International Journal of Agriculture, Environment and Bioresearch

Vol. 2, No. 04; 2017

ISSN: 2456-8643

EFFECT OF LIME AND MINERAL FERTILIZER ON GROWTH AND YIELD OF TWO VARIETIES OF OKRA (Abelmoschus Esculentus (L) Moench) GROWN ON SOIL FROM OTOBI ACID FLOOD PLAIN OF NIGERIA.

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ABSTRACT

This study evaluated the effect of combined application of Lime and NPK 15-15-15 to two varieties of Okra (Clemson spineless and Indigenous variety) grown on soil taken from Otobi acid flood plain of Nigeria. Lime at four levels (0,1.0,1.5 and 2 tons/ha) and NPK 15-15-15 fertilizer at four levels (0, 11.25, 22.5 and 45.0 Kg NPK/ha) were factorially combine in a completely randomized design (CRD), replicated 3 times to give a total of 96 pots arrangement (48 each for okra variety). The growth and yield parameters of the okra were measured during the experimental period as well as the chemical properties of the soil evaluated pre and post experimental trial. The combine application of lime and NPK fertilizer application affect the growth and yield components Okra differently. The data obtained consistently indicate that Clemson spineless variety has significantly ($P<0.05$) higher leaf area, plant height and fruit yield in comparison with the indigenous variety. The resultant effect of the combine application of Lime and NPK fertilizer raised the level of soil pH, OM, Total Nitrogen, Available Phosphorous, K, Ca and ECEC. The application of 11.5 Kg NPK + 1.5 tons CaC03/ha gave the highest fruit yield in Clemson spineless variety and it is appropriate for sustainable Okra production in this acid flood plain of Nigeria.

Keywords: Lime and Mineral fertilizer, two varieties of Okra, Otobi acid flood plain, Nigeria.

INTRODUCTION

Acidification is a slow process but is accelerated by agriculture through the use of some fertilizers, soil structure disturbance and harvest of yielding crops (Fageria and Baligar, 2008). The use of fertilizers such as urea, anhydrous ammonia and ammonium sulphate release hydrogen ions H^+ through a biological process in which NH_4^+ is oxidized to nitrate NO_3^- according to the following reaction:

bacteria

$$(NH_4)_2SO_4 + 4O_2 \xrightarrow{\text{Nitrifying bacteria}} 2NO_3^- + SO_4^- + 2H_2O + 4H^+$$

As soils become more acidic, plants intolerant to acidic conditions are negatively affected leading to productivity decline. In Nigeria, acid soils cover about 17 million hectares of land; this represents about 18% of total land area (Nicholaides *et al*., 1983).

Soil acidity affect crops in many ways and its effects are mostly indirect through its influence on chemical factors and biological processes. Chemical factors include Aluminium (Al) toxicity, Calcium (Ca), Phosphorus (P) and Magnesium (Mg) deficiencies (Uchida and Hue, 2000). Reduced fertilizer use efficiency and crop performance can be expected when soil is not properly controlled (Hardy *et al*., 1990). Due to low level nature of flood plains in terms of gradient, they are subjected to seasonal flooding during rainy season and this result into huge agronomic tasks on the soils which are more arduous and tedious in terms of acidity than upland soils (Jalloh and Anderson, 1986).

Liming is an important practice aimed at achieving optimum yields of all crops grown on acid soils. According to Kaitibie *et al* (2002), liming is the most widely used long term method of soil amelioration and its success is well documented (Scoot *et al*., 2001). Application of lime at an appropriate rate brings several chemical and biological changes in the soils which are beneficial or helpful in improving crop yields on acid soils (Fageria and Buligar, 2008). Liming raises soil pH, base saturation and Ca and Mg contents and reduces aluminum concentration in acidic soils (Fageria and Stone, 2004).

The liming of acidic soils results in the release of phosphorus for plant uptake; this effect is often referred to as "P spring effect" of lime (Bolan *et al*., 2003). In addition, liming acidic soils enhances the activities of beneficial microbes in the rhizosphere and hence improves root growth by fixation of atmospheric nitrogen because neutral pH allows more optimal condition for free living N fixation (Stephen *et al* ., 2011).

Okra is a vegetable crop that belongs to the genus Abelmoschus family and its cultivated widely in west and central Africa for its immature fruits (Purseglove, 1984; Schippers, 2000). Okra seeds contain approximately 21% protein, 14% lipids and 5% ash (Savello *et al*., 1980).

Increase in the productivity calls for better crop husbandry as it becomes imperative in these days of declining productivity from upland agriculture to expand arable cropping into vast and hitherto little exploited wetland resources. This work therefore tries to provide information on the effect of lime and fertilizer application on the acid soil of this study area in Benue State, Nigeria using okra as the test crop.

