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Abstract- Maize (Zea mays L.) is the most abundantly produced and consumed cereal in the world. Major challenge in maize production in Africa is low soil fertility due to lack of sustainable soil fertility restoring inputs among others. This study investigated the potentials of Moringa-banana- maize mix, a biodegradable, environment friendly and abundantly available free gifts of nature in soil fertility improvement. The objective of this study was to investigate the effects of the mixture of Moringa *olifera* leaves (MO) +Banana Peels (BL) +Maize Stalks (MS) on yield and profitability of maize production. Specifically, to choose the right combination of the mix and determine the correct mode of application. Field and screen house experiments were conducted in 2020 planting seasons, at the Teaching and Research Farm of Kwara State University, Malete. Four treatments were considered and each represented a technology on field/screen trials. These include; A=100N+40P+30K, B= 120N+50P+40K, C= 70N+30P+ 20K and the control using the national recommended dose of 90kg/ha of NPK fertilizer (for comparison).

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Keywords: maize, yield, economic performance, moringa leaves, banana peels, and maize stalks.

I. Introduction

a) Background to the study

Maize (Zea mays L.) (corn) is the most abundantly produced and consumed cereal in the world. It ranks first worldwide with wheat and rice following in terms of importance (OECD-FAO, 2016). Maize grains are useful raw materials in pharmaceuticals, food industries, domestic fuel and animal feed production (Relief Web, 2017) This makes it one of the crops with the highest demand in the world (IITA 2019). According to Urassa, (2015) the demand for maize worldwide hits 3Billion Metric Tonnes while the global production was about 1.1 Billion Metric Tonnes thereby leaving a deficit of 1.9 Billion Metric Tonnes. Hence the need for increased maize production.

Maize is the most important cereal crop in Africa. It is critical to more than 300 million small holder livelihoods and accounted for 30-50 percent of Africa expenditure (FAO, 2019).

Nigeria in 2019 was the second largest maize producer in Africa. It had an average maize production volume of about 11 million Metric Tonnes (MMT) after South Africa with 16 MMT and Ethiopia third with 8.4 MMT (USDA Data 2020). However, as of January 2021, Nigeria is ranked 40th largest maize importer in the world, importing about 400,000Metric Tonnes of maize on yearly basis (Premium Times 2021). This is because the local demand is more than the national production. In 2019, while total production was 11 MMT, total demand was more than 12 MMT leaving a deficit of more than 1MMT (Federal Ministry of Agriculture (2019).

This may not be unconnected with the fact that more than 80 percent of maize production in Africa is carried out by small holders whose major challenge is low soil fertility(Urassa,2015). Low soil fertility results from; continuous cropping, removal of crop residues for animal feed and shelter, bush burning, leaching as a result of torrential rain and lack of soil fertility restoring inputs to balance soil nutrients there by resulting into low crops yield and low income. (Adams *et al*., 2015). Unfortunately, the traditional measures of restoring soil fertility including bush fallowing and land rotation are no longer fashionable as a result of population pressure. Farmers therefore, embraced the use of inorganic fertilizers to augment soil nutrient and boost yield. However, inorganic fertilizers are mostly unavailable, and when available, are very expensive, hence, out of the reach of about 70% farmers (FAO, 2019; Urassa, 2015) who are responsible for feeding the people. Inorganic fertilizer besides promoting the luxuriant growth of pest habouring weeds which compete with and inflict injury on our crops on the field, produce weed seeds that contaminate stored grains, it is also associated with land degradation, increase in soil acidity, breakdown of microbial activities in the soil, and environmental pollution. According to Loks *et al*., (2015) ccontinuous use of inorganic fertilizer results in its reduced nutrient release efficiency thereby leaving behind in the soil large proportion of unused nutrients which are likely to damage the soil and the environment.

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The persistent exorbitant cost of fertilizer, over dependency on the use of inorganic fertilizers as a source of plant nutrients by farmers, land and soil degradation and environmental pollution have necessitateda serious demand for sustainable soil nutrient replenishment options in Africa which will be inexpensive, environment friendly and improves crops yield.This research was therefore, initiated in order to explore the potentials of the moringa/ banana/ maize technology- a natural organic fertilizerto serve as the best alternative to the expensive, scarce and hazardous chemical fertilizers. Moringa/banana/ maize technology is a low-cost bio-fertilizer which combines moringa leaves, banana peel and maize stalk in different ratios and different forms(solid or liquid) to replenish soil nutrients

b) Justification for the Study

The current study is a continuation of a baseline study on Moringa Technology carried out in 2016/17 by the author and team members. The moringa Technology a biofertilizer that emanated from the felt needs study carried out by the author's department (Agricultural Economics and Extension services) in 2013 where the community farmers lamented seriously on lack of access (in terms of cost and availability) to chemical fertilizers.

The baseline study ran a trial on the use of Moringa leaves, poultry manure and NPK 15-15-15 individually and their combinations at various levels. It was discovered that Moringa leaves alone could not support maize production 100% except when combined with NPK inorganic fertilizer. This was because Moringa leaves have high content of N (2.56%) and relatively low content of P (0.22%) and K (1.13%)(Moringa leave analysis in 2016).The relatively low level of other essential plant nutrients P and K in moringa leaves necessitated the inclusion of maize stalks and banana peels in the current study since the aim is to use only organic sources. Banana peels and maize stalks have been discovered to have large quantities of phosphorus (P) and potassium (K) but do not have usable Nitrogen (N) which makes the combination more perfect.

The current study is therefore, combining the three organic sources of soil nutrients to replace the use of inorganic fertilizer. So as to reduce cost of producing maize through complete removal of the cost of inorganic fertilizer which is the most expensive farm input on maize farms (Urassa, 2015). The outcome of this study will not only reduce cost of maize production in Africa, it will also produce maize cobs with acceptable taste and enhance sustainable income among maize farmers.

