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RISING TO THE CHALLENGE OF LOW SOIL FERTILITY IN NIGERIA; SUSTAINABLE MAIZE CROP PRODUCTION UNDER MORINGA OLEIFERA TECHNOLOGY.

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ABSTRACT

The moringa oleifera technology is a soil fertility improvement technique that is environment friendly. The objective of this study was to investigate the effects of moringa technology on yield and profitability of maize production. Field experiment was conducted in 2016 and 2017 planting seasons, at the Teaching and Research Farm of Kwara State University, Malete. 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 RCB design with three replicates. Data were collected on maize growth parameters; crop yield, cost and returns. These were subjected to statistical and economic viability analyses. Results showed that application of the mixed MO leaves +NPK significantly ($P< 0.05$) increased the growth parameters and grain yield of maize and net income. The highest grain yield (4.4 and 4.5t/ha) and net income [₦143,500 (US$ 448.44) were obtained from the mixture in 2016 and 2017 respectively. On the basis of these findings therefore, the use of moringa based fertilizer (MO+NPK) at the rate of 60 kg N/ha recommended for adoption by maize farmers.

Key: Maize, growth, yield, moringa leaves, NPK and poultry manure.

BACKGROUND TO THE STUDY

Maize is an important food crop which ranks third after wheat and rice in the world (Asadu *and* Unagwu 2012). Maize is the primary staple food in Nigeria and critical to about 112 million small holder livelihoods (NBS, 2013). 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). However, one of the major challenges of Tropical Africa smallholders is low crops yield, due to low soil fertility (Agbede, 2010) 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). To meet up with these challenges in the year 2020 and beyond, there is need to promote good crop performance, increased yield per cultivated area, increased economic benefits for producers and farmers through sustainable maintenance of soil fertility.

The traditional methods of maintaining soil fertility are through fallowing, use of a well planned system of crop rotation or application of inorganic fertilizers or organic manure (Compost, farm yard manure, e.t.c) (Makinde et al 2010., Asadu and Unagwu 2012).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. Compost manure 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 (Sullivan 2003). Applying inorganic fertilizer is one of the widely accepted ways of increasing soil nutrients both in the temperate and tropical regions of the world. However, long term studies have shown that there is limit to which inorganic fertilizer can sustain the productivity of intensely cultivated soil. This is because of problem of decrease in yield with time, enhancement of soil acidity, leaching losses, and degradation of soil physical and organic matter status (Ojeniyi 2002, Ogbalu 1999). Animal manure including poultry, cattle, sheep and pig

manure has been found to be effective in maintenance of adequate supply of organic matter in soil, with improvement in soil physical and chemical condition and enhanced crop performance (Ikpe 2002). Adeniyan and Ojeniyi (2005) Ojeniyi and Adegboyega \(2003) reported that addition of poultry and cattle manure to the soil lead to increase in soil PH, Organic Carbon, Nitrogen, Phosphorus, Calcium/ Potassium, Magnesium, Sodium and CEC.

Research has however shown that organic based fertilizers are cheap, less leached and less likely to pollute the ground water as much as chemical fertilizers. They improve soil fertility status as well as increasing the income of the farmers via increase in yield (Rachid and Ryan 2004). They provide a continuous decomposing substrate and consequent gradual input of soil organic matter, thereby increasing soil nutrients and improving the soil physical properties. Use of organic based fertilizers has been widely adopted in boosting crop production in Nigeria. There has been an increase in studies of organic sources of soil nutrients. Research on moringa application as fertilizer has been reported to increase the growth, yield and quality of crops. Several researches have indicated that M. oleifera is a highly valued plant with multipurpose effects (Fuglie 2000.,Yang et al 2006., Adebayo et al 2011). Increase in grain yield of maize has been reported by Emmanuel et al (2011). Moringa oleifera has been investigated to ascertain its effect on growth and yield of crops and therefore, can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (Mvumi et al 2013. Phiri 2010)

Complementary use of organic and inorganic fertilizers has been proved to be a sound soil fertility management strategy (Olowoake 2017., Olatunji & Ayuba 2012). Organic fertilizers fortified with inorganic materials have been formulated to replenish the soil and improve plant fertilization. They are said to release nutrients in soil in the form that the plants can easily absorb, activate soil microorganisms and increase microbes, which will help the decomposition processes of organic matter which will promote higher plant growth, healthier crops and better yield. The process also reduces the quantity of chemical fertilizer which will be used thereby leading to lower production cost and indirectly increase income There is now a growing demand for sound, ecologically compatible and environmental friendly techniques in agriculture, capable of providing enough food for the increasing human population; retaining soil quality and improving the quality and quantity of agricultural produce (Ojeniyi 2002., Abbas et al 2016., Makinde et al 2010). The current study is a rise to meet the stated need. The application of Moringa technology comprising Moringa oleifera leaves and its

complimentary use with poultry manure, and inorganic fertilizer is a new one that will promote sustainable increased soil fertility, high maize yield and net farm income.