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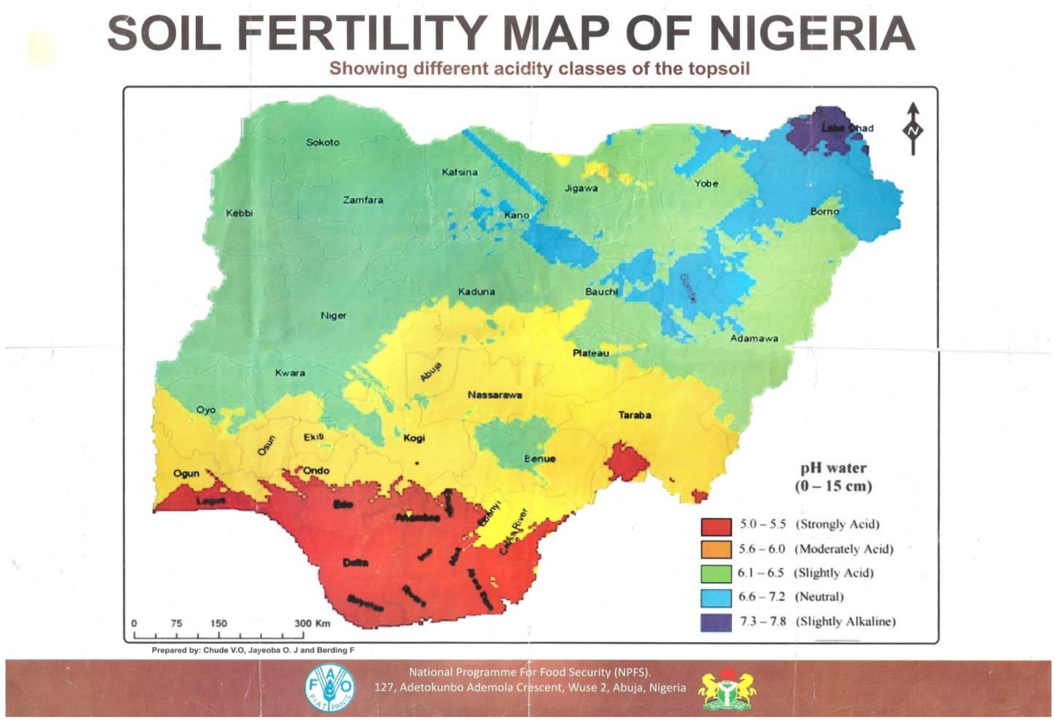
MATERIALS AND METHODS

Experimental Site:

The pot experiment was conducted in a screen house located at the Agronomy Teaching and Research Farm of the University of Agriculture, Makurdi, Benue State, Nigeria during the 2014 cropping season. The location falls between Latitude $7^0$41′N to $7^0$42′N and Longitude $8^0$37′E to $8^0$38′E. in the southern Guinea Savanna agro ecological zone of Nigeria.

Experimental Soil Sample

Surface soil sample (0 – 15 cm) of 500 kg was collected from Otobi (flood plain) area of the research farm for laboratory analysis before its use in the experiment. 5kg was sieved into 96 pots each making a total 480kg in all. The textural class of the soil is sandy loam with pH (KCl 1:1) of 5.3 (strongly acidic) and it is moderately drained. (Figure 1 shows the soil fertility map of Nigeria as classified by Chude *et al*., 2002.



Source of Planting Materials

An improved variety of okra known as Clemson Spineless was sourced from the Agricultural Development Programme (ADP) office Lafia Nasarrawa state, Nigeria. Another local variety commonly grown by the farmers in the locality known as 'Logo' was also sourced.

Experimental Treatment and Design

The factorial experiment consist of NPK (15:15:15) fertilizer at four levels: 0, 11.25, 22.5 and 45.0 Kg NPK ha^{-1}. Lime ($CaCO_3$) at four levels: 0, 1.0, 1.5 and 2.0 tons ha^{-1} were applied in

ISSN: 2456-8643

combination to two varieties of Okra (local and improved variety), laid out in a Completely Randomized Design (CRD).

NPK = 4 Levels

Lime = 4 Levels

Varieties = 2

Replication = 3

Total number of pots used = 4x4x2x3 = 96

Treatment combinations

TREATMENT	NPK	LIME
T_1	N_0	L_0
T_2	N_0	L_1
T_3	N_0	L_2
T_4	N_0	L_3
T_5	N_1	L_0
T_6	N_1	L_1
T_7	N_1	L_2
T_8	N_1	L_3
T_9	N_2	L_0
T_{10}	N_2	L_1
T_{11}	N_2	L_2
T_{12}	N_2	L_3
T_{13}	N_3	L_0
T_{14}	N_3	L_1
T_{15}	N_3	L_2
T_{16}	N_3	L_3

Key:

N_0 = 0 Kg NPK ha^{-1}

N_1 = 11.25 kg NPK ha^{-1}

N_2 = 22.5 kg NPK ha^{-1}

N_3 = 45.0 kg NPK ha^{-1}

L_0 = 0 ton $CaCO_3$ ha^{-1}

L_1 = 1.0 ton $CaCO_3$ ha^{-1}

L_2 = 1.5 tons $CaCO_3$ ha^{-1}

L_3 = 2.0 tons $CaCO_3$ ha^{-1}

Pot Preparation and Planting

Five (5) Kg of soil was weighed into 96 perforated plastic pots of 7 litres capacity, lime was applied to the pots to receive lime as indicated in the treatment design, after application of lime

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the soil in the pot were left to equilibrate for 2 weeks. Okra seeds were later sown directly into the pots at the rate of 3 seeds per pot. The plants were thinned to two stands per pot, two weeks after sowing. NPK fertilizer was applied to the pots according to the treatment design two weeks after two weeks after sowing, (2 WAS).