II. Objective of the Study

The general objective of the study is to explore the possibility of using MO, MS and BP mix to optimize maize crop production for increased sustainable income of small-scale farmers.

Specifically, to;

1. Investigate the effect of the different combinations of MO - MS -BP mix on the growth and yield of maize
2. Estimate the cost and benefit of the different combinations of MO- MS-BP technology
3. Determine the optimum combination of MO-MS-BP that will maximize net farm income.
4. Determine the best mode of application of MO + BP +MS mix that produces the highest yield.

III. Components of the Moringa Technology

a) Moringa oleifera leaves

Moringa *oleifera* Lam (family: Moringaceae) christened 'Miracle tree', is a prestigious multipurpose tree found in the tropics and subtropics (Morton, 1991) with highly abundant uses (Adebayo et al., 2011; Moyo et al., 2011). It is considered as one of the world's most useful trees, as almost every part of the tree has an impressive effect in food, medication and industrial purposes (Adebayo et al., 2011., Mishra et al., 2011). M. oleifera has remarkably great potential as organic fertilizer (Jahn 1988). It is a renewable, biodegradable, sustainable and environmentally friendly organic fertilizer that thrive on marginal lands (Adebayo et al., 2011) *M. oleifera* used in its natural form as organic fertilizer performs two functions, it releases nutrient just as required by plant for uptake thus preventing buildup of acidity in the soil. It also improves soil health, structure, pores for air and water retention and micro and macro-organism activities hence, promoting a balanced and sustainable ecosystem at the long run (Jahn 1988). Moringa leaves as organic fertilizer is unparalleled as it does not only contain macro and micro nutrients, but also contain growth hormones such as cytokinin and antioxidants (Abdalla and El-Khoshiban, 2012; Su and Chen, 2020). Empirical evidence abound on use of moringa leaves either in liquid or solid organic fertilizer with favorable and significant results in vegetable crops like rape, cabbage and tomato, and field crops like maize and common beans. Andrew (2011) demonstrated that the liquid spray of M. *oleifera* increased the crop production by 20-35%. Also, it's fast-growing nature makes it a good green manure especially when ploughs into the soil during land preparation. Thus, enriching depleted soils, saving farmers funds ought to be expended in buying inorganic fertilizer and increase quality and yield of food crops that will command higher market price and consequently increase in farmers' income.

b) Banana peels

Banana (*Musa spp*) is a tropical large herbaceous plant belonging to the family Musaceae with very tender stem which is a cylinder of leaf-petiole sheaths, reaching a height of (6-6.5 m) and arising from a fleshy rhizome or corm. Suckers spring up around the main plant forming a clump or "stool", the eldest sucker replacing the main plant when it fruits and dies, and this process of succession continues indefinitely. Bananas have a great economic impact in the world as one of the most popular fruits which is high in nutritive value and as cash export (Stone, 2015). Empirical evidence showed that banana peels contain 4.4 – 6.3% dry weight potassium (K) with significant amounts of Calcium, Magnesium and Sodium along with a number of other trace elements accounting for 9/15 of the commonly tested for elements (Hussain et al., 2019)). Banana peels according to Stone, 2015., Doran and Kaya, 2003 contain 42% potassium, making it one of the highest organic sources of potassium, and even higher than wood ash. Crops like tomatoes and peppers, which have a low nitrogen need respond well to banana peel fertilizer (Stone, 2015).The calcium in banana peel helps in N uptake, manganese aiding photosynthesis, the sodium helps in water movement between cells and magnesium and sulfur both helping in the chlorophyll formation. As important as bananas are, many African countries (Nigeria inclusive) after eating the flesh often toss the peels in the garbage. Banana residues being organic in nature are rich source of macro and micronutrient that can be recycled to prevent their disposal in environment, thus sustaining the balance between economic development and environmental protection (Memon et al., 2012). Application of banana waste improves soil structure, texture, aeration, water holding capacity, porosity, increases stress tolerance and productivity of sorghum bicolor (Mawahib et al., 2015) In addition to improving soil health, it also reduces the use of chemical fertilizers (Hussain et al., 2019) thus saving huge amount of foreign exchange incurred for import of fertilizers.

c) Maize stalk

Maize is cultivated in large quantum in the tropics for food and other uses. Each year, enormous quantity of debris results after harvest especially where maize stalks are not fed to animals or used for sheds and shelters. However, maize stalk has high potential use in organic fertilizer as it contains high content of Phosphorus (P) and Potassium (K) 370 and 1020 (mg/kg) respectively (Galila et al., 2012). The level of K in maize stalk can be increased by ten folds when fermented with fungi while some other mineral components also increased but by a lesser fold (Galila et al., 2012). However, the continuous removal of maize stalks makes the nutrients in maize stalks unavailable to the soil for crop use. The phosphorous in maize stalk is not easily available for plant use (Woldesenbet and Haileyesus 2016). Decomposition and grinding to reduce organic materials to particle size improve nutrient availability in the soil and uptake by plants as they increase the surface areas of organic materials.

Both maize stalk and banana peel do not contain usable nitrogen, hence, serve as perfect combination with Moringa oleifera for nutrient loving crops like maize, hence, Moringa- Banana peel – maize stalk technology has a great potential for cost effective, long- term, sustainable impact in improving maize productivity, soil fertility, structure and income of the resource-poor rural dwellers in Africa.

