The Effect of farmyard manure and urea on grain yield and agronomic characteristics of maize (*Zea mays*)

A. A. OLOWOAKE*, A. I. AFE, J. A. OJO, T. M. YUSUF, & S. K. SUBAIR
(A.A.O., A.I.A. & J.A.O.:Department of Crop Production, Kwara State University, Malete, Nigeria; T.M.Y. & S.K.S.: Department of Agricultural Economics and Extension Services, Kwara State University, Malete, Nigeria)
**Corresponding author's email: aolowoake@yahoo.com*

ABSTRACT

Combining organic and inorganic fertilizer has been proved to be an effective and sustainable soil management strategy for increased crop yield and safe environment. Field experiments were conducted in two locations in Nigeria namely Malete and Shao during 2018 and 2019 seasons. This was to find out the efficacy of organic and inorganic fertilizer (including prilled and granular urea) and their various combinations on grain yield and agronomic characteristics of maize. The use of full dose of P and K + 75% N through Granular Urea +25 % N through farmyard manure improved most of the soil chemical properties with high economic returns. It was concluded from the experiment that a combination of organic and inorganic fertilizers is an environmentally friendly practice and could lead to high yields and improve farmers' income and their livelihoods.

Keywords: Organic fertilizer; inorganic fertilizer; farmyard manure; granular urea; prilled urea
Original scientific paper. Received 30 Sep 2020; revised 21 Apr 2022

Introduction

Decrease in soil fertility after several years of cropping is a major limitation in sustaining crop productivity and ensuring food security. This may be due to the fact that continuos cropping without soil amendments may deplete the soil of its nutrients. It is noted that most tropical soils are composed of low activity clays characterized by low nutrient content, low pH, low organic matter content and high susceptibility to erosion (Ewulo *et al*., 2016). Currently application of inorganic fertilizers constitutes a practice by farmers in attempt to correct the deficiencies of nutrient elements. However, extensive use of inorganic fertilizers has a depressing effect on yield. This causes reduction in number of fruits, delays and reduces fruit setting, which subsequently delays ripening, and leads to heavy vegetative growth (Aliyu *et al*.,2003; John *et al*., 2004). Combining organic and inorganic fertilizer has been proven to be an effective and sustainable soil management strategy in many countries of the world (Eneji *et al*., 2001) for increased yield and safe environment.The complementary use of organic and inorganic fertilizers has been recommended for sustenance of long term cropping in the tropics (Ipimoroti *et al.,*2002).

Olowoake (2014) reported that nutrients from mineral fertilizers enhance the establishment of crops while those from mineralization of organic manures promote yield when both fertilizers are combined. Buri *et al*. (2004) in an experiment with poultry manure, cattle manure and rice husk, applied single or in combination with mineral fertilizer (using urea or sulphate of ammonia as N source), and found that a combination of half rate of organic amendment and half rate of mineral fertilizer significantly contributed to the growth and yield of rice. Also, the results from the study of Ewulo *et al*. (2016) shows that the combined use of poultry manure and urea is very good for tomato growth, yield and maintenance of soil physical, chemical and biological properties.Furthermore, Ubi *et al*. (2016), reported that combination of chicken manure with urea and muriate of potash enhanced maize growth and yield in soils derived from coastal plain sands of Akpabuyo, Nigeria.

Manure incorporation is considered as a primary substrate for replenishment of soil organic matter and can be regarded as an alternative way of adding fertilizer to increase soil fertility and crop productivity (Rasool *et al*., 2007). Farm yard manure had increased yield of maize, soil organic matter by 44% and soil porosity as well as water holding capacity (Gangwar *et al*., 2006). Furthermore, prilled urea is a nitrogenous fertilizer that releases quickly and is frequently dispersed in splits, resulting in significant losses such as ammonia volatilization, immobilization, denitrification, and surface runoff. Deep application of slow-release nitrogenous fertilizers, such as granular urea, on the other hand, minimizes loss and boosts use efficiency in dry-land rabi crops (Nahar *et.al*., 2015). When compared to prilled, proper application of granular urea can boost wheat yields and fertilizer-N usage while concurrently lowering N losses (Khalil *et al*., 2011).

Little or no research have been conducted on the effect of granular or prilled urea in combination with farmyard manure on growth and yield of maize, in Ilorin, North-central Nigeria. Thus, an experiment was set up to compare the effect of granular urea fertilizers in different combinations with farm yard manure, muriate of potash, prilled urea and single super phosphate on the growth and yield of maize. The experiment also set out to compare the economic use of their combinations in different proportion on the yield of maize.

Materials and Methods

Study area

The study was conducted at the Teaching and Research farm of Kwara State University, Malete (08^0 42 ′48.5″N and $004^0$26′17.9″E) and Kwara ADP farm at Shao, Ilorin, Nigeria, southern guinea savanna zone of Nigeria in 2018 and 2019 cropping seasons respectively. The region has temperature that varies between 33□C and 34□C, annual rainfall in the region is about 1200mm and during the period, with a dry spell from December to March. The Kwara State University land area forms part of the South-western region of Nigerian basement complex, a region of basement recurrence and plutonism during the Pan-African orogeny (Olowoake 2017). Monthly rainfalls during experimental period in Ilorin, Nigeria are presented in Table 1.