Cultural Practices

Weeds were pulled out manually weekly and pest (aphid) was controlled using Cymethoate and Pyrinex 48EC. While supplementary irrigation was done with watering can when required.

Soil data and analysis

Soil samples were collected with the aid of soil auger (0-15cm) depth at the beginning of the experiment, after harvest soil samples were also collected from the pots. 96 soil samples were collected and bulked according to their treatments to achieve homogeneity. The samples were taken to laboratory and analyzed for, pH, organic matter (OM), Organic carbon total Nitrogen (N), available Phosphorus (P), exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}), effective cation exchange capacity (ECEC), particle size distribution (PSD) using standard procedures.

Plant data collection

Plant data were collected on the growth and yield parameters of okra plant which include: plant height, leaf area, number of leaves, weight of crop, girth of fruit, and number of fruits. The heights, number of leaves, leaf area of the plants were measured using leaf area meter at 2 WAP, 4 WAP, 6 WAP and 8 WAP (Weeks After Planting). Weight of crops (using an electronic weighing balance.), Length of fruits and circumference were taken at maturity.

Plant Data Analysis

The plant data collected (Plant height, leaf area, number of leaf, number of fruits, weight of fruits, and circumference of fruits) were subjected to statistical analysis using GenStat computer package.

RESULTS AND DISCUSSION

Pre-Planting Soil Properties

The Physical and chemical properties of the soil used for the experiment before application of treatment are shown in Table 1.The result indicated that the textural class of soil is sandy loam; the exchangeable acidity of the soil was high. The chemical composition of the soil also indicated that the soil was low in organic matter. Total Nitrogen was low, the exchangeable bases and effective cation exchange capacity ECEC were low. Available phosphorus was low.This pre-planting soil analysis indicates a poor soil fertility status that requires fertilizer application and pH amendment (Total Nitrogen before planting i.e 0.8 g kg^{-1}) falls below the

ISSN: 2456-8643

optimum value of 1.50 kg ha^{-1} (Agboola, 1972). The pH of the soil used for the research was acidic, which was at variance with the observation of Lester and Seck (2004) that optimum pH range for vegetable production is between 5.8 – 6.8. Although the value of K in the soil (0.27cmolkg^{-1}) during the cropping seasons was within the critical value (0.01 cmolkg^{-1}) below which deficiency would occur in plants (Lester and Seck, 2004). The result of the pre-planting soil analysis indicates that soil amendment is required in line with earlier observation by Agboola (1975).

Plant height, leaf area, number of leaves

The results on Table 2 show that plant height was significantly ($P<0.05$) increased by the application of lime and NPK 15:15:15 applied in combination in the study carried out. The Control produced shorter plants than treated ones in both okra varieties. The tallest plant (32.50 cm) was obtained using 45 kg N ha^{-1} +2 tons $CaCO_3$ ha^{-1} on Clemson spineless variety and the shortest (7.50 cm) from the combination of 11.25 kg N ha^{-1} +1 ton $CaCO_3$ ha^{-1}. The application of 2 tons ha^{-1} lime and 22.5 kg NPK + 1.5 tons $CaCO_3$ ha^{-1} and 11.25 kg NPK ha^{-1} + 1.5 tons $CaCO_3$ ha^{-1} produced plants that were statistically similar.

The results (Table 3) also showed some increases due to application of lime and NPK 15:15:15 on the leaf area. However, significant response was observed at 6 WAP and the highest value (83.99 cm^2) obtained from the treatment combination of 11.25 kg NPK ha^{-1} + 2 tons $CaCO_3$ ha^{-1}. Although, there were increases from other treatment combinations but they are not statistically significant.

Table 1: Physical and chemical properties of soil before planting at the experimental site.

Properties	Value
Sand gkg^{-1}	753
Silt gkg^{-1}	112
Clay gkg^{-1}	135
Textural class	Sandy loam
pH (H_2O 1:1)	5.50
pH (KCl 1:1)	5.30
Organic matter gkg^{-1}	119
Organic carbon gkg^{-1}	6.90
Nitrogen gkg^{-1}	0.80
Available phosphorus (mg/kg)	3.40

ISSN: 2456-8643

Mg (cmol kg^{-1})	1.56
K (cmol kg^{-1})	0.27
Na (cmol kg^{-1})	0.55
Ca (cmol kg^{-1})	3.11
CEC Soil(cmolkg^{-1})	6.30
Base saturation gkg^{-1}	873
Exchangeable Acid/EA(kg)	1.77
ECEC (cmol kg^{-1})	8.07
Fe_2O_3 gkg^{-1}	61.4
Al_2O_3 gkg^{-1}	39.9

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ISSN: 2456-8643

Table 2: Effect of lime and fertilizer application on plant height of okra varieties.

