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Research Paper

Comparative assessment of effect of *Moringa* extracts, NPK fertilizer and poultry manure on soil properties and growth performance of *Solanium menlongina* in Abuja, North Central Region of Nigeria

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Abstract. The study was conducted to evaluate the effects of *Moringa oleifera* extracts, NPK fertilizer and Poultry manure on soil properties and growth performance of *Solanium melongena* in the Giri area of Federal Capital Territory, Abuja, Nigeria. Randomized Complete Block Design with 3 replicates was used. Data collected include pre- planting composite soil analysis, post harvest soil analyses, height per plant, number of fruits per plant, number of branches per plant and fruit yield. In the 2 years of the experiment, application of the *Moringa* extracts on the soil properties and growth performance of *S. melongen*a was significant. Soil pH was improved from 5.4 to 6.7 with application of *Moringa* extracts. In both 2012 and 2013, highest fruit yields (9.5 t ha $^{-1}$ in 2013 and 10.5 t ha $^{-1}$ in 2013) were obtained from stands of garden egg that received *Moringa* leaf extract combined with NPK fertilizer applied at the rate of 100 kg ha^{-1}. The yield of the crop was also improved by application of poultry manure though not significantly different from those given the solution obtained by soaking the bark and cut branches of *Moringa* stands. In all, the poorest results were obtained from the control plots.

Keywords: Comparative, *Moringa oleifera,* extract, poultry manure, decoction, NPK fertilizer.

INTRODUCTION

Farmers in the Federal Capital Territory especially in Giri, Gwagwalada, Mpempe and Kuje Area Councils respect-tively, grow *Solanium melongena* as one of their Principal crops. Giri junction as it is called, located along Zuba/Lokoga road, is a very popular garden egg market. Garden egg Merchants from far Northern zone of the country including Plateau and Bauchi States bring metric tons of fruits of garden egg varieties (deep green and yellow with white stripes) that are not grown in the north central ecological zone to Giri junction, Abuja and in return go back with the fruits of the variety (pure white) that is predominantly grown in this zone. This transaction, more than fifteen years old, is usually at its peak between August and October when the plants are at their very best. Ubani et al. (2011) had earlier indicated that there are many varieties of garden egg, each variety is peculiar to the locality where it is cultivated. The main variety of garden egg being grown by farmers in Giri area is the white variety. The garden egg stand grows in a manner much like tomatoes, hanging from the branches of the plant about 50 to 70 cm or more above the soil. The fruits are round in shape and contain numerous small, soft seeds which are edible. Its characteristic pure and dazzling white colour is an attraction to buyers especially travellers from the northern part of the country to its southern part. In recent times, farmers in the north central Nigeria have been making concerted effort to grow on commercial basis the deep green and the yellow with white stripe varieties either in place of or alongside the white variety. Ironically residents of Federal Capital Territory

(FCT), Abuja prefer the green and yellow with white striped varieties to the white variety that is grown in this area (Anyaegbu et al., 2013). Unfortunately they are being confronted by a number of problems, including lack of capital, high cost of inputs such as fertilizers, herbicides and high cost of labour due to the introduction of the Universal Basic Education in the areas (Anyaegbu et al., 2013). Anyaegbu et al. (2013) also reported that while 20% of the farmer's expenditure goes into purchase of inorganic fertilizers, 15% goes into weed control and other soil attendant problems.

The dependency on the use of inorganic fertilizers as a source of plant nutrients by farmers and their high cost is further associated with land and soil degradation and environmental pollution (Phiri, 2010). Thus, effort is being made by the Federal Ministry of Agriculture and other relevant Agencies to provide alternative safe natural sources of plant nutrients. *Moringa oleifera* is one of such alternative, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (Phiri, 2010). Moreover, several re-searches have indicated that *M. oleifera* Lam (family: Moringaceae) is a highly valued plant with multipurpose effects (Yang et al., 2006; Anwar et al., 2007; Adebayo et al., 2011; Moyo et al., 2011; Mishra et al., 2011).

Although extracts from parts of the plant are known to possess diverse medicinal and biological activity on human and animals which gave it the name "miracle plant", little is known scientifically about its effect as a bio-organic fertilizer on the hormonal, metabolic and antioxidant potential on plants. Few trials on the use of its extracts as organic fertilizer have shown significant results, (Anyaegbu et al., 2013; Emmanuel et al., 2011). Fortunately, the plant is widely distributed and abundant in FCT, Abuja and with its fast rate of growth, it will be readily available to the farmers for the extracts as organic fertilizer.