Description of maize variety

Maize variety ACR9931-DMRSR used in this study were collected from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The maize is yellow, streak resistance, downy mildew resistance, early maturing, medium plant height, good ear placement and very good response to nitrogen uptake.

TABLE 1
Monthly rainfall during experimental period in Ilorin, Nigeria (2018 and 2019)

Months	Amount of Rainfall mm **2018**	**2019**
January	0.0	0.0
February	13.5	13.5
March	49.5	94.9
April	70.4	147.8
May	323.6	349.6
June	144.2	235.7
July	184.1	186.1
August	126.0	126.7
September	451.6	181.9
October	87.0	96.4
November	0.0	0.0
December	0.0	0.0
Total	1449.9	1432.7

Source: Lower Niger River Basin Development Authority, Ilorin (Hydrology Section, 2019).

Soil analysis

Soil samples from the experimental area were analyzed prior and after the experiment with the aid of soil auger from each block. The samples were bulked, air-dried and crushed to pass through a 2mm sieve. Soil analyses were carried out using procedure described by Okalebo *et al*. (2002). Particle size distribution was determined by hydrometer method using calgon solution as dispersing agent. The soil pH was determined by measuring with a glass pH electrode in 1.1 soil/ water ratio suspension. The organic carbon content was determined by the modified wet oxidation method of Wilkey & Black and converted to organic matter by multiplying by 1.724. Total nitrogen was determined by the Micro-Kjeldahl digestion and distillation method. Available phosphorus was determined by the Bray 1 Acid Fluoride solution. Exchangeable cations were extracted with 1.1ml Ammonium acetate at pH 7. Na and K were measured with flame photometer while Ca and Mg were measured with atomic absorption spectrophotometer. Cation exchange capacity was measured by Ammonium acetate technique.

Land preparation and trial management

The fields were cleared and harrowed twice and the layout was done. The treatments were laid out in a randomized complete block design (RCBD) and replicated three times. The treatments were;

1. Control (zero fertilizer application) –T1
2. Recommended dose of NPK (100 % N through Indorama Granular Urea) –T2
3. Recommended dose of NPK (100 % N through prilled urea) –T3
4. Full dose of P&K + 75% N through indorama granular urea +25 % N through FYM -T4
5. Full dose of P&K + 75% N through prilled urea +25 % N through FYM – T5
6. Full dose of P&K + 75% N through indorama granular urea – T6
7. Full dose of P&K + 75% N through prilled urea – T7

The results of analyses of the farm yard manure are summarized in Table 2.

TABLE 2
Chemical composition of farmyard manure

Nutrient element	N (%)	P (g/kg)	K
Farnyard manure	2.8	19.9	20.9

Each plot size was measured 4.0 m x 4.0 m with 0.5 m between plots and 1.0 m between blocks. Four maize seeds were planted at intra and inter row spacing of 0.75m x 0.5 m respectively. At two weeks after planting, maize plants were thinned to two plants /stand .Farm yard manure was applied two weeks before planting for nutrient mineralization. Nitrogen fertilizer in the form of granular urea was applied to maize at the rate of 100 kg N ha^{-1}.SSP was applied at 40 kg P_2O_5 ha^{-1}, while Potassium nitrate was applied at 30 kg K_2O ha^{-1} (Kogbe & Adediran, 2003).

Full dose of P was applied at planting while 2/3 and 1/3 of N and K was applied at 4 and 6 weeks after planting respectively using side placement method. Manual weeding was carried out at 4 weeks after planting to keep the experimental plot weed free. Cypermethrin + dimethoate were applied to control army worm/ stem borer.

Data collection and analysis

The growth and yield data were collected from five tagged plants at the inner rows at the two locations during the period of 12 weeks.

Plant height: it was determined by measuring the height of 5 randomly sampled plants from ground level to the base of the tassel at physiological maturity.

Number of leaves: 5 randomly pre-tagged plants were taken from the net plot area, and then their leaves were counted at harvest and the average was recorded.

Stem girth: Maize girth was measured using Vernier caliper. The girth of each stem was measured at the third internode from the soil surface and recorded in millimeters (mm).

Hundred seed weight (g): Hundred seeds, counted at random from each treatment at 13% moisture content were weighed and recorded in grams (g).

Cob length (cm): it was recorded from 5 randomly taken cobs from the net plot area and measured from the point where the cob attached to the stalk to the tip of the cob with a glass ruler after harvest and the average was recorded.

Grain yield (t /ha): grain yield from the net plot area was weighed using field balance (Salter Model-235) and adjust to 12.5% moisture, finally, it was converted into hectare basis.

$$\text{Grain yield (t/ha)} = \frac{\text{Yield in plot (kg)} \times 10000\ m^2}{\text{Area of sub plot } (m^2) \times 1000}$$

Farm budgeting analysis was used to compute the farm income. Benefit cost analysis and the return on investment were used as economic indicators. To study the economic performance of different soil amendment on maize yield, total gross returns and net return were calculated based on the current market price of different inputs, transportation cost, weed management and labour wages, finally benefit cost ratio was calculate with the following equation by Pasqual *et al.,* 2013;

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Net farm income}}{\text{Total cost of production}}$$

Total cost = Variable cost + Fixed cost

Data collected were then subjected to Statistical Analysis System (SAS) for Analysis of variance (ANOVA) and the treatments means were compared at 5 % level of significance using the Duncan's Multiple Range Test (DMRT).