Treatments		2WAP		4WAP		6WAP		8WAP	
Fertilizer	Lime	Plant height (cm)		Plant height (cm)		Plant height (cm)		Plant height (cm)	
		V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
N_o	L_o	8.83	10.33	10.33	15.73	16.17	24.17	16.67	25.83
N_o	L_1	7.66	10.17	10.67	17.00	16.67	28.17	22.50	28.00
N_o	L_2	7.66	10.33	12.00	16.17	17.17	24.17	18.50	28.83
N_o	L_3	8.66	9.83	11.67	17.17	17.50	25.83	22.17	28.33
N_1	L_o	9.06	9.50	14.00	15.67	19.67	24.67	18.50	29.33
N_1	L_1	7.50	9.50	11.67	12.63	17.33	24.53	20.83	25.33
N_1	L_2	9.23	9.83	13.17	14.60	19.83	24.83	18.17	26.67
N_1	L_3	8.83	9.33	13.17	15.17	18.50	23.50	21.83	26.83
N_2	L_o	9.16	9.83	14.33	15.00	18.67	15.00	22.50	26.50
N_2	L_1	8.66	10.67	12.17	17.17	17.83	17.21	17.83	30.17
N_2	L_2	9.23	10.33	11.67	14.10	18.67	14.77	20.67	28.33
N_2	L_3	9.16	10.17	12.33	16.00	18.00	16.00	21.17	29.00
N_3	L_o	9.16	9.67	14.00	13.33	18.00	13.33	19.67	28.00
N_3	L_1	8.66	9.67	13.67	16.00	21.17	17.00	20.83	27.62
N_3	L_2	8.83	9.67	13.33	15.33	18.33	15.33	20.67	26.67
N_3	L_3	9.00	10.17	14.00	15.50	18.83	14.33	19.50	32.50
LSD (0.05)		0.47	NS	1.49	1.35	NS	1.72	NS	NS

KEY:

N_0 = 0 kg NPK ha^{-1} L_0 = 0 ton $CaCO_3$ ha^{-1}

N_1 = 11.25 kg NPK ha^{-1} L_1 = 1.0 ton $CaCO_3$ ha^{-1} V_1 = Local variety

N_2 = 22.5 kg NPK ha^{-1} L_2 = 1.5 tons $CaCO_3$ ha^{-1} V_2 = Clemson spineless

N_3 = 45.0 kg NPK ha^{-1} L_3 = 2.0 tons $CaCO_3$ ha^{-1} NS = Not Significant

Table 3: Effect of lime and fertilizer application on leaf area of okra varieties

Treatments		2WAP		4WAP		6WAP	
Fertilizer	Lime	Leaf area/plant (cm^2)		Leaf area/plant (cm^2)		Leaf area/plant (cm^2)	
		V_1	V_2	V_1	V_2	V_1	V_2
N_0	L_0	9.27	10.80	27.80	37.80	44.67	43.30
N_0	L_1	10.83	12.49	32.40	50.80	52.33	62.30
N_0	L_2	10.12	15.83	32.90	26.30	49.00	33.00
N_0	L_3	13.08	15.12	32.30	32.10	44.17	50.30
N_1	L_0	19.73	12.40	41.70	34.20	50.67	45.55
N_1	L_1	14.08	13.33	38.80	27.60	42.33	39.80
N_1	L_2	16.33	14.82	36.00	27.60	42.33	39.80
N_1	L_3	17.10	15.33	34.80	47.60	47.17	83.99
N_2	L_o	19.67	13.36	30.20	33.20	45.67	52.50
N_2	L_1	13.95	16.13	28.20	35.20	40.17	42.50
N_2	L_2	13.17	18.35	35.70	37.20	42.33	37.80
N_2	L_3	16.67	15.33	33.80	31.80	47.17	43.80
N_3	L_0	14.17	10.77	37.60	28.90	50.33	45.50
N_3	L_1	14.80	10.92	32.70	28.90	52.67	45.10
N_3	L_2	17.07	12.57	31.80	26.90	38.67	31.70
N_3	L_3	15.93	8.86	37.60	39.20	43.00	41.30
LSD (0.05)		2.40	3.32	NS	NS	NS	13.58

KEY:

N_0 = 0 kg NPK ha^{-1} L_0 = 0 ton $CaCO_3$ ha^{-1}

N_1 = 11.25 kg NPK ha^{-1} L_1 = 1.0 ton $CaCO_3$ ha^{-1} V_1 = Local variety

N_2 = 22.5 kg NPK ha^{-1} L_2 = 1.5 tons $CaCO_3$ ha^{-1} V_2 = Clemson spineless