IV. Materials and Methods

a) 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.

b) Materials and Collection

The materials for the experiment are; maize seeds, moringa leaves, maize stalks and banana peels and NPK 15-15-15 (control)Maize seeds, variety BR9928 DMR-SR (Yellow, Downy Mildew Streak Resistance) were collected from IITA Ibadan, Moringa leaves and maize stalks were collected from Kwara State University Teaching and Research Farm, Malete while banana peels were obtained from women selling roasted plantain by the road sides. N, P and K for the experiment were sourced from Moringa leaves (MO), maize stalk (MS) and banana peel (BP) respectively.

c) Measurement of variables

- *Maize plot:* The area of maize plot was a $3m^2$ divided into three replicates laid out in randomized complete block design (RCBD). Data were collected on ten plants at the middle.
- *Number of leaves(NoL):* were counted at two, four, six and eight weeks after planting WAP
- *Plant height(PLTH):* was taken from the base of the plant to tip stem at 2, 4,6 WAP and the base of the tassel at 8 WAP using meter rule
- *Grain yield:* This was estimated and expressed in ton/hectare.

$$\text{Grain yield (t/ha)} = \frac{\text{field weight (kg) x (100- grain moisture content) (\%) x 10,000}}{\text{85 x 3 x 1000}}$$

15% moisture content

Where shelling % = 85

1 hectare = 10,000m^2

1 tonne = 1,000kg

Stalk lodging (%) It is the percentage of plant stalks that broke below the ear two weeks before harvest.

d) Source of materials

Moringa leaves and maize stalks came from the university farm at no cost

Banana peels were collected from Ipata (a local market in Ilorin) through roasted plantain sellers

N was sourced from moringa

P sourced from banana peel

K sourced from maize stalk

Inorganic fertilizer was bought from the market

e) Experimental Design and procedure

The experimental design involved a screen house and field experimentation both at the Kwara state University Teaching and Research Farm. The Screen house experiment was laid out in complete randomized design (CRD) while the field experiment was randomized complete block design (RCBD) both in three (3) replicates.

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 m^2) with an inter-plot space of 0.5m. The fertilizer treatments consisted of four different nutrients combinations including; - (A) = 70N+30P+ 20K, (B) = 100N+40P+30K, (C) = 120N+50P+40K and a control, (D) = 90kg NPK 15-15-15, a recommended rate for maize. The N, P and K experimental content came from the mixture of Moringa leaves, maize stalk and banana peel. The fertilizer was incorporated into the soil and also applied as foliar. The solid fertilizer obtained from the air-dried and grounded moringa leaves and other components were incorporated into the soil a week before planting while the foliar fertilizer were applied 2 and 6 weeks after planting to reduce being washed off by rain. To form the foliar fertilizer, each of the plant components was dissolved in a litre of water in a jar and covered for three days, thereafter, sieved into sprayer tank containing 1 litre of water and sprayed on the foliar part of the plants. All required agronomic standard practices were used before and after the crop emergence. Maize crop was harvested fresh manually after maturity.

f) Analysis of Soil

Soil samples were randomly taken from the experimental site before planting with the aid of auger, bulked, air dried and ground to pass through a 2mm sieve. Soil analyses were carried out using (Okalebo2002). Soil particle size distribution was determined by hydrometer method using Calgon solution as dispersing agent. Soil pH was determined by using 1:1 soil: water ratio suspension with pH meter. Soil organic carbon was determined by modified wet oxidation method by Wilkey and Black, (1934.) and converted to organic matter by multiplying with 1.724. Total nitrogen was determined by the micro-kjeldahi digestion and distillation method. Available phosphorus was determined by the bray 1 Acid Fluoride Solution. Exchangeable cations were extracted with 1.1 ml Ammonium acetate at pH7.Na and K were measured with flame photometer while Ca and Mg were measured with atomic absorption spectrophotometer. Cation exchangeable capacity was measured by Ammonium acetate technique

g) Financial Analysis

The farm budgetary technique (Olukosi, 2006) was used to determine the net farm income for each treatment to allow for selection of the best alternative. The model for estimating farm budgeting is outlined thus;

$$NFI = GI – (TVC+TFC)$$

Where,

NFI is the net farm income

GI = Gross Income (Expected Total Revenue)

TVC= Total Variable Cost

TFC= Total Fixed Cost

Expected Total Revenue =yield in t/ha * price per tonne

One tonne of maize is # 250,000 (market price)

Total variable cost of production (TVC); Variable costs incurred were on labour, herbicide, transportation, harvesting, weed management, grinding and fertilizer& fertilizer application and maize seeds.

2 bags of NPK = #15,000

Maize Seeds = 5kg = #6000 /ha

Grinding = #3,000

Total Transportation=#18,000

For each of the other operations, labour cost = #15,000/3m^2 *1,000 m^2

Note;-1 US$ = #500

Total fixed cost (TFC); Depreciation on land and equipment, expenses on land preparation (clearing, ploughing and ridging),

To obtain the worth of each of the fixed cost items the straight-line method of depreciation was used.