Results and Discussion

Physico-chemical properties of the soil prior to application of treatmentsThe results of the physical and chemical analysis of the two experimental soils before cropping are presented in Table 3. The results showed that Shao and Malete textural soil is loamy sand, neutral, low in total nitrogen and low in available phosphorus.

TABLE 3

Physico-chemical properties of experimental site (Malete and Shao)

Parameters	**Soil test value**	
	Malete	**Shao**
pH(H_2O)	6.7	6.6
Org.C(%)	7.9	0.3
Total N(%)	0.82	0.05
P (mg/kg)	2.77	3.1
Exchangeable bases(cmol/kg)		
Mg	0.78	0.64
Ca	0.58	0.66
Na	0.43	0.48
K	0.28	0.38
Extractable micronutrients (mg/kg)		
Cu	0.90	0.77
Fe	107	101
Mn	106	201
Zn	7.0	6.6
Sand (%)	82.0	79.0
Silt (%)	15.0	14.0
Clay (%)	3.0	7.0
Textural class	Loamy sand	Loamy sand

Effect of treatments on *maize growth parameters*

Full dose of P and K + 75% N through indorama granular urea +25% N through FYM (T4) performed better in terms of plant height, number of leaves and stem girth of maize during 2018 and 2019 planting seasons (Table 4). Mean plant height ranged from 97.7 cm in T1 (Control: zero fertilizer application) at Malete to 156.5 cm in T4 at the same location (Table 4). Number of leaves ranged from 9.2 in T1 to 12.3 in T4 at Shao (Table 4). Similarly, mean stem girth was lowest in T1 (9.1 mm) in Shao and highest in T4 (19.4 mm) at Malete.

TABLE 4
Growth parameters of maize as influenced by application of fertilizer treatments during 2018 and 2019 planting season

Treatment	**Plant height (cm)**		**Number of leaves**		**Stem girth (mm)**	
2018	Malete	Shao	Malete	Shao	Malete	Shao
T1	97.7d	102.6d	10.7c	9.8c	16.1c	9.1c
T2	130.3b	125.8b	11.9a	10.3b	17.0b	11.5b
T3	130.8b	129.1a	11.4ab	11.7ab	18.2a	13.4a
T4	156.5a	131.7a	12.1a	12.3a	19.4a	13.7a
T5	117.1c	127.7b	12.1a	11.1ab	18.2a	11.7b
T6	105.7c	120.9c	11.3ab	10.7b	18.0a	11.5b
T7	132.9b	121.3c	11.0b	11.3ab	17.2b	11.8b
2019						
T1	141.3d	106.9d	10.9c	9.2c	16.3c	9.1c
T2	156.8a	143.1b	12.6ab	11.4b	19.5a	11.9b
T3	151.8b	145.7b	13.1ab	13.0a	18.8c	15.9ab
T4	156.8a	156.5a	13.6a	12.8a	19.8a	17.2a
T5	148.9c	145.0b	12.5ab	11.1b	19.8a	16.1ab
T6	154.1a	139.6c	12.3ab	11.9b	19.4a	12.7b
T7	148.7c	137.1c	12.0b	11.9b	18.3b	12.1b

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.T1 – Control (zero fertilizer application), T2 – Recommended dose of NPK (100% N through Indorama Granular Urea), T3 – Recommended dose of NPK (100% N through prilled urea), T4 –Full dose of P&K + 75% N through indorama granular urea +25% N through FYM, T5 – Full dose of P&K + 75% N through prilled Urea +25 % N through FYM, T6 – Full dose of P&K + 75% N through Indorama Granular Urea, T7 – Full dose of P&K + 75% N through Prilled Urea.

Effects of fertilizer treatments on yield parameters of maize

Full dose of P and K + 75% N through indorama granular urea +25 % N through FYM (T4) performed better in terms of 100-seed weight, cobs dry weight, cob length and grain yield during 2018 and 2019 planting seasons (Table 5). 100-seed weight ranged from 18.9 g in T1 (Control: zero fertilizer application) at Malete in 2018 to 35.9 g in T4 at the same location in 2019 (Table 5). Cobs dry weight ranged from 53.8 g in T1 at Shao in 2018 to 179.3 g in T4 at Malete in 2019 (Table 5). Cob length was lowest in T1 (8.5 cm) at Shao in 2018 and highest in T4 (20.5 cm) at Malete in 2019. Similarly, grain yields ranged from 2.9 t/ha in T1 at Shao in 2018 to 7.4 t/ha in T4 at same location in 2019 (Table 5).