N_3 = 45.0 kg NPK ha^{-1} L_3 = 2.0 tons $CaCO_3$ ha^{-1} NS = Not Significant

The results presented in Table 4 on the influence of the application of lime and NPK 15:15:15 on the number of leaves of the two varieties of okra do not show any statistical difference among the treatment combination from the data obtained. However, the data obtained range from 4 to 7. This result indicates that the combination of lime and NPK 15:15:15 fertilizer produced an increase in growth parameters taken although the trend was not consistent, however it appears that the highest rate of NPK 15:15:15 (45 kg/ha) in combination with other rates of lime gave the best result which corroborate the findings of Babalola *et al* (2002) who reported that increasing the rate of NPK fertilizer led to increase in growth parameters of okra. It appears that the best interaction (lime x fertilizer) for nutrient efficiency is best at the highest rate of NPK 15:15:15 used in the study and Clemson variety of okra.

Okra fruit yield and its parameters

The result presents in Table 5 on the influence of lime and NPK fertilizer on the fruit yield and its parameters showed increase in the yield obtained from the treatments applied. In terms of the number of fruits per plant there was no significant difference recorded among the treatments and varieties of okra used. The application of 11.25 kg NPK ha^{-1} + 1.0 ton lime ($CaCO_3$) ha^{-1} when applied to Clemson spineless variety (V_2) gave better fruit length when compared to similar treatment being applied to the local variety (V_1). Other treatments combination applied produced statistically similar result, but the least fruit length was obtained from the control.

In terms of the weight of fruit obtained, the application of 22 kg NPK + 1.0 ton lime ($CaCO_3$) ha^{-1} produced the highest weight in the local variety (V_1), but this is less than the highest weight obtained from the Clemson spineless variety (V_2). However, the application of 11.5 kg NPK + 1.5 tons lime ($CaCO_3$) ha^{-1} that was applied to Clemson spineless variety (V_2) gave the highest fruit weight obtained from the varieties of okra used. Interestingly, application of 11.25 kg NPK ha^{-1} and 45 kg NPK ha^{-1} gave similar fruit weight. This shows the importance of liming in achieving nutrient efficiency usage by crops, which is in consonance with the report of Oluwatoyinbo *et al*. (2005). More so, the lower rate of NPK fertilizer in combination with lime ($CaCO_3$) is a confirmation of their work that neutralization of exchangeable Al reduced fertilizer requirement.

Table 4: Effect of lime and fertilizer application on number of leaf of okra varieties

Treatments		2WAP		4WAP		6WAP	
Fertilizer	Lime	No of leaf/plant		No of leaf/plant		No of leaf/plant	
		V_1	V_2	V_1	V_2	V_1	V_2
N_0	L_0	4.00	4.33	6.00	6.00	4.33	5.33
N_0	L_1	4.00	4.00	5.33	7.00	4.66	5.67
N_0	L_2	4.00	4.00	5.67	5.33	5.33	6.00
N_0	L_3	4.00	4.33	7.33	6.67	5.66	7.00
N_1	L_0	4.00	4.00	6.00	6.33	5.66	5.67
N_1	L_1	4.00	4.33	5.67	4.67	5.66	6.00
N_1	L_2	4.00	4.00	5.33	5.67	5.66	6.00
N_1	L_3	4.00	4.00	5.67	7.67	6.33	5.67
N_2	L_0	4.00	4.00	6.67	6.33	5.66	6.33
N_2	L_1	4.00	4.00	5.67	5.67	5.33	5.67
N_2	L_2	4.00	4.00	5.33	6.00	4.66	6.00
N_2	L_3	4.00	4.33	5.33	5.33	5.33	5.33
N_3	L_0	4.00	4.00	6.33	6.00	5.66	6.00
N_3	L_1	4.00	4.00	5.00	6.00	5.33	6.00
N_3	L_2	4.00	4.00	5.00	5.67	5.33	5.67
N_3	L_3	3.99	4.00	6.00	5.67	5.66	6.33
LSD (0.05)		NS	NS	NS	NS	NS	NS

KEY

N_0 = 0 kg NPK ha^{-1} L_0 = 0 ton $CaCO_3$ ha^{-1}
N_1 = 11.25 kg NPK ha^{-1} L_1 = 1.0 ton $CaCO_3$ ha^{-1} V_1 = Local variety
N_2 = 22.5 kg NPK ha^{-1} L_2 = 1.5 tons $CaCO_3$ ha^{-1} V_2 = Clemson spineless
N_3 = 45.0 kg NPK ha^{-1} L_3 = 2.0 tons $CaCO_3$ ha^{-1} NS = Not Significant

Table 5: Effect of lime and fertilizer application on yield components varieties of okra

