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Prospects of Integrated Application of Moringa (*Moringa oleifera*) Leaf Extract, NPK Fertilizer and Poultry Manure on Okra (*Abelmoschus esculentus*) Production

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A field trial was conducted to investigate the effects of integrated application of moringa leaf extract (*Maringa oleifera)*, poultry manure, and NPK 15-15-15 fertilizer on the growth and yield attributes of okra (*Abelmoschus esculentus*)at the Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Nigeria during 2018 cropping season. The experimental design was a randomized complete block with three replicates. The treatments included; Poultry manure (PM), Moringa leaf (ML), NPK fertilizer (NPKF), NPK fertilizer + Moringa leaf (ML+ NPKF), poultry manure and Moringa leaf (ML+PM), and control (C). At 2 weeks after planting (WAP), PM, NPKF, and ML+PM gave okra plant height of 3.74 cm, 3.98 cmand 3.82 cm, respectively, which were higher than 2.7 cm for C. While ML gave the highest plant height of 4.05 cm, which was higher than other treatments. Of all the treatments, ML+PM gave the highest fruit weight of 1.343 t/ha and differed ($P < 0.05$) from the rest of other treatments; while C had the least fruit weight of0.199 t/ha. ML+PM, NPKF, and ML+ NPKF gave total fruit number per plant of 47, 44 and 36 respectively,

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which differed (P < 0.05) to other treatment and the C gave the least fruit number of 15.67 per plant. The results showed that the application of PM+ML improved the growth and yield of okra, hence poultry manure and moringa leaf should be used instead of NPK fertilizer, which can also lower the cost of production.

Keywords: Moringa oleifera; leaf extract; NPK fertilizer; poultry manure; Abelmoschus esculentus.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is one of the most widely cultivated and utilized species of the family Malvaceae [1]. It is an essential vegetable especially in India, West Africa, Brazil and the United States [2,3,4]. It is grown throughout the warm temperate and tropical regions of the world for its fruits or pods. It is found in almost every market in Africa and Nigeria [5]. In the recent years, increasing attention has been paid to the roles of okra diet in human health [6] as it is recommended to people suffering from renal colic, leucorrhoea and general weakness [7]. The major antioxidants of okra are vitamins C and E carotenoid which contribute to the first defense line against oxidative stress [8]. The seeds can be used as a source of edible oil as well as in the soap industry [9]. Okra seed is rich in protein and unsaturated fatty acids such as linoleic acids (Oyelade et al., 2003). Okra is a popular healthy food due to its high fibre, vitamin C and folate content. It is a good ingredient of soup and stew (Osekita, 2000) and can also be eaten raw, cooked or in processed forms.

Moringa (*Moringa oleifera*) belongs to the plant family Moringaceae [10]. Moringa can be used for food, medicine and other beneficiary uses [11]. Moringa contains over 40 anti-oxidants [12]. Moringa leaf extract is a natural plant growth enhancer [13]. The leaves of moringa are rich in zeatin (zeatin is one of the most powerful cytokinnins). Zeatin does not only promote the growth of a plant, but also have anti-aging potential and protective effect in plant [13].

The fertility of the soil can be maintained and nutrient status boosted through the use of fertilizers. However, application of inorganic fertilizer has its own demerits which include; soil acidification, also inorganic fertilizer is no longer within the reach of poor and local farmers due to its high cost (Rahman, 2004).Continuous use of inorganic fertilizers often results in a number of problems, such as leaching, surface and ground water contamination, reduction in useful microbial communities and increased sensitivity to harmful insects [14].Thus, there is need for alternative organic sources of nitrogen (N) to maintain the soil fertility.

Poultry manure is an organic fertilizer for the maintenance of soil physical and chemical conditions for good plant growth. It is cheap, readily available and effective as a good source of N for sustainable crop production.

To this end, this study is aimed at investigating the effects of *Moringa oleifera* as an organic fertilizer in combination with other nutrient sources.