TABLE 5

Yield parameters of maize as influenced by application of fertilizer treatments during 2018 and 2019 planting season

Treatment	**Hundered seed weight (g)**		**Cobs dry weight (g)**		**Cob length (cm)**		**Yield (t/ha)**	
2018	Malete	Shao	Malete	Shao	Malete	Shao	Malete	Shao
T1	18.9d	19.0d	64.6g	53.8f	11.0d	8.5c	3.6d	2.9c
T2	25.3b	20.8c	99.9c	88.2d	12.7c	12.5a	5.6c	4.4b
T3	28.6a	20.1c	121.6b	90.1c	13.7b	12.1b	6.0b	5.0ab
T4	28.7a	26.7a	125.3a	100.4a	14.4a	12.6a	6.4a	5.6a
T5	22.0c	23.5b	89.1d	91.9c	12.7c	12.5a	4.9c	5.1ab
T6	21.4c	25.7a	76.0f	96.1b	13.1b	11.9b	4.2cd	5.3ab
T7	21.2c	20.7c	83.2e	76.1e	12.6c	11.5b	4.6cd	4.2b
2019								
T1	20.4d	19.3c	109.8f	66.4e	12.5d	9.0d	3.3d	3.7e
T2	30.8b	26.5b	142.7d	93.8d	16.3c	13.4b	5.2b	5.2d
T3	32.1b	27.3b	170.1b	105.9c	18.4b	13.2b	5.4b	5.9c
T4	35.9a	32.9a	179.3a	142.6a	20.5a	14.8a	6.9a	7.4a
T5	22.7c	28.9b	168.9b	134.6b	18.1b	13.5b	5.3b	6.7b
T6	25.0c	27.8b	161.6c	104.1c	18.5b	12.9b	5.6b	5.8c
T7	25.1c	26.4b	123.7e	101.8c	15.1c	12.6c	4.6c	5.6c

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level. T1 – Control (zero fertilizer application),, T2 – Recommended dose of NPK (100% N through Indorama Granular Urea), T3 – Recommended dose of NPK (100% N through prilled urea), T4- Full dose of P&K + 75% N through indorama granular urea +25% N through FYM, T5 – Full dose of P&K + 75% N through prilled Urea +25 % N through FYM, T6 – Full dose of P&K + 75% N through Indorama Granular Urea, T7 – Full dose of P&K + 75% N through prilled Urea.

Combined analysis of variance for the growth and yield parameters of maize

Combined analysis of variance for the growth and yield parameters studied is presented in Table 6. Mean square of location was significant for all parameters. Mean squares due to treatment was significant for all the parameters. Mean squares due to interactions between location and treatments were significant for some growth parameters except the plant height, hundred weight seeds and grain yield.

TABLE 6

Means squares from combined analysis of variance for growth and yield parameters of maize in Shao and Malete during 2018 and 2019 planting season

Source	df	Plant height	Number of leaves	Stem girth	Hundred seed weight	Yield
Block	2	112.45	0.03	1.06	13.74	0.44
Location (L)	1	8648.75*	35.48**	519.83**	1374.86**	223.10*
Error	2	219.98	0.16	1.77	13.64	5.74
Treatment (T)	6	211.87*	1.31**	3.31*	23.42*	7.43**
L * T	6	106.39 ns	1.22**	3.44*	8.28 ns	0.87ns
Residual	24	74.67	0.33	1.24	6.48	1.30

df: degree of freedom; *, **: significant at $p = 0.05$ and 0.01 respectively.

Analysis of variance for the maize growth and yield parameters under varied treatments

Table 7 shows combined analysis of variance for the maize growth and yield parameters under varied treatments in 2018 and 2019 in. Mean square of year was significant for plant height and number of leaves except stem girth, hundred seed weight and maize yield. Mean squares due to treatment was significant for only plant height, hundred seed weight and maize yield. Mean squares due to interactions between year and treatments were significant for plant height, hundred seed weight and maize yield only.

TABLE 7

Mean squares from combined analysis of variance for the maize growth and yield parameters under varied treatments in 2018 and 2019

Source of variation	df	Plant height	Number of leaves	Stem girth	Hundred seed weight	Yield
Block	2	695.23	1.27	0.77	57.65	1.72
Year (Y)	1	4727.60**	21.57*	0.19	236.67	5.57
Error year	2	12.79	1.11	7.45	19.50	0.93
Treatment (T)	6	278.76*	1.08	4.06	35.70**	6.52**
Y*T	6	295.38*	0.54	1.73	32.19**	3.77**
Residual	24	100.74	0.51	2.14	8.74	1.02

df: degree of freedom; *, **: significant at $p = 0.05$ and 0.01 respectively.

Effects of fertilizer treatments on postharvest soil chemical properties

Table 8 shows the effect of fertilizer treatments on soil chemical properties at harvest in Malete and Shao during 2018 and 2019 planting season. In 2018, results obtained from the two sites indicated that there were significant differences ($p < 0.05$) in the soil pH among the various treatments and control. At both locations soil pH value ranged from 5.5 to 6.9 and 5.4 to 6.8 in Malete and Shao respectively. Soil pH in soil treated with T4 in both locations was significantly higher than all other treatments including control. There was not much change in soil pH of the plots treated with T3, T5, T6 and T7. Soil available P content ranged from

9.62 mg kg^{-1} to 15.20mg $kg^{-1}$and 9.26mg $kg^{-1}$to 14.70 mg kg^{-1} in Malete and Shao respectively. Soil treated with T4 significantly resulted in higher available P than other treatments in both sites. The organic carbon contents were significantly higher under soil treated with T4 than all other treatments and control in 2018 at Malete and Shao respectively (1.41 and 1.46 gkg^{-1}). The soil N values (1.71gkg^{-1} and 1.81gkg^{-1}) obtained from soil treated with T4 at Malete and Shao were significantly ($P<0.05$) higher than all other treatments. However, control plots produced the lowest values of nitrogen (0.46 gkg^{-1}) at Shao in 2019.