Treatments		Length of Fruit/plant (cm)		Weight of fruit/plant (g)		No of fruits/plant		Circumference of fruit/plant (cm)	
Fertilizer	Lime	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
N_0	L_0	4.03	10.67	2.67	7.07	1.66	1.33	4.00	6.00
N_0	L_1	7.13	15.33	4.50	8.67	1.66	2.00	5.40	6.00
N_0	L_2	4.77	12.33	3.33	7.57	1.66	2.00	4.67	5.33
N_0	L_3	4.93	11.00	3.00	6.83	1.33	2.00	4.50	5.50
N_1	L_0	8.33	3.17	6.86	16.33	2.00	2.00	4.83	6.40
N_1	L_1	3.83	7.30	5.07	13.33	1.66	2.00	5.33	6.23
N_1	L_2	3.17	8.90	3.54	18.67	1.33	2.00	5.67	6.17
N_1	L_3	5.17	5.57	7.13	9.33	2.00	2.00	5.40	5.50
N_2	L_0	8.57	3.17	5.18	15.33	1.66	2.00	4.17	6.00
N_2	L_1	5.00	7.30	4.03	12.00	2.00	2.00	6.33	5.67
N_2	L_2	3.50	7.07	6.86	10.00	1.66	2.00	4.17	5.23
N_2	L_3	2.67	6.83	5.18	11.33	1.66	2.00	3.67	5.00
N_3	L_0	7.70	2.67	7.50	16.33	2.00	2.33	3.67	5.83
N_3	L_1	3.50	8.97	6.29	17.67	1.66	2.00	4.67	6.00
N_3	L_2	3.00	7.00	5.17	8.50	1.66	2.00	3.83	6.33
N_3	L_3	3.67	5.57	5.37	12.67	1.00	1.33	4.17	5.50
LSD (0.05)		NS	NS	NS	1.42	NS	NS	NS	NS

KEY:

N_0 = 0 kg NPK ha^{-1} L_0 = 0 ton $CaCO_3$ ha^{-1}
N_1 = 11.25 kg NPK ha^{-1} L_1 = 1.0 ton $CaCO_3$ ha^{-1} V_1 = Local variety
N_2 = 22.5 kg NPK ha^{-1} L_2 = 1.5 tons $CaCO_3$ ha^{-1} V_2 = Clemson spineless
N_3 = 45.0 kg NPK ha^{-1} L_3 = 2.0 tons $CaCO_3$ ha^{-1} NS = Not Significant

Soil chemical properties after harvest

Table 6a and 6b show the influence of lime and NPK application on the soil chemical properties after harvest. There was little increase in pH of the applied treatments except in the control in both varieties of okra used (local and Clemson spineless). Lime application and NPK fertilizer increased pH from 5.5 to maximum of 7.35 under okra local variety and to maximum of 7.08 under okra improve variety Clemson spineless.

There was observed increase in the soil organic matter content resulting from the application of the treatments except in the control and application of 1.0 ton lime ($CaCO_3$) ha^{-1} under okra local variety. The combination of 22.5 kg NPK fertilizer and that of lime ($CaCO_3$) at all the levels used gave appreciable increased in soil organic matter after harvest. The highest value (30 g kg^{-1}) obtained from the treatment combination of 22.5 kg NPK +2.0 tons lime ($CaCO_3$) ha^{-1}.

The result in terms of post harvest total Nitrogen of the soil shows a decrease in comparison with the initial total soil N (0.08 g kg^{-1}). The highest total soil N obtained under okra local variety is from 22.5 kg NPK + 1.0 ton lime ($CaCO_3$) ha^{-1} (0.73 g kg^{-1}) and under okra Clemson spineless is from the application of 22.5 kg NPK fertilizer (0.77 g kg^{-1}).

Soil available phosphorus P seems to be positively influenced with the application of the treatments. Marginal increases were recorded in comparison with the initial soil available phosphorus P. application of 11.25 kg NPK + 2 tons lime (CaCO3), 22.5 kg NPK + 2 tons lime ($CaCO_3$) and 45 kg NPK ha^{-1} + 2 tons lime ($CaCO_3$) ha^{-1} gave better result of residual soil available phosphorus P.

The effects of the applied NPK fertilizer and lime on residual exchangeable bases do not present a definite pattern. In some treatments there were increases and in others there were decreases recorded. Magnesium (Mg) increased marginally in all treatments applied in both varieties of okra used. Exchangeable K do not follow this pattern, in most cases decreases were recorded. However, Calcium (Ca) increased in all treatments of lime and fertilizer application. This increase was more obvious under the local variety of okra than Clemson spineless variety, where decrease in Ca content of the soil were obtained.

The increase in soil pH following the application of lime and fertilizer can be attributed to the release of organic acids by soil microbes which in turn might have suppressed Al content in the soil through chelation as reported Onwonga *et al*., 2008 and Okwuagu *et al*., 2003 in their water leading to the production of OH^- ions and Ca^{2+} ions which displaces H^+ and Al^{3+} ions from soil adsorption sites resulting in an increase in soil pH as reported by Kisinyo *et al*, 2012. While, the result obtained in the increase of some of the exchangeable bases can be attributed to the precipitation of Al as hydroxyl Al by the applied lime thereby releasing these cations into the soil as reported by Ojeniyi *et al*., 2009.

