
PERFORMANCE AND ECONOMICS OF MAIZE CROP PRODUCTION UNDER MORINGA OLEIFERA TECHNOLOGY

Yusuf, T.M., Olowoake, A.A and Subair, S.K

Kwara State University, Malete, Nigeria, GSM; +2348036846332

ABSTRACT

The moringa oleifera technology is a soil fertility improvement technique that is environment friendly. It is based on the use of natural inputs including: moringa oleifera crop as green manure, poultry manure as animal manure and mineral fertilizer. The objective of this study is to investigate the effects of moringa technology on yield and profitability of maize production in Ilorin Southern Guinea Savannah of Nigeria. Field experiment was conducted in 2016 and 2017 planting seasons, at the Teaching and Research Farm of Kwara State University, Malete, Nigeria. The study comprised of six treatments including; control with zero addition, 100% MO, 100% NPK 15-15-15 fertilizer, 100% PM, 50% MO +50% NPK and 50% MO +50% PM all at the rate of 60 kg N/ha. The experiment was laid out in a randomized complete block design with three replicates. Data were collected on maize growth and yield parameters; cost of production and crop yield. These were subjected to statistical and economic viability analyses. Results showed that of all the treatments, application of the mixed MO leaves +NPK at 2,4, 8 and 12 weeks after planting (WAP) significantly ($P < 0.05$) increased the growth parameters and grain yield of maize when compared to other applications and the control (without application). The highest grain yield (4.4 and 4.5t/ha) was obtained from MO+NPK during 2016 and 2017 planting seasons respectively. The NPK, MO+PM, PM,MO and control treatments had (3.6 and 3.9 t/ha), (3.5 and 3.9 t/ha), (2.5 and 2.7 t/ha) and, (1.5 and 1.7 t/ha) respectively during 2016 and 2017 planting seasons. Overall, net income was higher in maize plot treated with MO leaves + NPK 15-15-15 fertilizer. On the basis of these findings therefore, the use of MO+NPK at the rate of 60 kg N/ha was judged more economical in the study area and recommended for adoption by maize farmers.

Keywords: Maize, growth, yield, moringa leaves, NPK and poultry manure

INTRODUCTION

Among food crops, maize a cereal crop is an important crop which ranks third after wheat and rice in the world (Adams *et al.*, 2015). Maize is the primary staple food in Nigeria and critical to about 112 million small holder livelihoods (NBS, 2012). Maize grains are useful raw materials in industries for the production of medicines and different food recipes (Otitoju *et al.*, 2016). In Nigeria, the increasing rate of demand for maize for different purposes had not been met with the local production (Relief Web, 2017)

One major challenge of tropical smallholder maize producers is low maize yield, due to low soil fertility resulting from torrential rainfall, inorganic residues, continuous cropping, manure and

crop residues removal and the fact that rural farmers do not have adequate knowledge of different soil fertility restoring inputs which will balance the soil nutrients (Loks *et al.*, 2014, Adams *et al.*, 2015)

For good maize crop performance, increased yield per cultivated area, and economic benefits for producers and farmers, proper and appropriate maintenance of soil fertility is crucial. The fertility of soil can be maintained through fallowing, that is, allowing the soil after use to rest for some time (for natural regeneration), or through the use of a well planned system of crop rotation or application of inorganic fertilizers or organic manure (comprising Compost, farm yard manure, animal manure and green manure)

Option of fallowing is ruled out by the issue of population pressure in the country, while the modern systematic planned crop rotation tends to be too technical for rural farmers whose main focus is to provide farm produce which would satisfy the needs of their families from the small land area available to them. Inorganic fertilizer has many vices including; land degradation, environmental pollution and promotion of herbs' growth which compete with soil nutrients and space with plants and also harbour most of pests and diseases which affect the plants both on the field and in the store. Compost which is often viewed as the cheapest and easiest way of improving soil fertility by improving soil physical properties and increasing soil nutrients has been rendered unsustainable as a result of bush burning and crop residue removal for animal feeding. All these facts point to the need for fertilizer recommendation that would be based on experimental results which is the focus of this study

Although, several researchers (Agboola 1990, Sullivan 2003) worked on green manure as a cheap source of soil fertility. It was however, discovered that though the sources supplied plant nutrients to the soil and improved soil texture and structure but the rate of release of nutrients was too slow compare to the rate plants root need to take nutrients from the soil for rapid growth and good performance. Uriyo,(1979), Tankou (2004), Makinde *et al.*, (2010) complemented the search by investigating the effects of combining different types of manures with different levels of inorganic fertilizers for rapid and long lasting release of plant nutrients in the soil. However, none of these studies had tried moringa oleifera leaves or its combination with poultry manure or inorganic fertilizer to determine which would give the best result in terms of growth, yield and economic performance of maize.