Objectives of the study;

The general objective of the 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 optimum combination of plant nutrients that will maximize net farm income.

MATERIALS AND METHODS

Experimental Site;

The Teaching and Research Farm, Kwara State University, Malete, (08^{o} 42'48.5''N and 004^{o} 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^{o} C and 34^{o} 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, 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 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

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 m^2) 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 (Makinde et al 2010). 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 were determined through reigning market prices. The US$ equivalent was obtained using official exchange of US$1 to N306.3 (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). To compare the net income, the total expenditure and total income were recorded for each sub plot.

RESULTS AND DISCUSSION.

Table 1 Physical – chemical properties of experimental soil.

Parameters	Soil test value
pH (H_2O)	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

Source; field survey 2016

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 (Wikki paedia, 2018). However, most Nigerian soils including the experimental site are deficient in NPK nutrients (Table 2) and (Olowoake et al., 2015), these nutrients therefore need to be supplied. The finding implies that

maize crop will respond positively to the different treatments of the study.

The different treatments in the study involves the use of , Moringa oleifera leaves (MO), Poultry Manure (PM) and inorganic fertilizer (NPK) and these are shown in Table 2 to have high content of NPK and other essential micro – elements required for good maize performance.

Table 2: 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
Inorganic fertilizer	15	15	15	-	-	-	-	-

Source; field survey 2016

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

MO =Moringa leaves, PM = Poultry manure, MO+NPK = Moringa leaves + NPK 15-15-15, MO + PM = Moringa leaves +poultry manure

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

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. Olatunji and Ayuba (2012), Rachid and Ryan (2004) 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

Legend; MO =Moringa leaves, PM = Poultry manure, MO+NPK = Moringa leaves + NPK 15-15-15, MO + PM = Moringa leaves +poultry manure

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 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 the highest total grain yield (4.4 t/ha and 4.5 t/ha) in 2016 and 2017 respectively, while the control had the least grain yield of (1.5 t/ha and 1.7 t/ha) in 2016 and 2017 respectively. The MO + NPK treatment produced 11-61 % and 20 – 26% more grain yield than other treatments in 2016 and 2017 respectively 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 physio-chemical analysis. This agrees with statement by FAO (2013) that increment in maize production occurred at higher levels of fertilizer application. The higher grain yield produced from the combination of MO and NPK was similar to the works of Chukwu et al (2012), Okigbo (2000) who reported that the combinations of organic and inorganic fertilizer perform better on the yield of maize, than when each of them is solely used .The fact that MO+NPK plot had significantly higher grain yield than any other treatments including NPK treatment plot, implies that the combination of 50% (MO) +50% NPK applied at the rate of 60 kg N/ha is the most effective option required to

supply appropriate nutrients for optimal performance of maize crop in the country.

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

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	34,000	8,000	42,000	72,000	2.7:1
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,ooo	117,000	3.8:1

- Means having the same letter indicate no significant difference using Duncan's multiple range test at 5% probability level

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 treatments differed, depending on the combinations of the nutrients. NPK and MO+PM have high net incomes, but the combination of MO+NPK proved economical by given higher income. It gave a net return of ₦143,500 (US$ 448.44) and a favorable benefit cost ratio of 4.2:1 which implies the benefit is four times the cost. This promises a sustainable profitability to farmers. The combination is therefore recommended for adoption by farmers

Conclusion and Recommendation

The study was carried out to investigate the possibility of optimizing maize crop production to maximize net farm income of rural farmers using moringa technology. Also to specifically investigate the effect of the different moringa technologies (treatments) on the growth, yield and net returns of maize with

a view of choosing one that will maximize net farm income. Six treatments were considered and each represented a technology on field trials conducted in 2016 and 2017 to investigate the response of maize to the different treatments Three major findings came out distintictly ;

- The study showed that moringa leaves combined with NPK at 60kg N/ha gave the best performance in all the growth and yield parameters.
- Maize planted with combination of MO+NPK fertilizer had the maximum net farm income implying the two different plant nutrients are combined at least cost
- The optimum quantity of yield was attained when 50% (MO) was combined with 50% NPK at the rate of 60 kg N/ha

On the basis of these findings therefore, the use of moringa based fertilizer: MO+NPK at the rate of 60 kg N/ha was judged more economical in the study area and was recommended for adoption by maize farmers