Table 6a: Physical and chemical properties of soil planted with local variety of okra at harvest

Properties	Treatments															
	T_1V_1	T_2V_1	T_3V_1	T_4V_1	T_5V_1	T_6V_1	T_7V_1	T_8V_1	T_9V_1	$T_{10}V_1$	$T_{11}V_1$	$T_{12}V_1$	$T_{13}V_1$	$T_{14}V_1$	$T_{15}V_1$	$T_{16}V_1$
Ph	5.3	7.35	7.02	7.29	7.00	7.01	6.81	6.79	7.05	6.91	7.18	7.17	6.95	6.79	6.88	6.97
Organic Carbon(OC) gkg^{-1}	60.0	4.20	13.8	16.0	12.0	16.0	9.00	18.0	5.80	12.0	9.00	15.4	11.0	15.0	15.0	17.4
Organic Matter(O.M) gkg^{-1}	10.3	7.20	23.8	27.6	20.7	27.6	15.5	20.6	10.0	20.7	15.5	26.6	19.0	25.9	25.9	30.0
P (mg/kg)	0.46	0.48	0.62	0.54	0.61	0.63	0.52	0.57	0.66	0.64	0.62	0.65	0.61	0.65	0.62	0.72
Total Nitrogen gkg^{-1}	0.62	0.60	0.63	0.68	0.56	0.62	0.59	0.61	0.53	0.73	0.50	0.62	0.62	0.60	0.61	0.68
Kcmol kg^{-1}	0.27	0.25	0.28	0.28	0.24	0.26	0.28	0.30	0.30	0.31	0.34	0.32	0.34	0.34	0.30	0.33
Nacmol kg^{-1}	0.24	0.21	0.22	0.26	0.21	0.23	0.26	0.28	0.29	0.28	0.28	0.30	0.31	0.32	0.29	0.32
Cacmol kg^{-1}	3.42	3.40	3.60	3.20	3.40	3.44	3.36	3.38	3.10	3.00	3.04	3.12	3.34	3.41	3.06	3.43
Mg cmol kg^{-1}	3.20	3.10	3.40	3.00	3.21	3.14	3.12	3.08	2.90	2.82	2.80	3.00	3.06	3.21	2.94	3.20
EAcmo kg^{-1}	1.21	1.20	1.10	1.20	1.13	1.21	1.20	1.12	1.02	0.98	1.10	1.20	1.14	1.12	1.05	1.13
TEBcmol kg^{-1}	7.14	6.96	7.48	6.74	7.06	7.07	7.02	7.04	6.59	6.41	6.46	6.74	7.05	7.28	6.59	7.28
CECcmol kg^{-1}	8.35	8.16	8.58	7.94	8.19	8.28	8.22	8.16	7.61	7.39	7.56	7.94	8.19	8.40	7.64	8.41
BS %	85.5	83.5	87.4	84.9	86.2	85.4	85.4	86.3	86.6	86.7	85.4	84.9	861	867	863	866

KEY:

T_1V_1= control, **T_2V_1** = 0kgNPK ha^{-1} + 1.0ton $CaCO_3$ ha^{-1}, **T_3V_1** = 0kgNPK ha^{-1} + 1.5tons $CaCO_3$ ha^{-1}, **T_4V_1** = 0kgNPK + 2.0tons $CaCO_3$ ha^{-1}, **T_5V_1**= 11.25kgNPK + 0kg$CaCO_3$ ha^{-1}, **T_6V_1** = 11.25kgNPK + 1.0ton $CaCO_3$ ha^{-1}, **T_7V_1** = 11.25kgNPK + 1.5tons $CaCO_3$ ha^{-1}, **T_8V_1** = 11.25kgNPK + 2tons $CaCO_3$ ha^{-1}, **T_9V_1** = 22.5kgNPK + 0kg$CaCO_3$ ha^{-1}, **$T_{10}V_1$** = 22.5kgNPK + 1.0ton$CaCO_3$ ha^{-1}, **$T_{11}V_1$** = 22.5kgNPK + 1.5tons $CaCO_3$ ha^{-1}, **$T_{12}V_1$** = 22.5kgNPK ha^{-1} + 2.0tons $CaCO_3$ ha^{-1}, **$T_{13}V_1$**= 45kgNPK + 0kg$CaCO_3$ ha^{-1}, **$T_{14}V_1$** = 45kgNPK + 1.0ton$CaCO_3$ ha^{-1}, **$T_{15}V_1$** = 45.0kgNPK + 1.5tons $CaCO_3$ ha^{-1}, **$T_{16}V_1$**= 45.0kgNPK + 2.0tons $CaCO_3$ ha^{-1}. EA = Exchangeable Acidity, TEB = Total Exchangeable Bases, CEC = Cation Exchange Capacity, BS = Base Saturation.