The formula for depreciation using straight line method is given as;

Depreciation = Purchase/No of Useful Years of the Asset

h) Data Analysis

All data collected were subjected to analysis of variance and correlation analysis. Significant mean values were separated with Duncan's Multiple Range Test. All data were analyzed using SAS program.

i) Procedure for data recording

Collection of data commenced from 2weeks and followed by4, 6 and 8 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. Average Number of Leaves and proportion of plants were physically counted and recorded. The yield was determined by measuring cob weight and dry grain weight of 100 grains. Cost of materials used and price of maize were determined through reigning market prices. The US$ equivalent was obtained using official exchange of US$1 to N500 (as at December 2021)

V. Results and Discussion

a) Soil Analysis

Table 1: Physical and chemical properties of the experimental soil

Physical properties	Soil test value
pH (H_2O)	6.8
Sand	82.4
Silt	6.4
Clay	11.2
Textural class	Sandy loam
Chemical properties: Exchangeable Bases (cmol/kg)	
Ca	1.65
Mg	1.02
K	0.3
Na	0.57
ECEC	3.59
Base saturation (%)	98.61
Total N (%)	0.08
Total Organic C(%)	0.66
Available P(mg/kg)	33.13
Micro nutrients (mg/kg)	
Mn	32.33
Fe	8.5
Cu	0.55
Zn	0.78

Source; field survey 2020

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 is considered to be the second important nutrient, as it 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 (Wikkipaedia, 2018). However, most Nigerian soils including the experimental site are deficient in NPK nutrients (Olowoake et al., 2015), these nutrients therefore need to be supplied. The finding implies that maize crop will respond positively to nutrient treatment.

b) Analysis of Moringa leaves, Banana peels and Maize stalks

The different treatments in the study involves the use of, Moringa oleifera leaves (MO), Banana Peels (BP) and Maize Stalks (MS) and these are shown in Table 2 to possess nutrients (NPK) beyond the critical requirement for maize good performance (Ayodele and Omotosho 2008)

Table 2: Proximate analysis of Moringa leaves, Banana peels and Maize stalks

Mineral content	N	P	K
Moringa leaves	2.56	0.10	1.93
Banana peels	1.736	0.09	7.61
Maize stalks	1.256	0.05	0.99
Maize stalks after fermentation	ND	3.75	10.232

Source; field survey 2020, ND; not determined

c) *Number of maize leaves*

i. *Number of leaves of Maize plant as influenced by fertilizer types in 2020 cropping season*

Table3 revealed that nutrient application resulted into production of varying number of leaves which are the precursors of grain yield. The finding implies that grain yield and subsequently farmers income can be improved through the application of nutrients in the study area. Among the experimental treatments both on the field and screen house, more number of leaves per plant were recorded under the control treated with 90kg NPK fertilizer but closely followed by treatment B=120N+50P + 40K, followed by treatment A=100N+40P+30K while treatment C=70N+30P+20K had the least number of leaves per plant. Although, the control treated with 90kg NPK fertilizer produced a greater number of leaves it was discovered that there were no significant differences between the number of leaves on the NPK treatment and A&B treatments for each mode of application.

ii. *Comparison of number of leaves under different methods of fertilizer application and site of the experiment in 2020 cropping season*

Tables 3&4 showed the number of leaves under different methods of fertilizer application and site of the experiment (i.e., solid vs foliar and field vs screen+) in 2020 cropping season. The analysis revealed that the number of leaves per plant differed significantly ($P < 0.05$) among the different modes of fertilizer application and the site of the experiment. The number of leaves was higher on the plots treated with solid fertilizer applied one week before planting than foliar application 2 and6 weeks after planting both on the field and in the screen house. This result is similar to Dahiru et al., (2016) in his study on crop growth and mode of nutrients application reported that incorporated fertilizer a week before sowing had superior performance with regards to vegetative traits compare to foliar spray on maize. The significance difference between the two modes of nutrient application was explained by Machado et al., (2011) also had similar finding in their study and explained that organic fertilizer release nutrients slowly and the nutrient might have been washed off by rain even before the nutrients are released and absorbed by plants.

Table 3: Number of leaves of Maize/ plant under different treatment, mode of nutrient application and site of the experiment (Field)

Mode of Nutrient Application/site	Solid on field				Spray on field			
Mean no of leaves in WAP per Treatment	A	B	C	D	A	B	C	D
NOL 2	7.2a	7.3a	7.3a	7.5a	5.50b	5.60b	4.98b-e	6.90a
NOL 4	14.60a	14.80a	14.6a	15.0b	11.20b	11.60b	9.92b-e	13.80a
NOLL6	23.50a	23.80a	23.12a	23.75a	17.73b	17.62b	15.71b-e	21.85c-e
NOL 8	24.33a	24.33a	24.33a	25.00a	18.67b	18.33b	16.53b-e	23.00a

Source; Field analysis, 2020

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting

Table 4: Number of leaves of Maize/ plant under different treatment, mode of nutrient application and site of the experiment (Screen)

Mode of fertilizer Application	Fertilizer solid in screen house				Fertilizer spray screen house			
Mean No of leaves in WAP Treatment	A	B	C	D	A	B	C	D
NOL2	5.87a	5.98a	5.97a	6.30a	4.46d	3.58b	4.26b	5.87a
NOL4	11.70a	11.80a	11.97a	12.30a	8.82b	6.49d	7.66b-d	10.98a
NOL6	19.68a	19.81a	19.88a	20.43a	15.25b	11.71e	13.51b-e	18.79a
NOL8	21.60a	21.90a	21.90a	22.50a	16.80b	12.90e	14.88b-e	20.70a

Source; Field analysis, 2020

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting

d) Maize Plant Height

i. *Maize plant height as influenced by nutrient levels*

In the study, maize plant height was significantly influenced by the variation in the level of nutrients and mode of fertilizer application (Table 4). The height of the maize plants under each treatment ranged in the following order; 120N+50P+40K>100N+40P+30K 90kg NPK > 70N+30P+20K with C= 70n+30p+20k having the least height. This finding is synonymous with karasus, 2012 who discovered that vegetative growth increased with increased nutrient application.

ii. *Maize plant height as influenced by mode of nutrient application*

The plants treated with solid fertilizer incorporated in the soil one week before planting appeared taller than the plants treated with foliar application both on the field and in the screen house. However, the plants on the field have more luxuriant growth than those in the screen house. The height of the maize plants under inorganic fertilizer NPK 15-15-15 were the tallest, but as in the case of number of leaves (Table 3) there were no significant differences in the maize height under 120N+50P+40K &100N+40P+30K treatments.