During 2019 planting season in Malete and Shao, T4 plots had the highest pH values of 6.9 when compared to other fertilizer treatments and control. Soil available P across the two sites ranged from 8.96 to 16.64 mg $kg^{-1}$and 9.93 to 15.28mg kg^{-1} in Malete and Shao respectively.Control plots had the lowest post-harvest available soil P (8.96 mg kg^{-1}) at Malete.

Soil treated with T4 had the highest exchangeable K value of 0.85c mol/kg in Malete and Shao (0.43c mol/kg). These values were 87.1 and 62.8 % higher than control respectively.Soil organic carbon ranged from 0.36 to 1.73g kg^{-1} and 0.43 to 1.65 g kg^{-1}across the two sites. There was a general increase in the values of organic carbon compared with control. Soil treated with T2, T3, T4, T5, T6 and T7 increased soil total N content in the soil over control plots in Malete and Shao respectively. Soil N ranged from 1.01 to 1.84g kg^{-1} and 0.46 to 1.80g kg^{-1}across the two sites. Conclusively, T4 significantly ($p < 0.05$) improved the pH, available P,exchangeable K, organic carbon and total nitrogen of the soil compared to the control across the two sites.

TABLE 8

Effects of fertilizer treatments on post harvest soil chemical properties during 2018 and 2019 planting season.

Treatment	pH (H_2O)	Avail P	K	OC	N	pH (H_2O)	Avail P	K	OC	N
		mg kg^{-1}	c mol kg^{-1}	gkg^{-1}	gkg^{-1}		mg kg^{-1}	cmol kg^{-1}	gkg^{-1}	gkg^{-1}
	Malete					Shao				
Before experiment	6 .7	2.77	0.28	0.79	0.82	6.6	3.1	0.38	0.3	0.05
After experiment 2018										
T1	5.5c	9.62d	0.23c	0.84c	1.03d	5.4c	9.26d	0.11c	0.53d	1.07e
T2	5.6c	10.56c	0.36b	0.99b	1.15c	5.8c	12.66b	0.24b	0.84b	1.65b
T3	6.5b	10.80c	0.27b	0.89b	1.60b	6.4b	10.10c	0.15c	0.97b	1.18d
T4	6.9a	15.20a	0.98a	1.41a	1.71a	6.8a	14.70a	0.41a	1.46a	1.81a
T5	6.7a	12.20b	0.36b	1.35a	1.62b	6.4b	13.60a	0.39a	1.04a	1.74a
T6	6.5b	10.87c	0.28b	0.93b	1.08d	6.5b	10.70c	0.34a	0.66b	1.19d
T7	6.3b	10.84c	0.44b	0.86b	1.19c	6.4b	11.60b	0.22b	0.62b	1.41c
2019										
T1	5.3c	8.96e	0.11b	0.36d	1.01d	5.4d	9.93d	0.16d	0.43d	0.46f
T2	5.6c	13.24c	0.15b	0.82b	1.05c	5.9d	13.52b	0.25c	0.48d	1.09d
T3	6.0b	11.51d	0.14b	0.65c	1.07c	6.2c	11.67c	0.17d	0.86b	1.35c
T4	6.9a	16.64a	0.85a	1.73a	1.84a	6.9a	15.28a	0.43a	1.65a	1.80a
T5	6.7a	14.83b	0.15b	1.59a	1.33b	6.6b	13.58b	0.32b	0.97b	1.54b
T6	6.1b	10.69d	0.15b	0.41c	1.12c	6.3c	11.67c	0.29b	0.44d	1.17d
T7	6.2b	10.02d	0.17b	0.72b	1.18c	6.3c	11.33c	0.24c	0.75c	1.32c

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level. T1 – Control (zero fertilizer application), T2 – Recommended dose of NPK (100% N through Indorama Granular Urea), T3 – Recommended dose of NPK (100% N through prilled urea), T4 – Full dose of P&K + 75% N through indorama granular urea +25% N through FYM, T5 – Full dose of P&K + 75% N through prilled Urea +25 % N through FYM, T6 – Full dose of P&K + 75% N through Indorama Granular Urea, T7 – Full dose of P&K + 75% N through Prilled Urea.

Economic analysis

All the treated plots recorded profits in both locations (Table 9). Application full dose of P&K + 75% N through Granular Urea +25% N through FYM (T4) maximized profit in all fertilizer treatments. However, the control plot (T1) gave minimum returns. Similarly the net farm income from different plant nutrient treatments was different depending on the combinations of the nutrients. Recommended dose of NPK (100% N through prilled urea), (T3) had high net income, but full dose of P&K + 75% N through Granular Urea + 25% N through FYM (T4) proved economical by giving higher income. It gave a net return of ₦479418.75 (US$1322.53) and ₦508918.75 (US$1403.91) at Malete and Shao respectively. Among the various fertilizer treatments used, T4 recorded the highest benefit cost (4.4 and 4.6), followed by T3 (4.2 and 3.9) at Malete and Shao respectively. However, control plots recorded lowest benefit cost ratios.