Table 6b: Chemical properties of soil planted with Clemson spineless variety of okra at harvest

Properties	Treatments															
	T_1V_2	T_2V_2	T_3V_2	T_4V_2	T_5V_2	T_6V_2	T_7V_2	T_8V_2	T_9V_2	$T_{10}V_2$	$T_{11}V_2$	$T_{12}V_2$	$T_{13}V_2$	$T_{14}V_2$	$T_{15}V_2$	$T_{16}V_2$
pH	5.30	6.93	6.92	6.96	6.88	6.95	7.10	7.06	6.94	6.08	7.08	6.91	7.06	7.00	6.82	6.78
Organic Carbon (OC) gkg^{-1}	18.0	13.2	11.8	9.00	11.2	11.0	18.0	17.6	23.5	16.8	12.0	8.80	9.80	16.2	14.6	17.4
Organic Matter (O.M) gkg^{-1}	20.6	22.8	20.4	15.5	19.3	19.0	20.6	30.4	40.7	29.0	20.7	15.2	16.9	27.9	25.2	30.0
P (mg/kg)	0.44	0.50	0.47	0.52	0.54	0.51	0.62	0.63	0.70	0.66	0.58	0.68	0.60	0.61	0.56	0.64
Total Nitrogen gkg^{-1}	0.58	0.56	0.53	0.48	0.58	0.49	0.60	0.64	0.77	0.64	0.63	0.59	0.56	0.60	0.63	0.66
Kcmol/kg	0.31	0.29	0.32	0.26	0.26	0.26	0.36	0.24	0.28	0.34	0.33	0.29	0.30	0.32	0.31	0.30
Nacmol/kg	0.29	0.24	0.28	0.22	0.24	0.23	0.32	0.22	0.24	0.30	0.31	0.26	0.28	0.29	0.30	0.30
Cacmol/kg	3.20	3.10	3.10	3.02	3.36	3.30	3.40	3.60	3.40	3.20	3.32	3.13	3.10	3.05	3.10	3.20
Mg cmol/kg	2.90	2.86	2.88	2.80	3.13	3.10	3.20	3.22	3.14	3.00	3.12	2.96	2.85	2.98	3.00	3.00
EAcmol/kg	1.00	1.10	1.20	1.12	1.11	1.10	1.20	1.21	1.21	1.00	1.21	1.04	1.00	0.96	1.23	1.24
TEBcmol/kg	6.7	6.37	6.58	6.3	6.99	6.89	7.28	7.28	7.06	9.54	7.08	6.64	6.53	6.64	6.71	6.85
CECcmol/kg	7.7	7.4	7.78	7.42	8.1	7.99	8.48	8.49	8.27	10.54	8.29	7.68	7.53	7.60	7.94	8.09
BS gkg^{-1}	87	853	846	849	863	862	858	859	854	905	854	865	867	874	845	847

KEY:

T_1V_1= control, **T_2V_1** = 0kgNPK ha^{-1} + 1.0ton $CaCO_3$ ha^{-1}, **T_3V_1** = 0kgNPK ha^{-1} + 1.5tons $CaCO_3$ ha^{-1}, **T_4V_1** = 0kgNPK + 2.0tons $CaCO_3$ ha^{-1}, **T_5V_1**= 11.25kgNPK + 0kg$CaCO_3$ ha^{-1}, **T_6V_1** = 11.25kgNPK + 1.0ton $CaCO_3$ ha^{-1}, **T_7V_1** = 11.25kgNPK + 1.5tons $CaCO_3$ ha^{-1}, **T_8V_1** = 11.25kgNPK + 2tons $CaCO_3$ ha^{-1}, **T_9V_1** = 22.5kgNPK + 0kg$CaCO_3$ ha^{-1}, **$T_{10}V_1$** = 22.5kgNPK + 1.0ton$CaCO_3$ ha^{-1}, **$T_{11}V_1$** = 22.5kgNPK + 1.5tons $CaCO_3$ ha^{-1}, **$T_{12}V_1$** = 22.5kgNPK ha^{-1} + 2.0tons $CaCO_3$ ha^{-1}, **$T_{13}V_1$**= 45kgNPK + 0kg$CaCO_3$ ha^{-1}, **$T_{14}V_1$** = 45kgNPK + 1.0ton$CaCO_3$ ha^{-1}, **$T_{15}V_1$** = 45.0kgNPK + 1.5tons $CaCO_3$ ha^{-1}, **$T_{16}V_1$**= 45.0kgNPK + 2.0tons $CaCO_3$ ha^{-1}. EA = Exchangeable Acidity, TEB = Total Exchangeable Bases, CEC = Cation Exchange Capacity, BS = Base Saturation.

Conclusion

The result of this work shows that complimentary application of lime and NPK fertilizer on a soil obtained from acidic flood plain is very effective in the production of vegetable crop such as okra in our study. The presence of lime ameliorates soil acidity as evidence in the reduction of the soil pH as well as an improvement in the residual N, P, K, Ca and organic matter which will form the basis for sustainable crop production. The application of 11.25 kg NPK ha^{-1} and 1.5 tons lime ($CaCO_3$) ha^{-1} is considered beneficial and optimum in the meantime.

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ISSN: 2456-8643

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