2. MATERIALS AND METHODS

2.1Site Description

The study was conducted at Ekiti State University, Ado-Ekiti, Teaching and Research farm, between June and September, 2017. The experimental area presents tropical climate with distinct wet and dry season. The rainy season spans from late March or early April to late October with a break in August. The dry season starts from November to early March. The mean annual total rainfall is about 1,367 mm while the average number of rainy days is about 112 days per annum. Temperature is almost uniform throughout the year with very little deviation from the mean annual temperature of 27°C.

2.2 Experimental Design and Treatments

Six treatments were arranged in a randomized complete block design with a sub-plot dimension of 2.4 m x 1.5 m and replicated three times. The treatments included; a control (C), poultry manure (PM), air dried moringa leaf (ML), NPK 15-15-15(NPK), moringa leaf + poultry manure (ML + PM), and moringa leaf + NPK 15-15-15 (ML + NPK) to give 18 experimental units. The milled moringa leaves and the poultry manure already cured were added to the soil at the rate of 10t/ha, two weeks before planting (WBP) to allow for proper decomposition and mineralization while the NPK fertilizer was applied two weeks after planting (WAP) at the

rate of 250 Kg/ha. Three okra seeds were sown per hole at 30 cm x 60 cm spacing and later thinned down to two seedlings per stand at 2WAP. Weeding was done manually on a regular basis.

2.3 Collection and Analysis of Soil, Moringa Leaf and Poultry Manure Samples

Top soil (0-15 cm) samples were randomly collected from cultivated farm, bulked to form a composite sample, which was air dried and sieved using a 2mm mesh size. The routine analyses as described by Udo et al. [15] for physical and chemical properties were carried out on the composite sample. Fresh moringa leaves collected from the research site, were oven dried at 65^{o}C to a constant weight and ground to pass through a 0.5 mm and analyzed for N, P, K, Ca, Mg, and organic C. Poultry manure was obtained from the dump site of the Faculty Poultry House, processed and analyzed.

2.4 Collection and Analysis of data

Data were collected on stem girth, plant height, leaf area, and fruit and yield attributes of okra. Fruit yield was determined at each harvest using weighting balance. Plant height and stem girth were measured with a measuring tape and vernier caliper, respectively. Data collected were subjected to analysis of variance and treatment means separated using Duncan's Multiple Range Test, at 0.05 level of probability.

3. RESULTS

3.1 Pre-cropping Physical and Chemical Properties of Soil in the Study Site and Soil Samples

Tables 1 show the pre-cropping physical and chemical properties of soil used for the experiment.The soil was slightly acidic (pH=6.59) and sandy loam. The soil had 1.45% N; 2.50% organic matter; 24.20 mg/100 g available P; while exchangeable K, Ca, and Mg were 34.5 mgkg^{-1}, 50.5 mgkg^{-1}, and 39.2 mgkg^{-1}, respectively.

3.2 Chemical Analyses of Moringa Leaf and Poultry Manure Used in the Experiment

The ML was slightly acidic (pH=6.39), while PM was slightly alkaline (pH=8.16). The ML exchangeable K, total N and available P, were 104.0 mgkg^{-1}, 4.70% and 0.72 mgkg^{-1}, respectively. While PM had 0.9 mgkg^{1} exchangeable K; 3.49% total N and 4.1 mgkg^{-1} available P.

Table 1. Pre-cropping physical and chemical analyses of experimental soil

Physical Parameters	**Value (%)**
Sand	74.32
Silt	8.08
Clay	17.60
Textural class	Sandy loam
Chemical properties	**Value (%)**
pH	6.59
Organic carbon	1.55
Organic matter	2.50
Total Nitrogen	1.45
Available P (mg/100 g)	24.20
Exchangeable bases	**Value (mg/Kg)**
K	34.5
Ca	50.5
Mg	39.2
Zn	19.9

Table 2. Chemical analyses of poultry manure and moringa leaf

Chemical properities	**PM**	**ML**
N%	3.49	4.70
P(mg/100 g)	41.00	7.19
K(mg/100 g)	9.00	1040.00
pH	8.16	6.39
Organic carbon (%)	21.25	50.77
Organic matter (%)	35.29	88.10
Mg(mg/100 g)	159.00	22.00
Ca (mg/100 g)	13.00	212.45
Zn (mg/100 g)	31.90	37.95
Fe	905.00	205.00
Mn	6.60	2.09
C:N	5.49	10.95