TABLE 9

Economic analysis of maize yield as influenced by fertilizer treatments at Malete and Shao (Average of 2018 and 2019 planting season)

Treatment	Average Maize yield (t/ha)	Variable cost ₦	Fixed cost ₦	Total cost ₦	Revenue per treatment ₦	Net farm income ₦	Cost Benefit ratio
Malete							
T1	3.5	37813.75	33477.5	71291.25	270700	199.408.75	2.8
T2	5.4	63901.15	33477.5	97378.65	482800	385421.35	3.9
T3	5.7	65406.75	33477.5	98784.25	510600	411815.75	4.2
T4	6.7	76213.75	33477.5	109681.25	589100	479418.75	4.4
T5	5.1	77213.75	33477.5	110691.25	451700	341008.75	3.1
T6	4.9	72449.35	33477.5	105926.85	428400	322473.15	3.0
T7	4.6	73449.35	33477.5	106926.85	409400	302473.15	2.8
Shao							
T1	3.3	37813.75	33477.5	71291.25	279300	208008.75	2.9
T2	5.3	63901.15	33477.5	97378.65	422800	325421.35	3.3
T3	5.5	65406.75	33477.5	98784.25	480100	381315.75	3.9
T4	6.5	76213.75	33477.5	109681.25	618600	508918.75	4.6
T5	5.9	77193.75	33477.5	110691.25	516300	405608.75	3.7
T6	5.6	72449.35	33477.5	105926.85	541200	435273.15	4.1
T7	4.9	73449.35	33477.5	106926.85	428400	321473.15	3.0

1 USD is approximately ₦362.5 (between December 2018 and 2019); Cost of maize – ₦300 /kg. T1 – Control (zero fertilizer application), T2 – Recommended dose of NPK (100% N through Indorama Granular Urea), T3 – Recommended dose of NPK (100% N through prilled urea), T4 – Full dose of P&K + 75% N through indorama granular urea +25% N through FYM, T5 – Full dose of P&K + 75% N through prilled Urea + 25% N through FYM, T6 – Full dose of P&K + 75% N through Indorama Granular Urea, T7 – Full dose of P&K + 75% N through prilled urea.

The soil of the two sites (Shao and Malete) was generally low in total N, and P (Adeoye & Agboola, 1985). Thus, the soil required fertilizers or soil amendment to improve its fertility. The available P of 2.77 and 3.1 mg/kg mg kg-1 was below the critical level of 10-16 mg kg-1 (Adeoye & Agboola, 1985). The K status of the soil which was 0.28 and 0.38 cmol/kg was higher than the critical level of 0.2 cmol kg-1 (Adeoye, 1986). Therefore, indicating that the soil may be poor in N and P. The relatively poor performance of the unamamended plots as compared to the plots where soil were amended as observed in the study was due to inherent poor quality of the experimental field. The available P was below the critical level with very low nitrogen. Nitrogen and phosphorous are critical determinants of plant growth and productivity. The two elements according to Razaq *et al.* (2017) affect the growth of the plant as well as root morphology which are important parameters for evaluating the effects of supplied nutrients. Both N and P are important nutrients for ecosystem structure, processes, and function in plants because their unavailability limits the production of plant biomass and growth.

The high values of plant height and number of leaves of maize plant grown in the plot treated with T4 (Full dose of P&K + 75% N through indorama granular urea +25% N through FYM) during the 2018 and 2019 cropping in the two sites (Shao and Malete) might be as a result of favourable nutrient mineralization of this fertilizer as a result of the influence of the mineral component on the organic (Adeoye *et al*. 2008). The performance of T4 fertilizer treatment in maize growth parameters was also better than that of mineral fertilizer (T2, T3 and T6). This is in line with the reports that the combinations of organic and mineral performed better on crop yield than when each of them is solely used (Sridhar & Adeoye, 2003; Ogunlade *et al.,* 2011; Olowoake, 2014).

Plot receiving application of T4 was better than other treatments and control with respect to maize yield; cobs dry weight, cob length and hundred seed weight. These results indicated that under the given experimental conditions, combined application of mineral and farm yard manure significantly improved yield parameters of maize. These findings are in agreement with Negi & Mahajan (2000), and Mishra (2000) who reported significant increases in wheat grain and straw yields with addition of FYM to inorganic fertilizers. Comparism of performance of T4 and T5 on maize yield revealed that granular urea with full dose of P and K in combination with farm yard manure performed better compared to when prilled urea was involved in the fertilizer treatments. This result is in line with Singh *et al*. (2008) that granular urea as N source was a better option than prilled urea in pearl millet – wheat cropping sequence as it produced higher grain and straw yields, because it is a slow-release nitrogenous fertilizers.