This study is therefore, exploring the potentials of moringa technology to determine the appropriate combination of plant nutrients that will promote sustainable increased soil fertility, high maize yield and net farm income.

Objectives of the study;

The general objective of this study is to explore the possibility of using Moringa oleifera technology to optimize maize crop production at least cost to increase the income of rural farmers.

Specifically, to;

1. Investigate the effect of the different treatments of the technology on the growth and yield of maize
2. Determine the combination of plant nutrients that will maximize economic performance of maize crop.

MATERIALS AND METHODS

Experimental Site;

The Teaching and Research Farm, Kwara State University, Malete, (08° 42'48.5''N and 004° 26'17.9''E) Ilorin, Nigeria was used for the experiment. The area is in the southern guinea savanna zone of Nigeria. It has an annual rainfall of about 1200 with a dry spell from December to March. Mean maximum temperature varies between 33° C and 34° C. The soil is slightly acidic (PH 6.5), sandy loam, low in organic matter (8.76g/kg) and deficient in nitrogen (0.7g/kg), phosphorus (9.7mg/kg) and potassium (0.41cmol/kg). The site is mainly used for experimentation.

Materials and Collection

The materials for the experiment are; maize seeds, moringa leaves, poultry manure and NPK 15-15-15 fertilizer. Maize seeds of variety BR9928 DMR-SR (Yellow, Downy Mildew Streak Resistance) was collected from IITA Ibadan, Moringa leaves (Aleshinloye Grade B) and dried poultry manure were collected from Kwara State University Teaching and Research Farm, Malete while NPK 15-15-15 fertilizer was purchased from general market at Ilorin.

Chemical Analysis of the Materials

Chemical analysis for N, P, K, Mg, Cu, Fe and Mg was carried out on Moringa leaves and poultry manure to ensure their suitability as sources of plant nutrients.

Analysis of Soil

Soil samples randomly taken from the experimental site before planting with the aid of auger, bulked, air dried and ground and sent to laboratory for analysis to determine its capacity in terms of the available plant nutrients.

Experimental Design;

The experimental site was cleared and prepared manually and then divided into plots using a randomized complete block design with split plot arrangement in three replications. The size of each plot was 3.0 X 3.0 (9 m²) with an inter-plot space of 0.5m. The Moringa leaves and Poultry manure were applied two weeks before planting to allow for their mineralization. Maize seeds were planted at the rate of two seeds per stand and later thinned to one after seedling emergence

to maintain constant plant population of maize (75,000 stands ha⁻¹) The NPK 15-15-15 fertilizer was applied two weeks after planting. The treatments used were; control (No Application), 100% NPK 15-15-15, 100% Moringa oleifera leaves (MO), 100% Poultry manure (PM), 50% (MO) +50% NPK and 50% MO + 50% PM. All the treatments except the control were applied at the rate of 60 kg N/ha for optimum maize growth (Aduloju et al., 2013). All required agronomic standard practices were used before and after the crop emergence. Maize crop was harvested fresh manually in October 2017

Procedure for data recording.

Collection of data commenced from 4 weeks, followed by 8 and 12 weeks after planting (WAP) after when fresh maize was harvested. To record plant height of maize, ten plants were randomly selected from each plot and measured from the ground level to the tip of the plant. The yield was determined by measuring cob weight and dry grain weight of 100 grains. Cost of materials used and price of maize produce were determined through reigning market prices. The US\$ equivalent was obtained using official exchange of US\$1 to N303.3 (as at December 2017)

Statistical analyses

The data recorded for different parameters were subjected to statistical analysis using SPSS package for analysis of variance (ANOVA) and the treatment were compared at 5% level of significance using Duncan's Multiple Range Test (DMRT). Farm budgeting analysis was used to compute the farm income. Benefit cost ratio and the return on investment were used as economic indicators

RESULTS AND DISCUSSION.

Table 1: Proximate analysis of moringa leaves and poultry manure

Nutrient element	N (%)	P (%)	K (%)	OC (%)	Ca (%)	Mg (%)	Fe (%)	Zn (%)
Moringa Leaves	2.56	0.22	1.13	68.9	0.84	0.29	2001.0	31.45
Poultry Manure	1.14	0.41	2.06	62.5	1.83	0.93	3560.0	32.85

Maize is an exhaustive crop, demanding nutrients at all stages of its growth. Among the most essential nutrients required by maize crop for healthy growth and high yield are; nitrogen (N), phosphorus (P) and potassium (K). N plays a vital role in overall production (Abbas et al., 2016) as it is linked with dark green color of vegetative parts, branching and leaf production. P influences the growth and yield related traits of plants that are ultimately allotted to the embryo

to improve seed vigor (Seyyedi et al., 2015). K plays an important role in persistently keeping the plants standing during strong winds and its deficiency or inadequate supply always result into stunted growth and reduced yield (Wikki paedia, 2018). However, most Nigerian soils including the experimental site are deficient in NPK nutrients (Table 2) and (Olowoake et al., 2015), this implies that maize crop will respond positively to the different treatments of the study.