Table 5: Maize plant height (cm) as influenced by fertilizer types and mode of fertilizer application on the field in 2020 cropping seasons

Mode of fertilizer Application	Fertilizer solid on field				Fertilizer spray on field			
Mean Plant height/Treat ment	A	B	C	D	A	B	C	D
PLTH2	19,83ab	19.90ab	16.30c	19.70ab	17.20a	14.43ab	15.73ab	13.83ab
PLTH4	49.58ab	49.70a	40.75c	49.25ab	43.00a	36.08ab	39.33ab	34.58ab
PLTH6	119.60ab	119.80a	97.80c	118.20ab	103.20a	86.60ab	94.40ab	83.00ab
PLTH8	198.33ab	198433a	163.00c	197.00ab	172.00a	144.33a	157.33ab	1386.33ab

Source; Field analysis, 2020

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting

Table 6: Maize plant height (cm) as influenced by fertilizer types and mode of fertilizer application in the screen house in 2020 cropping seasons

Mode of fertilizer Application	Fertilizer solid in screen				Fertilizer spray in screen			
Mean Plant height WAP/ Treatment	A	B	C	D	A	B	C	D
PLTH2	15.70ab	15.90a	12.51ed	15.63a	13.20a	11.48ab	12.32a	10.59ab
PLTH4	38.37ab	38.63ab	31.47c-g	37.00a-e	33.07a	28.00ab	30.00ab	26.00ab
PLTH6	84.57a-g	84.67ab	70.77d	88.42a	76.82a	61.33a-c	67.33a-c	58.12bc
PLTH8	155.27a	155.33a	128.40d-e	145.00a-c	133.67a	114.33ab	123.00ab	108.80ab

Source; Field analysis, 2020

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting, PLTH =plant height

e) Maize Grain Yield

i. *Grain yield on the basis of different nutrients levels*

Table 7 shows that after the control of 90kg inorganic fertilizer, treatment B =120N+50P+40K produced the highest total grain yield (4.76 t/ha and2.81 t/ha) on the field and screen house respectively, this was followed closely by treatment A = 100N+40P+30K with (4.50 t/ha on field and 2.67 t/ha screen house) while treatment C= 70N+30P+20K had the least yield (4.43t/ha on field and 2.72t/ha) in screen house). This finding shows that vegetative growth and grain yield in maize increase with increased nutrient application (karasus, 2012)

ii. *Grain yield on the basis of mode of fertilizer application*

Table 7 also shows that, the maize grain yield differed significantly ($P < 0.05$) among the different modes of fertilizer application. The maize grain yields under fertilizer solid on the field and in the screen, were significantly higher than the maize grain yields under fertilizer spray on both sites. This finding agrees with Machado et al., (2011) who explained that since organic fertilizer releases nutrients slowly, its application as spray, might encourage washing off by rain even before the nutrients are released and absorbed by plants.

iii. *Differences in yield of field and screen*

Comparatively, the maize grain yields under fertilizer solid and fertilizer spray in the screen are significantly($p<0.05$)lower than the yields from the field(Table 5).The implication is that foliar application of organic fertilizer had no influence on yield of maize. Incorporated fertilizer applied a week before sowing had superior performance on maize grain yield. Reason for this could be because of the serious lodging that occurred on the different treatment pots in the screen house. Serious lodging according to Symons et al., (2008) and Bänziger et al., (2006) occurs as a result of etiolation (weak stems) of the maize stands due to water stress or abiotic stress such as Nitrogen. When this happens, maize cobs are rendered susceptible to rodent attack and decay which could reduce grain yield. (Ajala et al., 2018), Xu et al. (2017) and Bänziger et al. (2006)also reported reduced yield in the screen house compared to the open field.

Table 7: Maize grain yield (T/Ha) under different treatments and modes of fertilizer application on the field and in the screen house

Mode of fertilizer Application	Fertilizer solid on field				Fertilizer spray on field			
Mean yield (t/ha)per Treatment	A	B	C	D	A	B	C	D
Field	4.5 de	4.76 bc	4.43 def	4.87 ab	2.67efg	2.81 ef	2.72 efg	3.33 b
Screen House	1.92bc	1.94bc	1.86bc	2.1ab	1.43f-h	1.49f-g	1.45f-h	2.1ab

Source; Field survey 2020

i. *Differences in yields of control and experimental treatments*

Quantitatively, the control- inorganic NPK fertilizer produced higher yield than each of the three organic fertilizer treatments both as solid or spray, on the field or in the screen house. However, statistically, there was no significant difference between grain yield produced from the recommended 90kg/ha NPK inorganic fertilizer and the 120N+50P+40K organic fertilizer when applied under solid mode on the field. The finding implies that the organic fertilizer applied at the rate of 120N+50P+40K competes very well with NPK 15-15-15 and may be used in place of the inorganic fertilizer and still get about the same quantity of output.

f) *Economic Performance of Maize*

Table 8: Economic performance of maize using different Treatments under solid and spray on the Field

Economic performance Indicators	Yield (T/ha)	Revenue/ maize treatment ₦/ha	Total Variable cost (₦/ha)	Total Fixed cost (₦/ha)	Total cost (₦/ha)	Net farm income₦/ha	Rev/cost ratio
Treatment under Solid on field							
A	4.5de	1,570,000	18,500	8,000	26,500	1,543,500	59:1
B	4.76bc	1,760,000	18,500	8,000	26,500	1,733,500	66:1
C	4.43def	1,502,000	18,500	8,000	26,500	1,475,500	56:1
D	4.77ab	1,870,000	200,000	8,000	208,000	1,662, 000	9:1

i. *Economic performance of maize using different Treatments under solid and spray on the Field*