PM = poultry manure; ML moringa Leaf

3.3 Effects of Poultry Manure, NPK Fertilizer, Moringa Leaf Extract and their Combination on the Growth Parameters of Okra

Effects of integrated application of poultry manure, NPK fertilizer, and moringa leaf extract on okra plant height are presented in Table 3. It can be observed that at 4 WAP, ML + PM had the highest plant height of 9.90 cm, followed by NPKF (9.48 cm), with no difference to other treatment, but to ML (8.22 cm), ML + NPKF

(7.70 cm). The least value was giving by C, while at 8 WAP, PM+ML showed the highest value of 60.49 cm and differd from NPKF (44.91 cm), PM (42.72 cm), ML + NPKF (39.98 cm), ML (36.80 cm); and the least plant height of 25.64 cm was obtained at C. The effects of integrated application of moringa leaf extract, poultry manure and NPK fertilizer on okra number of leaves as presented in Table 3 showed that ML + PM (4.98) recorded the highest number of leaves for okra at 4 WAP, while ML+PM gave the highest number of leaves of 4.98 at 8 WAP, which also differed to other treatments and C had the least value of 5.61 at 8 WAP. Effects of integrated application of moringa leaf, NPK fertilizer and poultry manure on the leaf area of okra, it could be seen that ML + PM had the highest leaf area of 32.70 cm^2 and 138.45 cm^2at 4 and 8 WAP respectively, differed from other treatments in all the weeks of samplings except at 4 WAP where it differed not to ML (32.09 cm^2). The effects of integrated application of moringa leaf, NPK fertilizer and poultry manure on the stem girth of okra also presented in Table 3, showed that ML had highest values of stem girth of 1.12 cm at 4 WAP among the treatments; While NPKF gave the highest values of 1.70 cm at 8 WAP with no difference to ML+PM (1.69 cm) and ML (1.67 cm); but differed to ML + NPKF (1.5 cm), PM (1.37 cm) and C (1.40 cm).

3.4 Okra Fruit Yield and Yield Components

The effects of integrated application of moringa leaf, NPK fertilizer and poultry manure on the okra fruit yield and yield components were presented in Table 4. It can be observed that, ML+PM gave the highest total fruit weight of 1.343 t/ha, which was higher than 0.684 t/ha for NPKF, 0.549 t/ha for ML+NPKF, and 0.226t/ha for ML; where C the least value of 0.199t/ha. Also ML + PM had the highest fruit number of 47 per plot and differed to ML (21) but not toNPKF (44) and ML+ NPKF (36) and C recorded the least value of 15.67.

4. DISCUSSION

The pH value of the soil was within the range of 6-7 which is adequate for optimum performance of vegetables (Purselglove, 1991). This revealed that there is need for soil amendment to improve the growth and yield of okra. Previous studies had shown that milled moringa leaf and poultry manure are rich in nutrient [12,10,16] and thereby can be used as soil amendments. Milled moringa leaf has been used as growth enhancer and as a soil amendment through foliar spray [12]. The application of these treatments had positive and significant effects on the growth and yield of okra.

Application of moringa leaf with poultry manure consistently and increased the plant height compared to other treatments except NPKF at 4WAP. This might be due to the enhanced mobilization of metabolites/inorganic solutes such as zeatin, ascorbic acid, Ca and K present in moringa leaf leading to the growth of plumule and the increase in the amylase activity and reducing sugars, contributing to early vigor and increase plant growth (Foidi, 2012). The increase in number of leaves of okra overtime might have resulted from consistent and adequate supply of nutrient to the soil by poultry manure and moringa leaf which in turn must have enhanced vegetative growth of the okra plant. The higher value of 138.45 cm^2 recorded by treatment ML+PM in the leaf area of okra at 8WAP could be attributed to the fact that the nutrient status of the plot treated with moringa leaf and poultry manure increased the availability of nutrient in the soil for plant uptake, also increased the microbial activity in the soil. Treatment ML and NPKF had the highest value for stem girth of