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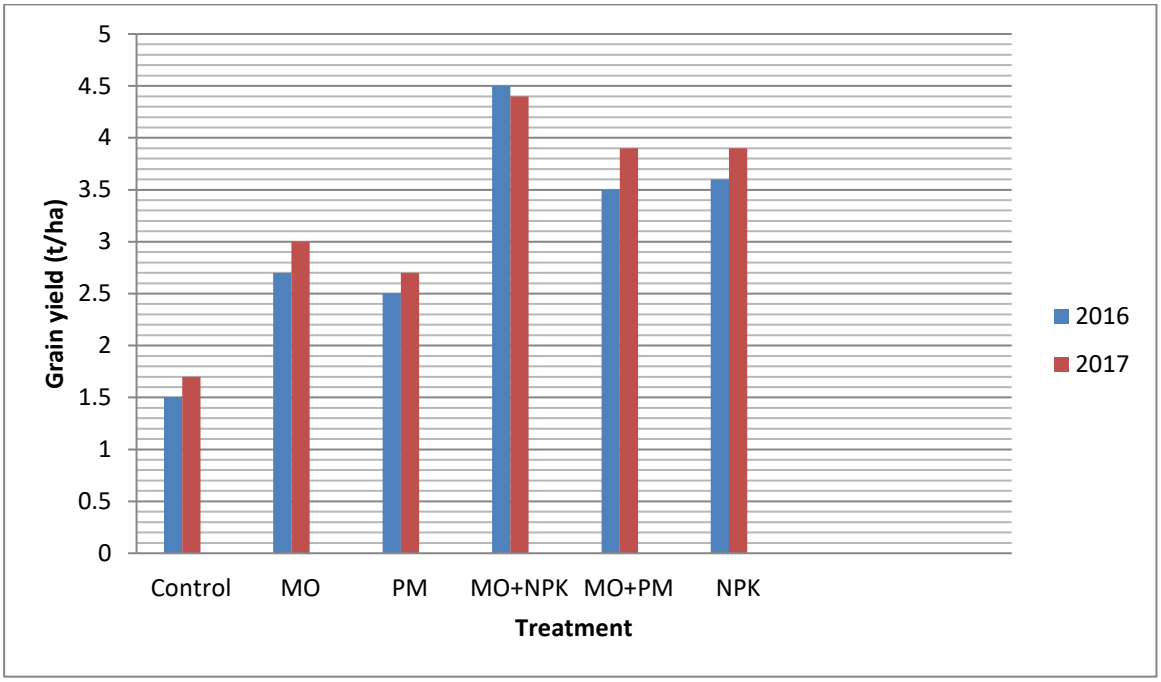


Fig.1. Maize Grain yield (t/ha) as influenced by fertilizer types in 2016 and 2017 cropping seasons

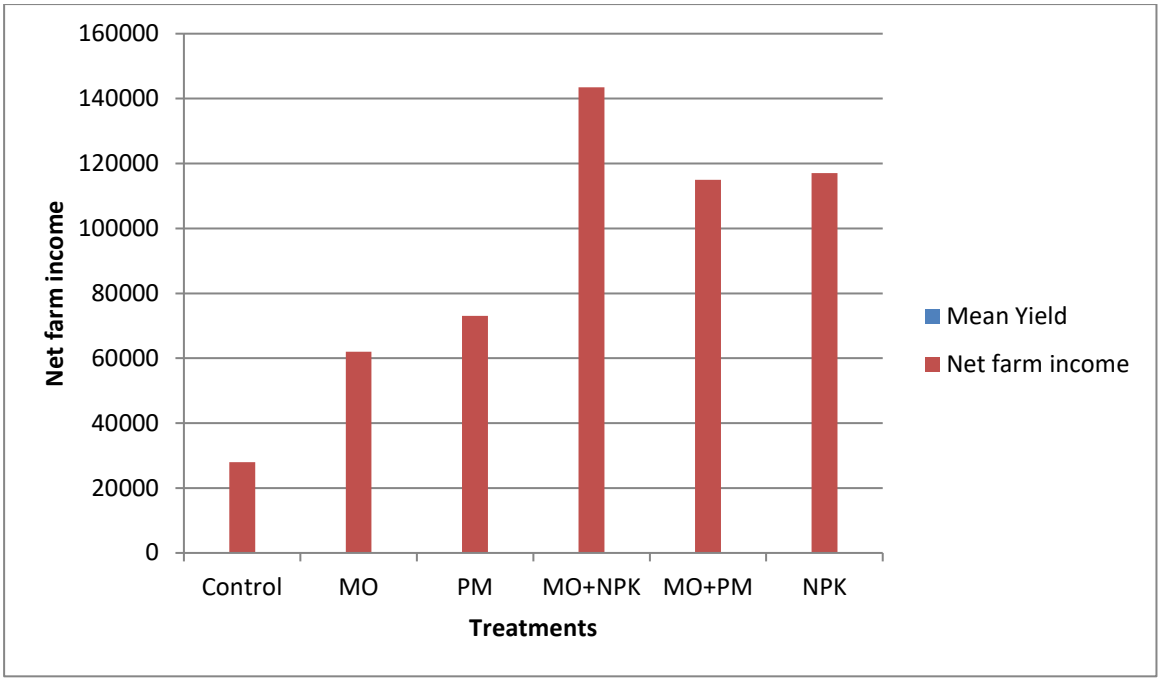


Fig.2. Net income under different fertilizer treatments