This study is therefore designed to assess comparatively, the effect of *M. oleifera* extracts and different fertilizers on the yield and yield components of garden egg and to determine how the soil properties would be influenced with the application of *M. oleifera* extracts.

MATERIALS AND METHODS

The study, an on-farm trial, was conducted at Giri, Abuja (8° 21′ N; 6° 25′ E), Nigeria in 2012 and 2013, respectively. Giri, during the planting season had an average temperature of 33°C, 14% humidity, and annual rainfall range of 1300 to 1600 mm. The experimental site was under one year fallow following *Zea mays* sole cropping.

In the first year, the experimental site was cleared manually and the experimental layout (23.5 m × 7 m) of Randomized Complete Block Design (RCBD) with 3 replications was established. Each replicate contained 8 plots and each plot measured 2.5 m × 2 m. Thus a total of 24 experimental plots were used in the study. Prior to planting, soil samples for proximate soil analysis to determine the nutrient status of the soil was collected within 0 to 15 cm depth. After harvest, soil samples were taken within 0 to 15 cm and 15 to 30 cm to assess the effect of the *Moringa* extracts on soil properties. Each of the composite soil samples was air-dried and sieved through a 2 mm mesh before the chemical analysis (Table 2). Soil pH was determined at the ratio of 1:1 in distilled water. The pH in 1M KCL solution was also determined.

Garden egg seedlings were raised in the nursery prior to the period of planting. Planting was done at the first week of April and the planting spacing was 50 cm × 50 cm, giving a population of 40,000 stands per hectare. Each plot contained 30 stands of garden egg.

The experimental treatments of which effects were estimated include N.P.K (20:10:10) 200 kg ha^{-1}, Aqueous solution of *Moringa* leaves and twigs, Aqueous solution of *Moringa* leaves + N.P.K. (20:10:10), 100 kg ha^{-1}, Solid extracts of *Moringa* leaves and twigs, Solid extract + NPK fertilizer (100 kg ha^{-1}), Solution from soaked *Moringa* barks and cut branches, poultry manure (5 t ha^{-1}) as recommended by Anyaegbu (2008) and the control.

The aqueous solution of *Moringa* leaves and twigs was prepared by pounding measured quantity of *Moringa* leaves and twigs in a mortar. For each bundle of 2 kg crushed, 20 L of water was poured into it, stirred properly for about 5 min, allowed to stay for 30 min and then filtered by placing in a pot and wringing out the liquid. The solid substance left after filtration was also kept as experimental treatment (solid extract). For the bark and cut branches decoction, the pilled barks and the branches of the plant (4 kg) were cut into smaller bits, put into a plastic basin and water was poured on to it. The soaking was allowed to stay for 48 h before it was poured out and used for application.

Treatment application was done accordingly. For the plots that received *Moringa* based treatment, application started the moment the *Solanium* seedlings established in the field. For plants that received poultry manure, application was done 4 days before planting to allow the manure to set properly. For foliar application, the aqueous extract of the leaves and twigs was sprayed directly on the entire plant from the tip to the entire basal region. 25 ml of the aqueous solution was sprayed per plant every two weeks. For the stands that received a combination of aqueous solution and 100 kg ha^{-1} NPK (20:10:10), the chemical fertilizer was first applied to them two weeks after transplanting and then 25 ml of the aqueous solution of the *Moringa* leaves and twigs was applied per plant two weeks after fertilizer application and during flower initiation. For the stands that were treated

Table 1. Analysis of garden egg fruits.

Nutrients	Value
Carbohydrate	5.7 g
Sugar	2.35 g
Fat	0.19
Protein	0.01
Vitamin B6	0.084 mg (6%)
Vitamin C	2.2 mg (4%)
Calcium	9 mg (1%)
Manganese	0.35 mg (13%)
Iron	0.24 mg (2%)
Phosphorous	25 mg (4%)

Table 2. Analysis of parts of *Moringa oleifera* per 100 g.

Components	Fresh leaves	Bark powder
Moisture (%)	75.0	45.4
Calories	92	35
Protein (g)	6.7	5.8
Fat (g)	1.7	0.8
Carbohydrate (g)	13.7	5.3
Fiber (g)	0.9	23.3
Ca (mg)	440	1,221
Cu (mg)	1.1	0.87
Fe (mg)	7.0	19.8
K (mg)	259	456
Mg (mg)	24	25
P (mg)	70	136
S (mg)	137	23

Table 3. Chemical properties of the poultry manure used for the study.

