509.5c	456.3c	1,320.6c	6.6c
NPK 20:10:10	576.3a	724.5a	603.1a	1,840.9a	9.2a

Means with the same letter(s) in the column are not significantly different (P<0.05) using DMRT.

Table 5: Effects of fertiliser treatments on growth performance of okra at successive weeks after sowing

Treatment	Plant height (cm)			Number of leaves			Stem girth (cm)			Leaf area (cm ²)
	4	6	8	4	6	8	4	6	8	
Control	15.6d	36.7e	66.6e	9.2d	14.7e	20.8e	0.9d	1.6e	2.3e	338.7f
Moringa Leaf	22.7b	59.6b	102.4b	13.5a	24.6a	37.8a	1.7a	2.7a	3.9a	657.9a
Moringa Leaf Petiole	20.7b	57.0bc	98.6bc	11.9b	20.9c	31.1c	1.5bc	2.4bc	3.5bc	549.7c
Gliricidia Leaf	21.6b	56.4b	93.3c	11.6bc	20.7c	29.9c	1.5bc	2.3cd	3.4c	524.1d
Organic Fertiliser	18.8c	54.1d	79.8d	10.7c	19.2d	27.6d	1.4c	2.2d	3.2d	474.3e
NPK 20:10:10	26.3a	66.2a	116.7a	12.5ab	22.7b	33.7b	1.6ab	2.5b	3.6b	623.6b

Means with the same letter (s) in the column are not significant (P<0.05) using DMRT. WAS = Weeks After Sowing.

Table 6: Effects of fertiliser treatments on okra pod yield

Treatment	Fresh-pod yield (g/plot) at 12 WAS	Total pod yield (g/plot) at 15 WAS	Total pod yield (t/ha)
Control	109.8d	520.9d	2.6d
Moringa Leaf	239.1a	1,210a	6.0a
Moringa Leaf Petiole	184.3b	1,030.8b	5.1b
Gliricidia Leaf	177.1c	980.8b	4.9bc
Organic Fertiliser	160.4c	890c	4.5c
NPK 20:10:10	234.2a	1,200a	5.9a

Means with the same letter (s) in the column are not significantly different ($P < 0.05$) using DMRT. WAS = Weeks After Sowing.

Table 7: Post-planting chemical properties of soil collected from amaranth plots at 12 WAS and okra plots at 16 WAS

Treatment	pH (1:1 H ₂ O)	pH (1:1 KCl)	N (g/kg)	P (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)
Amaranth plot							
Control	5.6	4.1	0.09	1.2	0.09	0.02	0.02
Moringa Leaf	6.4	6.0	1.61	14.4	0.22	0.10	0.35
Moringa Leaf Petiole	6.9	5.7	1.37	9.7	0.26	0.07	0.38
Gliricidia Leaf	6.5	5.5	1.40	11.5	0.17	0.09	0.24
Organic Fertiliser	6.3	5.5	1.12	8.0	0.11	0.05	0.16
NPK 20:10:10	5.1	3.6	0.59	7.1	0.10	0.03	0.13
LSD (0.05)	0.6	1.0	0.57	4.5	0.08	0.03	0.13
Okra plot							
Control	5.4	3.9	0.05	1.0	0.06	0.01	0.01
Moringa Leaf	6.2	5.8	1.50	12.7	0.14	0.05	0.30
Moringa Leaf Petiole	6.3	5.7	1.10	8.3	0.18	0.04	0.31
Gliricidia Leaf	6.2	5.8	1.15	10.4	0.10	0.04	0.20
Organic Fertiliser	6.1	5.6	1.07	6.9	0.09	0.03	0.18
NPK 20:10:10	5.0	3.2	0.48	5.3	0.08	0.01	0.12
LSD (0.05)	0.5	1.1	0.52	4.0	0.05	0.01	0.10

WAS= Weeks After Sowing; Critical levels of N = 1.5 – 2.0 g/kg, P = 10 – 15 mg/kg, Ca = 2 – 2.6 cmol/kg, Mg = 0.2 – 0.5 cmol/kg and K = 0.3 – 0.5 cmol/kg

Discussion

It is evident in this study that high nutrient content found in moringa leaf and its nutrient release into the soil improve soil pH from 5.2 to 6.4 and increase residual N, P and K of the experimental plots seven times from initial values obtained before cropping. These findings support the result of Morafa (2007) on performance of gliricidia leaf over *Chromoleana odorata* and mineral fertiliser in cassava-maize intercrop. However, Morafa (2007) also reported that Gliricidia leaf treatment improved soil pH and increased residual nutrient elements more than in mineral fertiliser and *Chromoleana odorata* plots. Application of moringa leaf on degraded acidic soil brings about an increase in calcium and potassium contents of the soil after first cropping.