Table 3. Effects of poultry manure, NPK fertilizer, moringa leaf extract and their combination on the growth parameters of okra

Treatment	Number of leaves		Leaf area (cm^2)		Plant height (cm)		Stem girth (cm)	
	4WAP	8WAP	4WAP	8WAP	4WAP	8WAP	4WAP	8WAP
C	4.10ab	5.61b	23.44b	103.52c	7.04b	25.64c	0.92ab	1.40b
PM	3.27ab	6.71b	28.32ab	110.53b	7.08b	42.72ab	0.90ab	1.37b
NPKF	4.74a	6.77ab	29.16ab	116.64ab	9.48a	44.91ab	0.91ab	1.70a
ML	3.73b	6.54ab	32.09a	119.59ab	8.22ab	36.80b	1.12a	1.67a
ML+NPKF	4.14ab	6.27ab	29.26ab	123.60ab	7.70ab	39.98ab	0.93ab	1.50ab
ML+PM	4.98a	7.13a	32.70a	138.45a	9.90a	60.49a	1.01a	1.69a

PM= Poultry manure; NPKF=NPK fertilizer; ML= moringa leaf; ML+NPKF=moringa leaf + NPK fertilizer; ML+PM= moringa leaf + poultry manure; C=control. Mean values with different letter (s) in the same column are significantly different at 0.05 (DMRT)

Table 4. Effects of poultry manure, NPK fertilizer, moringa leaf extract and their combination on the yield of Okra

Treatment	FN (per plot)	F/P	AFL	AFD	TFW (t/ha)
C	15.67b	3.00	5.87ab	2.17ab	0.199bc
NPKF	44.00a	5.03	6.22a	2.12ab	0.684ab
ML	21.00ab	9.47	5.42ab	2.09b	0.226b
ML+NPKF	36.00a	6.27	5.48ab	2.17ab	0.549ab
ML+ PM	47.00a	9.50	5.68ab	2.20a	1.343a

FN=Fruit Number;F/P=Fruit/Plant;TFW=Total fruit Weight;AFL=Average Fruit Length;AFD=Average Fruit Diameter. Mean values with different letter (s) in the same column are significantly different at 0.05 (DMRT). PM= Poultry manure; NPKF=NPK fertilizer; ML= moringa leaf; ML+NPKF=moringa leaf + NPK fertilizer; ML+PM= moringa leaf + poultry manure; C=control.

okra of 1.12 cm and 1.70 cm at 4 and 8 WAP, respectively. The increased in stem girth of okra at 8 WAP by NPKF could be as a result of abundant supply of N by the NPK fertilizer [17].

ML+PM gave increased fruit number of 47.0 compared to other treatments except ML+NPKF and NPKF, while the control had the lowest value (14.67). PM+ML gave the highest total fruit weight (1.343 t/ha) of okra in the experiment and differed from other treatments and C gave the least value of 0.199 t/ha.

From the findings in this study, combination of poultry manure and moringa leaf consistently gave the highest values of growth and yield parameters of okra, compared to sole NPK fertilizer.

There is an increase in the mineral content of the soil as a result of the application of the moringa extracts which in turn improved the growth performance of the crops. Hussein [18] had earlier reported that application of poultry manure increased soil pH, organic matter and available P, microbial activity in the nutrient metabolism. Rao et al. [19] reported that juice extracted from the leaves of moringa can be used to make foliar nutrient capable of increasing crop yield by 38%. Anyaegbu [20] reported enhanced growth performance of *Telfaria occidentalis* with the application of moringa extracts. Jason [21] noted in his experiment that moringa leaf extract contains a plant growth hormone called zeatin. Which has been reported to increase yields by 25 – 30% for nearly any crop, the researcher added that the compound leaves and stems of moringa make excellent fertilizer.

5. CONCLUSION

The results of this study showed that solely application of moringa leaf extract, as a growth enhancer or biostimulant increased the growth and yield of okra. It also indicated that the complimentary application of moringa leaf especially with poultry manure increased the growth and yield of okra, thus application of moringa leaf either sole or with poultry manure increase the yield and reduce the production cost with marginal profit. Hence ML + PM is recommended to the farmer.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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