Element	Percentage (%)
Magnesium	1.95
Calcium	6.96
Sodium	0.62
Phosphorous	1.30
Nitrogen	1.37
Potassium	0.52
Organic carbon	27.15
Organic matter	50.53
Carbon – nitrogen ratio	19.81

with the solution extracted by soaking of the bark and cut branches of *Moringa* stands for 48 h, 25 ml was poured directly at the base of each plant at 2 weeks interval. When combined with 100 kg N.P.K (20:10:10), the fertilizer was first applied two weeks after transplanting and then the solution was applied to the plants two weeks after fertilizer application and during flower initiation. In solid leaf extract application, each plant received a heap of the extract around it, 2 cm away from the base of the plant and in 10 cm radius. The process was repeated during flower initiation. In combination with NPK fertilizer application (100 kg ha^{-1}), the fertilizer was applied weeks after transplanting and the solid leaf extract was applied three weeks after fertilizer application and during flower initiation. In control plots, no application was done. Weeding was done manually.

Table 4. Pre-planting soil physico-chemical properties of the experimental site in 2012 and 2013 before planting.

Parameters	Value
pH in water (1:2.5)	5.4
%Organic matter	0.55
%Nitrogen	0.41
P (Cmol kg^{-1})	6.20
K (Cmol kg^{-1})	0.45
Ca (Cm0l kg^{-1})	0.48
Mg (Cmol kg^{-1})	2.15
Na (Cmol kg^{-1})	1.14
Clay (%)	28.5
Silt (%)	14.3

Data collected include, pre- planting composite soil analysis, post harvest soil analysis, height per plant, number of fruits per plant, number of branches per plant and fruit yield.

Data were assessed by analysis of variance (ANOVA) for a Randomized Complete Block Design (RCBD), Xij = μ + Ti + βi + €ij, where, Xij = Trial SS, μ = population mean = 0, Ti = Experimental Treatment effect, βi = Block effect and €ij = Error term. Treatment means were separated and compared by the use of Duncans Multiple Range Test (DMRT). Results of parameters were presented in form of Tables.

RESULTS AND DISCUSSION

Table 1 shows the mineral content of *S. melongena* and Table 2, the mineral contents of *M. oleifera* parts. From the analyses, there is an indication that both the leaves and the bark of *Moringa* have high content of macro- and micro-elements apart from the carbon and hydrogen component of the organic matter. It is worthy to note that its mineral content in both micro and macro nutrients seems to be greater than that of the poultry (Tables 2 and 3).

The pre-planting composite soil analysis is shown in Table 4 while the post harvest soil analyses for 2012 and 2013 are shown in Tables 4 and 5. Basically from the pre-planting and post harvest soil analyses, the results as compared with the control indicates an increase in the fertility status of the soil due to the application of *Moringa*

Table 5. Soil physico-chemical properties of the experimental site as influenced by *Moringa oleifera* liquid and solid extracts, 2012.

Experimental	Parameters % (Cmol kg $^{-1}$)									
	PH	N	P	K	Ca	Mg	Na	OM	Clay	Silt
Treatments										
Aqueous leave extracts	6.3	0.52	7.9	0.52	0.61	2.40	0.71	0.54	28.5	14.3
Aqueous leave extract + 100 kg NPK	6.1	0.65	9.8	0.61	0.62	2.40	0.72	0.53	28.5	14.3
Solution from bark and branches	6.5	0.68	8.5	0.55	0.55	2.51	0.64	0.54	28.4	14.5
NPK (20:10:10) 200 kg ha $^{-1}$	5.0	0.72	9.3	0.59	0.68	2.13	0.75	0.47	28.5	14.2
Solid leaves/ twigs extract	6. 4	0.46	7.8	0.51	0.50	1.88	0.55	0.61	28.5	14.4
Solid leave extract + 100 kg NPK	6.2	0.53	8.9	0.54	0.61	1.90	0.62	0.51	28.2	14.3
Poultry manure	6.7	0.68	10.4	0.67	0.62	2.43	0.61	0.62	28.5	14.2
Control	5.0	0.32	4.6	0.72	0.71	1.12	1.54	0.21	28.5	14.2

Table 6. Soil physico-chemical properties of the experimental site as influenced by *Moringa oleifera* liquid and solid extracts, 2013.