There were variations in the economic performance among the different treatments using solid or foliar fertilizer application on the field. Tables 8 & 9 show that treatments under solid fertilizer application performed better than those under foliar application. The following Net Farm Income were obtained for treatments under solid application; A = 100N+40P+30K = #1,543,500 ($3,087), B =120N+50P+40K = # 1,733, 500 ($3,467), C= 70N+30P+20K = # 1,475,500 ($2,951) and D=NPK 15-15-15= #1,662, 000 ($3,324). However, under foliar application on the field the Net Farm Incomes are; A = 100N+40P+30K = #641,000 ($1,282), B = 120N+50P+40K = # 676,000 ($1,352), This result shows that treatment B = 120N+50P+40K = # 1,733,500 which gave the highest net income has the highest economic value especially when incorporated as solid fertilizer one week before planting. The reason for poor economic performance of the different combinations of moringa technology under screen house may have been as deduced by Machado et al., (2011) that organic fertilizer releases nutrients slowly, its application as spray, might encourage washing off by rain even before the plants absorbed the nutrients.

Table 9: Economic performance of maize under different treatments using spray on the Field

Economic performance Indicators	Yield (T/ha)	Revenue/ maize treatment ₦/ha	Total Variable cost (₦/ha)	Total Fixed cost (₦/ha)	Total cost (₦/ha)	Net farm income₦/ha	Rev/cost ratio
Treatment							
A	2.67efg	667,500	18,500	8,000	26,500	641,000	25:1
B	2.81ef	702,500	18,500	8,000	26,500	676,000	26:1
C	2.72efg	680,000	18,500	8,000	26,500	653,500	25:1
D	3.33	832, 500	200,000	8,000	208,000	632,500	4:1

ii. *Economic Performance of Maize Under Fertilizer Solid and Foliar in the Screen House*

Economic performance of maize under fertilizer application as solid or as spray in the screen house are significantly ($p<0.05$) lower than the performance on the field(Tables 8&9).This finding followed the same pattern as previously discussed under differences in the growth traits and yields between the plants on the field and those in the screen house. Reason for this could be explained by the fact that there was too much lodging of maize plants in the screen house. This led to maize cobs decay which reduced the total yield. Since yield determines sales, it implies that revenue will be low when yield is low and so will be net income.

Table 8: Economic performance of maize under different Treatments (Screen House)

Economic performance	Yield (T/ha)	Revenue/ maize treatment ₦	Total Variable cost (₦)	Total Fixed cost (₦)	Total cost (₦)	Net farm income₦	Rev/cost Ratio
Treatment: Solid screen house							
A	1.92be	480,000	18,500	8,000	26,500	453,500	18:1
B	1.94bc	485 ,000	18,500	8,000	26,500	458,500	18:1
C	1.86bc	465,000	18,500	8,000	26,500	438,500	17:1
D	2.12a	525,000	200,000	8,000	208,000	317,000	3:1
Treatments: Spray screen house							
A	1.43f-h	357,500	18,500	8,000	26,500	331,000	13:1
B	1.49fg	372,500	18,500	8,000	26,500	346,000	14:1
C	1.45fh	362,500	18,500	8,000	26,500	336,000	13:1
D	2.1ab	525,000	200,000	8,000	208,000	317,000	3:1

Field analysis, 2020

iii. *Economic performance of maize under Organic and inorganic fertilizers using solid approach on the field*

Table 8 shows variations in the economic performances of maize under organic and inorganic fertilizers applied as solid on the field. The performance followed the earlier discussions on maize yield and other agronomic traits except that the control (D= the inorganic fertilizer) with the highest yield gave way to treatment B =120N+50P+40K in terms of economic performance. Treatment B had the highest net income because of its low cost. The net income from treatment B =120N+50P+40K stood at N 1,733,500 per hectare while that of control with the recommended dose 90kg/ha of NPK 15-15-15 was N1,662,000 per hectare Although there was no significant difference ($p<0.05$) between the two. The implication of this outcome is that Moringa /banana / maize mixture (organic fertilizer) at the rate of 120N+50P+40K competes well with inorganic fertilizer and can replace it use conveniently. Also, that the adoption and use of this organic mixture at the recommended rate of 120N+50P+40K will facilitate sustainable income of maize farmers.

VI. Summary

The study was carried out to investigate the possibility of optimizing maize crop production in Africain order to maximize net farm income of rural farmers using moringa leaves/bananapeels/maize stalk technology. Also, to specifically investigate the effect of different rate of combining the mixtures (treatments) on the growth, yield and net returns of maize with a view of choosing appropriate combination that will maximize net farm income. And to also compare the yield and economic performance of maize on the field and screen house. Four treatments were considered and each represented a technology on field/screen trials conducted in 2021. These include; A=100N+40P+30K, B= 120N+50P+40K, C= 70N+30P+20K and the control using the national recommended dose of 90kg/ha of NPK fertilizer. Results of the study showed that:

1. Application of organic fertilizer in solid form incorporated into the soil a week before planting produced the highest number of leaves, tallest plants, and heaviest cobs on both the field and screen house experiments. The observed variations across the treatments follow the order of 90kg NPK >120N+50P+40K > 100N+40P+30K while 70N+ 30P+20K was always having the least.
2. Economic performance of the treatments under solid fertilizer application were better than those under foliar application.
3. Economic performance of maize under the or application as solid or as spray in the screen house are significantly ($p<0.05$) lower than the performance on the field
4. The result of the study showed variation in the economic performances of maize under organic and inorganic fertilizers applied as solid on the field. The inorganic fertilizer applied at the national recommended dose of 90kg/ha NPK had excellent performance in all the agronomic traits (highest number of leaves, tallest plants biggest grain yield) but failed in the area of net farm income. Treatment B = 120N+50P+40K had the highest net farm income of. # 1,733,500 ($3,352) while inorganic fertilizer had N1,662,000 ($3,324) both per hectare respectively.