The T4 treated soils increased pH, P, organic carbon, K and N compared with the control values in both years. These observations are in agreement with the findings of Afolabi *et al*. (2017) and Ogundare *et al*. (2012), who reported that application of manure and inorganic fertilizers improved soil chemical properties. The improvement in most of the soil chemical properties by the T4 treatment is in line with the findings of Abbasi *et al*. (2010), who observed highest improvement in pH soil organic matter, phosphorus and potassium with the combination of urea and poultry manure. This may be due to the fact that poultry manure contains significant amounts of Ca, Mg and K, and this led to the increase in exchangeable bases in soil resulting in high pH and addition of organic matter through poultry manure and microbial activity could explain the increase in organic carbon concentration in urea with poultry manure treatments. (Whalen *et al.,* 2000: Sharma *et al.,* 2008).

The economic analysis amongst the treatments in the two sites (Malete and Shao) indicated higher net revenues on the maize plot with T4 treatments than other plots (BCRs >1). This could be due to excellent and balanced nutrient in the farm yard manure that was associated with the slow released that accommpanied that of granular urea. According to Kombat (2015) balanced and adequate fertilizer application is essential for increasing crop yields and net returns, whiles ensuring sustainability.The higher the cost-benefit ratios, the higher the profit margin and the lower the cost-benefit ratio, the higher the loss. Similar result for increased net profit in tomato due to combination of urea fertilizer and farm yard manurehas been reported by Gebretsadkan (2018).

Conclusion and Recommendation

Maize grain yield was found to be enhanced by using full dose of P&K + 75% N through indorama granular urea +25% N through FYM. Thus, the use of inorganic fertilizer combination with farmyard manure gave better improvement in soil chemical properties, growth and yield of maize and, therefore, it was more economical to apply. The implications of the results are that when farmers adopt this fertilizer combination it would lead to increase in their incomes and improvement of their livelihoods. Soil improvement as a result of this type of combination is environmentally friendly and addresses aspects of environment as contained in the sustainable development goals. A combination with liquid fertilzer could be added in future research.

Acknowledgment

The authors would like to thank Indorama Eleme Fertilizer and Chemicals Limited for a research grant in support of this project.

REFERENCES

Abbasi, M. K., Khaliq, A., Shafiq, M., Kazmi, M. & Ali, I. (2010) Comparative effectiveness of urea N, poultrymanure and their combination in changing soilproperties and maize productivity underrainfed conditions in Northeast Pakistan. Experimental Agriculture, 46 (2), 211 – 230. doi:10.1017/S0014479709991050.

Adeoye, G. O. & Agboola, A. A. (1985) Critical levels for soil pH, available P, K, Zn and Mn and maize ear leaf content of P, Cu and Mn on sedimentary soils of southwestern Nigeria. Fertilizer Research, 6 (1), 65 – 67.

Adeoye, G.O. (1986) Comparative studies of some extractants for sedimentary soil of South Western Nigeria. Ph.D. Thesis, University of Ibadan, Ibadan,Nigeria, pp. 201.

Adeoye, G. O., Sridhar, M. K. C., AdeOluwa, O. O., Oyekunle, M., Makinde, E. A. & Olowoake, A. A. (2008) Comparative evaluation of organo-mineral fertilizer (OMF) and mineral fertilizer (NPK) on yield and quality of maize (*Zea mays (L) Moench*). Nigerian Journal Soil Science, 18, 141 – 147.

Afolabi, S. G., Odofin, A. J., Adeboye, M. K. A., Samson, V. M. & Popoola, A. F. (2017) Comparative effects of sole and combined applications of poultry manure and inorganic fertilizers on soil quality and maize performance at Minna and Ayingba, Nigeria. Nigerian Journal Soil Science, 27, 82 – 91.

Aliyu, L., Karikari, S. K. & Ahmed, M. K. (2003) Yield and yield components of eggplant (*Solanium nigro L.*) as affected by date of transplanting, intra row spacing and nitrogen fertilization. Journal of Agricultural Science and Technology, 2 (1), 7 – 12.

Buri, M. M., Issaka, R. N., Wakatsuki, T. & Otoo, E. (2004) Soil organic amendments and mineral fertilizers: Options for sustainable lowland rice production in the forest agro-ecology of Ghana. Agricultural and food Science Journal of Ghana, 3, 237 – 248.

Eneji, A. E., Yamamoto, S. & Honna, T. (2001) Rice growth and nutrient uptake as affected by livestock manure in four Japanese soils. Journal of Plant Nutrition, 24, 333 – 343.

Ewulo, B. S., Sanni, K. O. & Eleduma, A. F. (2016) Effects Of urea and poultry manure on growth and yield attributes of tomatoes (*Lycopersicon Esculentum Mill*) and soil chemical composition. International Journal of Innovative Research and Advanced Studies, 3 (3), 5 – 9.

Gangwar, K. S., Singh, K. K., Sharma, S. K. & Tomar, O. K. (2006) Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gangetic plains. Soil and Tillage Research, 88, 242 – 252.

Gebretsadkan, G. (2018) Evaluating the effect of integrated use of farm yard manure and urea on the socio economic performance of tomato (*Lycopersicon esculentum Mill*) at Tselemti Woreda, North-Western Tigray, Ethiopia. International Journal of Plant Science and Agriculture, 1 (1), 1 – 7.