Experimental	Parameters % (Cmol kg $^{-1}$)									
Treatments	PH	N	P	K	Ca	Mg	Na	OM	Clay	Silt
Aqueous leave extracts	6.4	0.62	7.9	0.54	0.64	2.20	0.41	0.52	28.5	14.3
Aqueous leave extract + 100 kg NPK	6.1	0.62	7.3	0.54	0.67	2.46	0.52	0.50	28.5	14.3
Solution from bark and branches	6.5	0.64	7.3	0.54	0.58	2.31	0.34	0.53	28.4	14.5
NPK (20:10:10) 200 kg ha $^{-1}$	5.0	0.62	8.3	0.64	0.57	2.13	0.75	0.33	28.5	14.2
Solid leaves/ twigs extract	6. 2	0.42	7.3	0.50	0.56	1.88	0.35	0.58	28.5	14.4
Solid leave extract + 100 kg NPK	6.0	0.54	7.4	0.55	0.53	1.90	0.62	0.50	28.2	14.3
Poultry manure	6.3	0.62	8.4	0.55	0.59	2.43	0.61	0.54	28.5	14.2
Control	5.0	0.33	4.1	0.68	0.68	1.12	2.54	0.11	28.5	14.2

extracts which is evidenced in the improved yield of the crop*. M. oleifera* extract significantly increased the availability of micro and macro nutrients in the soil for plant up take. This is shown in the level of the nutrients in the soil after harvesting as compared with the control and the nutrient status before planting commenced. The application of *M. oleifera* extracts significantly ($P > 0.05$) ameliorated the soil in both 2012 and 2013 respectively. The pH of the soil in both cropping seasons showed improved soil pH due to *Moringa* extracts application. Plots that received a combination of *Moringa* extracts and 100 kg ha^{-1} NPK (20:10:10) have improved soil pH compared with those that received only NPK fertilizer (Tables 5 and 6). Anyaegbu et al. (2013) reported increased soil pH with application of *Moringa* extracts.

M. oleifera extracts apart from improving the fertility status of the soil, acted as a scavenger of certain nutrients such as calcium. Potassium, and sodium, as indicated by the high level of these elements in the control plots compared with the plots that received *Moringa* extracts.

The nutrient status of the plots that received poultry manure was also significantly improved like the areas that received *Moringa* extracts. Stevenson and Ardakani (1991) in their work reported that organic substances play significant role in the weathering of rocks. Perhaps, this may be responsible for the increase in the mineral content of the plots that received *Moringa* extracts and poultry manure respectively. Hussein (1997) has earlier reported that poultry manure application increased soil pH, organic matter, available phosphorous and microbial activity in nutrient metabolism.

In the control plots, quite a number of insects were observed on the leaves of the *S. melongina* stands. Some were adult insects while some were in form of caterpillars feeding on the leaves of the *S. melongena* stands leaving behind multiple perforations on the plants which invariably reduced the photosynthetic ability of the affected plants and ultimately the yield. Conversely, in the areas that received foliar application and the decoction from the *Moringa* barks/cut branches, the presence of the insects were not observed. This perhaps lends credence to the report that the plant has insecticidal properties. Application of various forms of *M. oleifera* extracts significantly affected the growth development of *S. melongena* in both 2012 and 2013 respectively.

The vegetative parameters of *S. melongena* as influenced by *M. oleifera* extracts, poultry manure and NPK fertilizer is shown in Tables 7 and 8. In both 2012 and 2013, highest plant height was recorded from garden egg stands that were treated with a combination of aqueous leaf extract and NPK (20:10:10) at the rate of 100 kg ha^{-1}. This is closely followed by those that were given poultry manure, solid leaf extract combined with NPK at the rate of 100 kg ha^{-1}. Comparatively, the lowest plant height was recorded from stands in the control plots

Table 7. Plant height and number of branches per plant of *Solanium melongena* as influenced by *Moringa oleifera* extracts, 2012.

Treatments	Parameters	
	Height/plant (m)	No. of branches/plant
Aqueous leave extracts	1.86[b]	21.4[c]
Aqueous leave extract + 100 kg NPK	2.86[a]	28.3[a]
Solution from bark and branches	1.35[c]	23.1[b]
NPK (20:10:10) 200 kg ha $^{-1}$	1.83[b]	24 7[b]
Solid leaves/twigs extract	1.27[c]	21.5[c]
Solid leave extract + 100 kg NPK	1.89[b]	23.7[b]
Poultry manure	2.10[b]	23.8[b]
Control	0.67[d]	8.6[d]
DMRT **(**α = 0.05)		

Values in each column bearing the same letters (a – e) are not significantly different, DMRT (P > 0.05).

Table 8. Plant height and number of branches per plant of *Solanium melongena* as influenced by *Moringa oleifera* Extracts, 2013.

Treatments	Parameters	
	Height/plant (m)	No. of branches/plant
Aqueous leave extracts	1.76[c]	21.4[b]
Aqueous leave extract + 100 kg NPK	2.45[a]	24.3[a]
Solution from bark and branches	1.85[b]	21.2[b]
NPK (20:10:10) 200 kg ha $^{-1}$	2.11[b]	23.6[a]
Solid leaves/ twigs extract	1.52[c]	21.7[b]
Solid leave extract + 100 kg NPK	2.27[b]	24.4[a]
Poultry manure	2.16[b]	24.3[a]
Control	0.58[d]	4.9[c]
DMRT (α = 0.05)		

Values in each column bearing the same letters (a to d) are not significantly different, DMRT (P > 0.05).