High contents of calcium and potassium in a soil have the ability to stabilise soil pH by neutralising acid content present in the soil (Wang *et al.*, 2019). The improvement in soil pH as a result of low concentration of acid in the soil could be the reason nutrients released from moringa leaf increase yield of amaranth and okra than other treatments. This statement is in line with the report of Kekong *et al.* (2016) that moringa leaf has a positive effect on soil pH and a higher impact in the yield of garden egg. On the field, significant reduction in number of leaves of amaranth and okra, leaf area and stem girth resulted to low yield recorded in control and commercial organic fertiliser plots. This is in line with the result obtained by Osumah (2010) in the reduction of amaranth and okra leaf biomass produced with human urine-water dilution ratio (1:6) which

resulted in low yield due to low nutrient supply from the treatment plots. However, the highest amaranth fresh biomass yields were recorded at moringa leaf plots. The highest values of amaranth fresh matter yield obtained from plots treated with moringa leaf could be as a result of the effects of N, P and K on amaranth nutrient uptake together with efficient use of nutrients and water in the soil by the amaranth.

Nitrogen effect is expected since it is an important constituent of leaf formation and development (Osumah *et al.*, 2011), while potassium helps in translocation of end products of photosynthesis to reproductive site (Omotosho and Shittu, 2007). Higher leaf biomass produced during the growth of okra could be responsible for the highest fresh pod yield per plots obtained from okra grown with moringa leaf at 12 weeks after sowing. The high fruit yield obtained from okra plants could be as a result of assimilate produced in the leaf during photosynthesis and better translocation of the assimilate from plant leaves to the reproductive site.

Moringa leaf could also be used to support long duration crops such as cassava in their early stage of establishment as a result of its fast decomposition with high macronutrient elements and organic matter release into the soil (Foidl *et al.*, 2001). The statement of Foidl *et al.* (2001) is in accordance with fast decomposition and steady increase of nitrogen, phosphorus and potassium release from moringa leaf blade observed in this study. This is in line with the report of Morafa (2007), which stated that plant materials of high N content such as *Gliricidia sepium*, support cassava in their early stages of growth due to its

steady decomposition rate and release of nutrient elements into the soil.

Furthermore, moringa leaf increased amaranth shoot yield and okra pod yield by over 50%, 25% and 15% when compared with control, commercial organic fertiliser and gliricidia leaf respectively as a result of steady release of nitrogen, phosphorus and potassium from fast decomposing moringa leaf. Similar observations were reported by Foidl *et al.* (2001) on tomato and pepper when moringa leaf extract was used as growth enhancer. Effects of moringa leaf blade on growth and yield of amaranth and okra therefore were significantly superior over commercial commercial organic fertiliser and gliricidia leaf. This confirms the potential of *Moringa oleifera* as organic fertiliser in amaranth and okra production.

Conclusions

This work has clearly showed that Moringa leaf with over twice as much N (2.79 %), four times as much K (1.85 %) and P (0.42 %) as the commercial “Sunshine” organic fertiliser with 1.41 % N, 0.44 % K and 0.19% P is a good organic fertiliser for amendment of infertile soils. The order of yield performance is moringa leaf > NPK fertilizer > gliricidia leaf > commercial “Sunshine” organic fertiliser. This confirms the superiority of moringa leaf over NPK fertiliser, gliricidia leaf and “Sunshine organic fertiliser”. Dry moringa leaf blade at the rate of 100 kg N/ha could be recommended as an soil amendmdent for improved yield and soil management alongside or as an alternative soil amendment to NPK fertiliser and

commercial organic fertiliser in amaranth and okra production.

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