Ipimoroti, R. R., Daniel, M. A. & Obatolu, C. R. (2002) Effect of organic mineral fertilizer on tea growth at Kusuku Mabila Plateau Nigeria. Moor Journal of Agricultural Research 3, 180 – 183.

John, L. W., Jamer, D. B., Samuel, L. T. & Waner, L. W. (2004) Soil fertility and fertilizer: An introduction to nutrient management. Pearson Education, India. Pp. 106 – 153.

Khalil, M., Schmidhalter, I. U., Gutser, R. & Heuwinkel, H. (2011) Comparative efficacy of urea fertilization via supergranules versus prills on nitrogen distribution, yield response and nitrogen use efficiency of spring wheat. Journal of Plant and Nutrition 34 (6), 779 – 797.

Kogbe, J. O. S. & Adediran, J. A. (2003) Influence of nitrogen, phosphorus and Potassium application on the yield of maize in the savanna zone of Nigeria. African Journal of Biotechnology, 2 (10), 345 – 349.

Kombat, R. K. (2015) Effect of four NPK fertilizer formulations and their application rates on growth and yield of maize (*Zea mays L.*) in the Guinea Savannah agro-ecology of Ghana. MSc. Thesis, Department of Agronomy University for Development Studies, Ghana, pp. 97.

Mishra, V. K. (2000) Water expense and nutrient use efficiency of wheat and winter maize as influenced by integrated nutrient management. Agropedology 10 (1), 1 – 5.

Nahar, L., Ali, M. H., Masum, S. M., Mahbub, M. M. & Haque, S. R. (2015) Performance of prilled urea and urea super granules on the growth and yield of wheat. Bangladesh Agronomy Journal 18 (1), 37 – 48.

Negi, S. C. & Mahajan, G. (2000) Effect of FYM, planting methods and fertilizer levels on rain-fed wheat. Crop Research Hisar., 20 (3), 534 – 536.

Ogundare, K., Agele, S. & Aiyelari, P. (2012) Organic amendment of an ultisol: Effects on soil properties, growth, and yield of maize in Southern Guinea savanna zone of Nigeria. International Journal of Recycling of Organic Waste in Agriculture, 1, pp. 11. doi:10.1186/2251-7715-1-11.

Ogunlade, M. O., Adeyemi, E. A., Ogunleti, D. O. & Ibiyomi, P. S. (2011) Effect of cocoa pod husk, urea fortified cocoa pod husk and NPK fertilizers on the growth and yield of Solanummacrocarpon. International Journal of Organic Agriculture Research and Development, 3, 1 – 8.

Okalebo, J. R., Gathua, K. W. & Woomer, P. L. (2002) Laboratory method of soil and plant analysis: A working manual. 2nd Edition. TSBFCIAT and SACRED Africa, Nairobi, Kenya.

Olowoake, A. A. (2014) Influence of organic, mineral and organomineral fertilizers on growth, yield and soil properties in grain amaranth (*Amaranthus cruentus. L*). Journal of Organics, 1 (1), 39 – 47.

Olowoake, A. A. (2017) Growth and nutrient uptake of maize (Zea mays L.) amended with compost-enriched palm kernel cake. Ibadan Journal of Agricultural Research, 12 (2), 23 – 32.

Pasqual, J., Padilla, E. & Jadotte, E. (2013) Equivalence of different profitability criteria with the net present value. International Journal of Production Economics, 142, 205 – 210.

Rasool, R., Kukal, S. & Hira, G. (2007) Soil physical fertility and crop performance as affected by long term application of FYM and inorganic fertilizers in rice–wheat system. Soil and Tillage Research, 96, 64 – 72.

Razaq, M., Zhang, P., Shen, H. & Salahuddin, I. (2017) Influence of nitrogen and phosphorous on the growth and root morphology of Acer mono. PLoS ONE, 12 (2). doi:10.1371/journal.pone0171321.

Sharma, K. L., Neelaveni, K., Katyal, J. C., Srinivasa, A. S., Srinivas, K., Grace, J. K. & Madhavi, M. (2008) Effect of combined use of organic and inorganic sources of nutrients on sunflower yield, soil fertility, and overall soil quality in rain-fed Alfisol. Communications in Soil Science and Plant Analysis, 39, 1791 – 1831.

Singh J. P., Phogat, V. & Singh, A. (2008) Comparative study of prilled versus granular urea in pearl millet-wheat cropping system. Haryana Journal of Agronomy, 24 (1&20), 55 – 58.

Sridhar, M. K. C. & Adeoye, G. O. (2003) Organomineral fertilizer from urban wastes. The Nigerian Field, 68, 91 – 111.

Ubi, M. W., Akpan-Idiok, A. & Eneji, A. E. (2016) Efficiency of some maize (*Zea mays L.*) cultivars treated with chicken manure and inorganic fertilizers in soils derived from coastal plain sands of Akpabuyo, Nigeria. International Journal of Agriculture, Environment and Bioresearch, 1 (1), 85 – 97.

Whalen, J. K., Chang, C., Clyton, G. W. & Carefoot, J. P. (2000). Cattle manure amendments can increase the pH of acid soils. Soil Science Society of America Journal, 64, 962 – 966.