VII. Conclusion and Recommendation

The outcome of the study revealed that; Moringa-banana peel-maize stalk fertilizer incorporated in the soil in solid form, a week before planting at the rate of 120N+50P+40K on the open field provided

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sustainable, eco-friendly, and cost-effective alternative to inorganic NPK fertilizer at national recommended rate. On the basis of these findings the use of moringa based fertilizer: MO+MS+BL at the rate of 120N+50P+40K was judged more economical in the study area and was recommended for adoption by maize farmers

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References Références Referencias

1. Abbas A, Muhammad A.K, Ashiq S, Marwat K.B, Abbas U.K, Dawood J and Shahid S. 2016. Performance and economics of growing maize under organic and inorganic fertilization and weed management. Pak. J. Bot., 48 (1):311-318.
2. Abdalla MM., El-Khoshiban N. 2013. The parliative effect of bio-organic fertilizer on landpoution in Lycoperscicum esculentum plants. J. Basic App. Sci. 8: 1 -12.
3. Adams, H., Gebrekidan, H, Bedadi, B., Adgo, E. 2015. Effect of organic and inorganicon yield and yield components of maize at Wujirab watershed, North Western Highlands of Ethiopia American Journal of plant Nutrition and fertilizer Technology, 5: pp 1-15.
4. Adebayo, A.G., Akintoye, H.A., Olufolaji O.O., Aina, M.T., Olatunji, M.T. and Shokalu, A.O. 2011. Assessment of organic amendments on vegetative development and nutrient uptake of *Moringa oleifera* Lam in the nursery. Asian J. Plant Sci. 10(1):74-79.
5. Ajala, S. O., Olaniyan, A. B., Olayiwola, M. O., Job, A. O. 2018. Yield improvement in maize for tolerance to low soil nitrogen. Plant Breeding, 1-9 https://doi.org/ 10.1111/pbr.12568.
6. Andrew Young, United Nations Ambarssador, 2011. Amaizing Benefit of Moringa oleifera in Agriculture. Richmond Vale Academy Chateaubelair St. Vincent and the Grenadines. Retrived Oct, 2014 +1784 458 2255 www.Richmndvale.org
7. Ayodele, O. J., Omotoso, S. O. 2008. Nutrient Management for Maize Production in the Soils of Savannah Zone of South-Western Nigeria International Journal of Soil Science, 3:pp 20-27.
8. Bänziger, M., Setimela, P. S., Hodson, D., Vivek, B. 2006. Breeding for improved abiotic stress tolerance in maize adapted to southern Africa Agricultural water management, 80: pp 212-224.
9. Dahiru, T. M., Bamai, N., Yamma, K. M. 2016. Effects of Combined Application of NPK and Foliar Fertilizer (Boost-Extra) On Yield and Yield Components of Maize (Zea mays L.) In Mubi, Northern Guinea Savannah Zone of Nigeria International Journal of Innovative Agriculture & Biology Research, 4:pp 17-25.
10. Doran I, Sen B, Kaya Z. The effects of compost prepared from waste material of banana plants on the nutrient contents of banana leaves. J Environ Biol. 2003 Oct; 24(4):437-44. PMID: 15248659.
11. Emmanuel S.A, S.G. Zaku, S.O Adedirin, M. Tafida, S.A. Thomas 2011.. Moringa oleifera seed cake, alternative biodegradable and biocomtibility organic fertilizer for modern farming.
12. Agriculture and Biology Journal of North America, 2(9): 1289 – 1292. Retrieved Oct. 2014. http://www, Scihub. Org. ABJNA
13. FAO, 2019. The state of food security and nutrition in the world. Food and Agriculture. Rome. 2019. ISBN978 – 92 – 5 – 131570-5
14. A. M. A., Darwish, A. A., Bakr, M. M. F., Abdallah, A. 2012. Nutritional value upgrading of maize stalk by using Pleurotusostreatus and Saccharomyces cerevisiae in solid state fermentation Annals of Agricultural Science, 57:pp 47–51.
15. Hassan, H. F; Hassan, U.F; Usher, O. A; Ibrahim, A.B; and Tahe, N.N. 2018.
16. Exploring the potentials of banana (Musa sapinetum) peels in feed formulation. International journal of advanced research in chemical science (IJARC) VOL5, ISSUE 5, 2018 www.arcjournalsorg.
17. Arabloo M, Taheri M, Yazdani H, Shahmoradi M (2017) Effect of foliar application of amino acid and calcium chelate on some quality and quantity of Golden Delicious and Granny Smith apples. Trakia J Sci 15(1):14–19
18. IITA, 2019. International Institute of Tropical Agriculture. Guide to maize production in northern Nigeria. Retrieved from https://www.iita.org
19. Jahn, S.A.A. 1988. Using Moringa Seeds as Coagulants in Developing Countries. *Journal (Mangement Operations*: 43-50.
20. Karasus A. 2012. Effect of nitrogen levels on grain yield and some attributes of some hybrid Maize cultivars (Zea mays indentata Sturt.) grown for silage as second crop. Bulgarian Journal of Agricultural Science, 18, 42-48.
21. Loks NA, Manggoel W, Daar JW and Manzing D. (2014). The effects of Fertilizer residues in soils and crops performance in northern Nigeria: A Review, Int. Res. J Agric. Sci. Soil Sci. 4(9):180-184.
22. Machado, D. L. M., de Lucena, C. C., dos Santos, D., de Siqueira, D. L., Matarazzo, P. H. M., Struiving,