Table 2: Physical – chemical properties of experimental soil.

Parameters	Soil test value
pH (H ₂ O)	6.5
EC (dS/.m)	0.3
Org.C (g/kg)	8.76
Total N (g/kg)	0.7
P (mg/kg)	9.7
Exchangeable bases cmol/kg	
Mg	4.54
Ca	2.34L
Na	16.19
K	0.41
Extractable micronutrients	
Cu	45.5
Fe	35.75
Mn	70.5
Zn	377.5
Textural class (%)	
Sand	69.4
Silt	24.4
Clay	6.2

Textural class	Sandy loam
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Maize Plant Height

In 2016, maize plant was significantly influenced by application of moringa leaves when combined with NPK fertilizer. At 4, 8 and 12 WAP maize plant in the MO+NPK treatment was taller than other treatment 11-45% ,12-55% , and 8-31% , respectively. The control treatment consistently produced the shortest plant height. In 2017, maize plant height also deferred significantly ($P < 0.05$) among the fertilizer treatments (Table 3). Percentage differences observed in maize plant height in 2016 at the different sampling intervals were also maintained in 2017. The application of MO+NPK treatment was better than the use of sole NPK or MO or PM. This is in line with the results of Olowoake et al., 2015 who reported that the combination of organic and mineral fertilizer performed better on plant height than when each of them is solely used

Table 3. Maize plant height (cm) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks After Planting (WAP)		
	4	8	12
2016			
Control	10.2 c	50.0d	63.5d
MO	16.4b	61.3c	66.0c
PM	18.0a	68.5c	73.0b
MO+NPK	18.7a	94.0a	104.0a
MO+PM	17.2b	81.9b	90.5a
NPK	16.6b	60.3c	77.0b
2017			
Control	20.8d	43.1d	89.9d
MO	33.9b	85.5b	111.3b
PM	25.5c	59.1c	108.7c
MO+NPK	37.9a	96.8a	130.8a

MO+PM	31.9b	63.1b	99.4c
NPK	30.0b	65.2b	119.7b

Mean having the same letter along the columns indicate no significant difference using Duncan's multiple range tests at 5% probability level

Number of leaves of Maize plant

In 2016, the number of leaves per plant differed significantly ($P < 0.05$) among the different fertilizer treatments (Table 4). At 4 WAP, NPK treatment had 3-19% more number of leaves per plant than others while at 8 and 12 WAP, MO+NPK had 12- 18 % number of leaves than others. All the fertilizer plots had higher number of leaves per plant than the control treatment. The number of leaves per plant also differed significantly ($P < 0.05$) among the fertilizer treatments in 2017 (Table 4). At 4 WAP, there were no significant differences on number of leaves for plots treated with MO+NPK and NPK. However, at 12 WAP higher number of leaves was recorded from organomineral MO+NPK plot. Ogundare et al., (2012), Olowoake and Ojo (2014) also found similar results

Table 4. Number of leaves of Maize plant as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks After Planting (WAP)		
	4	8	12
2016			
Control	5.9c	8.2d	9.7c
MO	6.8b	10.4b	11.0b
PM	6.4b	8.7c	10.5b
MO+NPK	7.1a	11.1a	11.9a
MO+PM	6.6b	9.9b	11.3b
NPK	7.3a	9.9b	11.0b
2017			
Control	5.0b	9.0c	10.0d

MO	5.5a	11.5b	13.0b
PM	6.0a	12.0a	12.0c
MO+NPK	6.5a	13.0a	14.0a
MO+PM	6.0a	11.6b	12.5b
NPK	6.0a	11.0b	12.0b

Mean having the same letter along the columns indicate no significant difference using Duncan’s multiple range tests at 5% probability level