(Tables 7 and 8). The result on plant height as influenced by the various treatments was similar to that of number of branches per plant. Hence the highest number of branches produced per plant of *S. melongena* was obtained from the plots that received the aqueous leaf extract supplemented with NPK fertilizer at the rate of 100 kg ha^{-1}. The fair performance of the stands treated with NPK fertilizer at the recommended rate of 200 kg ha^{-1} in both 2012 and 2013 may be due to prolonged use of the fertilizer in the area or wrong fertilizer application by the farmers which as seen in Tables 5 and 6 has led to reduced soil pH. Reduced soil pH is an indication of soil acidity which of course renders the soil infertile.

The yield and yield components of *S. melongena* as influenced by various *Moringa* extracts, NPK fertilizer and poultry manure is shown in Table 9. The results of the vegetative parameters as influenced by the various experimental treatments in this study were almost the same as those of the fruit yield and yield components. When compared with stands in the control plots and those given NPK fertilizer, the stands treated with *Moringa* extracts recorded the significant (P > 0.05) fruit yield.

Recent studies conducted on the effect of *M. oleafera* extracts on the growth performance of *Telferia occidentalis* (Anyaegbu et al., 2013), showed that *M. oleifera* extracts increased significantly the yield and yield components of *T. occidentalis.* The above results confirmed the name “fertility plant” being given to *Moringa* plants. A report by FAO (2010) suggest that the use of organic fertilizer derived from *Moringa* seed processed with the right procedure can increase the density and richness of indigenous invertebrates, specialized endangered soil species, beneficial arthropods, earthworms, symbionts and microbes. The highest fruit yield being recorded from garden egg stands treated with *Moringa* leaf extract applied in combination with NPK fertilizer (20:10;10) at the rate of 100 kg ha $^{-1}$ is an indication that the leaf extract of *Moringa* has a blending effect on the NPK fertilizer applied perhaps by ameliorating

Table 9. Fruit yield and yield component of *Solanium melongena* as influenced by *Moringa oleifera* Extracts, 2012.

Treatments	Parameters			
	2012		2013	
	No. of fruits/ plant	Fruit yield (t ha^{-1})	No. of fruits/plant	Fruit yield (t ha^{-1})
Aqueous leave extracts	37.6^{d}	5.7b^{c}	41.3^{c}	5.6^{c}
Aqueous leave extract + 100 kg NPK	58.9^{a}	9.5^{a}	64.4^{a}	10.5^{a}
Solution from bark and branches	49.3^{b}	7.3^{b}	37.5^{d}	8.8^{b}
NPK (20:10:10) 200 kg ha^{-1}	36.7^{c}	5.8^{bc}	45.3^{c}	5.8^{c}
Solid leaves/ twigs extract	32.6^{c}	4.6^{c}	37.9^{d}	4.8^{c}
Solid leave extract + 100 kg NPK	44.6^{c}	6.9^{b}	57.6^{b}	7.7^{b}
Poultry manure	45.8^{c}	7.4^{b}	58.5^{b}	6.9^{b}
Control	16.2^{e}	0.6^{d}	20.1^{e}	0.8^{d}
DMRT (α = 0.05)				

Values in each column bearing the same letters (a – e) are not significantly different ; DMRT(P > 0.05).

the soil as shown in Tables 5 and 6. Jason (2013) reported that *Moringa* leaf extract contains a plant growth hormone, called Zeatin. Zeatin has been reported to increase yields by 25 to 30% for nearly any crop. Jason (2013) recommended that the foliar spray should be used in addition to a balanced nutritional fertilizer program containing NPK and minerals.

Generally, *M. oleifera* has been reported by many authors (Caceres, 1999; Zarkales et al., 1995; Palada, 1996) as growth enhancer. Significant yield increases had also been reported in pea nut, soy beans, sorghum and tomato with foliar application of *Moringa* leaf extracts (Palada, 1996).

This study therefore tend to give credence to Okoh (2010) remark that organic farming builds on the principles of improving soil fertility through incorporation of legumes and compost materials.

The result of this study will thus give hope to the garden egg farmers in Giri who according to earlier report, do spend 20% of their income on purchase of inorganic fertilizers. *M. oleifera* which is seen growing commonly around homes and homestead gardens will present a suitable substitute to the chemical fertilizers which are costly if seen.

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