T. B. 2011. Slow-release and organic fertilizers on early growth of Rangpur lime. Rev. Ceres, Viçosa, 58, 359-365.

23. Memon, F., Bhutto, N.A. and Abbas, G., 2012. Capital structure and firm performance: A case of textile sector of Pakistan. *Asian Journal of Business and Management Sciences*, *1*(9), pp.9-15.
24. Mishra G, Singh P, Verma R, Kumar S, Srivastava S, Jha KK, Khosa RL (2011). Traditional uses, phytochemistry and pharmacolical properties of Moringa oleifera plant: an overview. Der PharmaciaLettre. Scholar Res. Lib. 3(2):141-164
25. Moyo, B., Masika, P. J., Hugo, A., & Muchenje, V. (2011). Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. *African Journal of Biotechnology*, *10*(60), 12925-12933.
26. Monneveux, P., Zaidi, P. H., Sanchez, C. 2006. Population density and low nitrogen affects yield-associated traits in tropical maize. Crop Science 45: pp 535-545.
27. National Bureau of Statistics, (NBS) 2012. Social Statistics in Nigeria; statistics on health, employment, public safety, population and vital registration in Nigeria. National Bureau of Statistics, Nigeria.
28. National Bureau of Statistics, 2013. Sector Statistics. Retrived Dec. 2014 h
29. OECD-FAO, 2016. Agriculture in Sub-Saharan Africa: Prospects and challenges for the next decade. Agricultural Outlook 2016-2025.
30. Okalebo, J.R., K.W. Gathua, and P.L. Woomer. (1993).Laboratory method of soil and plantanalysis: a working manual. Tropical Soil Biology and Fertility Programme (TSBF),Nairobi, Kenya.88p
31. Olowoake, A.A., Ojo J.A. and Osunlola, O.S. 2015. Growth and yield of okra (*Abelmoschus esculentus* L.) as influenced by NPK, jatropha cake and organomineral fertilizer on an Alfisol in Ilorin, Southern Guinea Savanna of Nigeria. Journal of Organic Systems, 10(1): 3-8.
32. Olukosi, J.O Isitor, S.U. and Ode, M.O. (2006). *Introduction to agricultural marketing and prices: principle and application*. Living book series, GU publications Abuja, 115p.
33. Premium Times, 2021. Nigeria's Agriculture in facts and figures. Retrieved from premiumtimesng.com/category/agriculture on February 2021.
34. Reliefweb, 2017. East Africa: Regional Maize Supply and Market Outlook - September 14, 2017. Retrieved from https://reliefweb.int/report/uganda/eastafrica-regional-maize-supply-
35. SAS Institute Inc. (1996) SAS Software Version 9.4. Cary, NC: SAS Institute Inc; 2014.
36. Seyyedi S.M, Hosseni M.K, Moghaddam P.R, and Shahandeh h. 2015.Effects of Phosphorus and seed priming on seed vigor, fatty acids composition and heterotrophic seedling growth of black seed (Niggella sativa L) grown in a calcareous soil. Indust. Crops Prod., 74:939-949.
37. Soyelu, L. O., Ajayi, S. A., Aluko, O. B., Fakorede, M. A. B. 2001. Varietal Differences in Development of Maize (Zea mays L.) Seedlings on Compacted Soils Journal of Agronomy and Crop Science, https://doi.org/10.1046/j.1439-037X.2001.00467.x
38. Stone, K. 2015. Banana Peel Fertilizer Benefits and Uses http://stonefamilyfarmstead.com/bananapeel-fertilizer/
39. Symons, G. M., Smith, J. J., Nomura, T., Davies, N. W., Yokota, T., Reid, J. B. 2008. The hormonal regulation of de-etiolation. Planta, 227: pp 1115-1125.
40. Su B and Chen X (2020). Current status and potential of Moringa oleifera leaf as an alternative protein source for animal feeds. Vet. Sci. 7:53 Doi 103389/fvets 2020.00053
41. USDA, 2020.Haytowitz, David B.; Ahuja, Jaspreet K.C.; Wu, Xianli; Somanchi, Meena; Nickle, Melissa; Nguyen, Quyen A.; Roseland, Janet M.; Williams, Juhi R.; Patterson, Kristine
42. Y.; Li, Ying; Pehrsson, Pamela R.. (2019). USDA National Nutrient Database for Standard Reference, Legacy Release. Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, ARS, USDA. https://data.nal.usda.gov/dataset/usda-national-nutrient-database-standard-reference-legacy-release. Accessed 2022-03-03.
43. Urassa, J. K.2015. Factors influencing maize crop production at household levels: A case of Rukwa Region in the southern highlands of Tanzania. African Journal of Agricultural Research,2015; 10(10): 1097-1106. URl: http://www.suaire.sua.ac.tz/handle/123456789/2139 Access; 3/3/2022
44. Woldesenbet, M., Haileyesus, A. 2016. Effect of nitrogen fertilizer on growth, yield and yield components of maize (Zea mays L.) In Decha district, southwestern Ethiopia. International journal of research granthaalayah, 4: 95-100. www.fao.org/faostat/en/#data/QC (accessed 7 December, 2020) 2018 FAO statistics.
45. Xu, G., Liu, X., Wang, Q., Xiong, R., Hang, Y. 2017. Effects of screen house cultivation and materials incorporation on global warming potential in rice fields Environmental Science and Pollution Research 24:pp 7 DOI:10.1007/s11356-017-8397-7.