Maize Grain Yield

Table 5 shows that, the maize grain yield differed significantly ($P < 0.05$) among the different fertilizer treatments in 2016 and 2017. The MO+NPK treatment produced higher total grain yield (4.4 t/ha and 4.5 t/ha) in 2016 and 2017 respectively. Similar result was achieved from the works of Olowoake and Ojo (2014), Nwaogu (2013) and Ogundele et al., (2011) who reported that the combinations of organic and mineral fertilizer perform better on the yield of *Amaranthus caudatus* and maize, than when each of them is solely used. There was no significant difference between grain yield produced from MO+ PM and NPK treated plots in 2016 and 2017 respectively. The maize plants without fertilizer treatment had the lowest yield which could be due to deficiency of nutrients as revealed by the low nutrient status of the soil from the initial physic-chemical analysis. The fact that MO+NPK plot had significantly higher grain yield than any other treatments including NPK treatment plot, implies that the possibility of reducing cost of producing maize crop in the study area and increasing farmers income. NPK fertilizer aside from its hazardous effects on land, soil and environment, its often a limiting factor to maize production in Nigeria as its generally scarce, very expensive and may also be adulterated if obtained. Substituting the use of 50% NPK fertilizer with moringa oleifera leaves which is not only easy to produce on farmers’ farms but also environment friendly will go a long way to ease the fundamental challenge in maize production in the country.

It was also discovered that the yields in the various treatments increased slightly in 2017, this goes to show that the experiment improved soil fertility rather than depleting it.

Table 5. Maize Grain Yield (t/ha)

Treatments	2016	2017	Mean Yield
Control	1.5d	1.7d	1.6
MO	2.7c	3.0c	2.9

PM	2.5c	2.7c	2.6
MO+NPK	4.5a	4.4a	4.5
MO+PM	3.5b	3.9b	3.7
NPK	3.6b	3.9b	3.8

Table 6. Economic performance of maize under different Treatments (Average of 2016 and 2017 Experiments)

Treatment	Yield (kg/ha)	Revenue per maize treatment (₦)	Total Variable cost (₦)	Total Fixed cost (₦)	Total cost (₦)	Net farm income (₦)	Benefit Cost Ratio
Control	1.6	64,000	28,000	8,000	36,000	28,000	1.7:1
MO	2.85	114,000	44,000	8,000	52,000	62,000	2.2:9
PM	2.6	104,000	31,000	8,000	39,000	73,000	2.6:1
MO+NPK	4.45	178,000	34,500	8,000	42,500	143,500	4.2:1
MO+PM	3.7	148,000	33,000	8,000	41,000	115,000	3.6:1
NPK	3.75	150,000	33,000	8,000	39,000	117,000	3.8:1

The use of MO, PM, NPK and their combinations increased cost of production but resultantly increased the net income (Table 6), while the control (no fertilizer application) proved to be more expensive by giving minimum returns. Similarly the net income from different plant nutrient treatments was different depending on the combinations of the nutrients. NPK and MO+PM have high net income, but the combination of MO+NPK proved economical by giving higher income. It gave a net return of ₦143,500 (US\$ 47.31) and a favorable benefit cost ratio of 4.2:1 which implies a return of ₦4.2 naira on every ₦1.00 invested. The combination of MO + NPK is therefore recommended for adoption by farmers

CONCLUSION

The study was carried out to investigate the possibility of optimizing maize crop production at least cost to maximize net farm income of rural farmers using different combinations of plant nutrients. And to specifically; Investigate the effect of the different plant nutrients (treatments) on the growth and yield of maize and determine the least cost combination of plant nutrients that will maximize net farm income.

To achieve the objectives, field trial was conducted in 2016 and 2017 planting seasons, at the Teaching and Research Farm of Kwara State University, Malete, to investigate the response of maize to six different treatments including; control with zero addition, 100% MO, 100% NPK, 100% PM, 50% MO +50% NPK and 50%MO +50% PM all at the rate of 60 kg N/ha. The experiment was laid out in a randomized complete block design with three replicates. Data were collected on growth and yield parameters, cost of inputs and price of output. These were then subjected to statistical and economic viability analyses. Three major findings came out distinctly; Maize plants on MO+NPK treated plot performed better in all the measured growth and yield parameters. The combination significantly ($P < 0.05$) increased the growth parameters and grain yield of maize when compared to other treatments. The highest grain yield was obtained from MO+NPK plot during 2016 and 2017 planting seasons.

The economic performance of the maize crop in MO + NPK plot was judged the best. The overall net income, the benefit/cost ratio and return to investment were higher in maize plot treated with MO leaves + NPK 15-15-15 fertilizer.

On the basis of these findings therefore, the use of 50%MO+50%NPK at the rate of 60 kg N/ha is recommended for adoption by maize farmers in Ilorin, southern guinea savannah in Nigeria.

Conflict of interest:

The authors declare that there is no conflict of interest with regard to the publication of this article

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