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Response of Four Varieties of Cocoyam (*Colocosia esculenta*) to Liming in Acid Soils of Mgbakwu, South-Eastern Nigeria

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ABSTRACT

A study was carried out at the teaching and research farm of the Agricultural Technology Department in Anambra State Polytechnic, Mgbakwu to determine the response of four varieties of cocoyam to liming in acid soils. The experiment was a 4 x 4 factorial experiment fitted into a Randomized Complete Block Design (RCBD) replicated four times, sixteen treatment combinations, involving four levels of lime rates, 0, 1.0, 1.5 and 2.0 tons/ha were used. Four local varieties of cocoyam (*nach, nworoko, ugwuta* and *odogolo*) was used as the test crop. F-LSD was applied to detect significant differences between two means at 5% probability level. Results show that growth parameters such as plant height and the number of suckers were influenced by the application of lime at 2 t/ha on the four varieties of cocoyam with *odologo* giving the tallest plant height at 1, 3 and 5 MAP (14.30 cm, 65.02 and 70.01). *Odologo* variety also gave a significant yield increase in the number of tubers per plant (17.84) and tuber yield (18.90 t/ha) at the rate of 2 t/ha. From the results shown, it is reasonable to recommend the use of 2 t/ha of lime in the cultivation of cocoyam in acid soils of south-eastern Nigeria.

KEYWORDS: *Cocoyam, varieties, acidity, liming*

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1. INTRODUCTION

The problem of acid soils is a common phenomenon with soils of humid tropical areas where intense rainfall leaches out basic cations from the exchange site of the soil (the soil colloids) leaving predominantly aluminum ion Al^{3+} and hydrogen ions (H^+) in the soil. The hydrolysis of the aluminum ions further increases the level of the acidity of the soil. The acidity of the soil affects the soil's nutrients availability and releases. At a high-level acidity, that is low pH, the soil macro-nutrients like calcium, phosphorous, potassium, sulphur etc., are in their less available or tied form, while at a low acidity or very high pH, the micro-nutrient e.g., zinc, manganese are in their less available or tied form, while the macro nutrients tend to be more available vice versa.

Application of lime material improves soil pH, improves exchangeable bases, Cation Exchange Capacity (CEC), reduces aluminum toxicity, increases phosphorus uptake in a high phosphorus fixing soil and plants rooting system (Black, 1993: Nweke, 2017).

Cocoyam (*colocosia esculenta*) is one of the tropical crops valued and cultivated in the south east Nigeria by the small holder farmers as both food and cash crop, in a similar way like yam and cassava. Their edible corms and cormels are rich in starch and nutritionally superior to yam and cassava. According to Akomas, 1987, the dry matter content of cocoyam and its total amino acid content is greater and more than that of other tuber crops. However, its growth and yield according to Igbokwe (1982) has been low as a result of the acidic nature of the soils of the area. There is yet no information on the relative acid tolerance of cocoyam cultivators in Nigeria, south east and Mgbakwu in particular. Hence, the need for the study "The Potential advantages of acid-tolerant crop production in the humid tropics" where peasants farmers do not have the necessary resources to

carryout soil amendment cannot be over-emphasized. Most of the south eastern soils where cocoyam is grown have a moderately high Al^{3+} content and are deficit in Calcuim and Phosphorus.

Therefore, the objectives were to: to determine the appropriate lime rate that will give optimum cocoyam corms and cormel yields and also to determine or select the acid soils tolerant cocoyam varieties (that have no significant corms and cormels yield differences when limed).

2. MATERIALS AND METHODS

The study area was at the teaching and research farm of the Agricultural Technology Department in Anambra State Polytechnic, Mgbakwu. Mgbakwu is located at latitude 06° 30 'North and longitude of 07° 29 'East. The experimental area has a mean annual rainfall of over 2000 mm with two climatic seasons which last from April to October and November to March for wet season and dry season respectively with a relative humidity of 81.6%. The study area is characterized as a ferralitic red yellow soils of the humid tropics. The study area has a cropping history of root, tubers and vegetable crops.

2.1. Land Preparation

The site was ploughed, ridged and later marked into blocks and plots according to the experimental design. Each plot had a size of 4 m x 3 m in dimension with a spacing of 0.5 m between plots and 1.0 m between blocks.

2.2. Soil Sampling

Soil samples were collected with an auger at the beginning of planting from different locations of the experimental site at the depth of 0-20 cm. The samples were properly mixed to get a composite sample which was air dried and sieved with a 2 mm sieve from which a subsample was used for laboratory analysis to determine both the physical and chemical properties of the soil (Table 1). Soil pH was determined in calcium chloride in soil solution ratio 1:2.5 using a glass electrode pH meter. Particle size analysis was determined using hydrometer method. Organic carbon by wet oxidation method while total nitrogen was determined by Kjidehal method. Available phosphorus was determined by Bray and Kurtz No.1 method. The exchangeable bases were determined by leaking the soil sample with IN ammonium acetate at pH 7 to extract the basic cation (Ca, Mg, K and Na). K and Na were determined by flame photometer while Ca and Mg were determined using EDTA titration method.

2.3. Experimental Design and Treatments Allocation

A 4 x 4 factorial experiment fitted into a Randomized Complete Block Design (RCBD) replicated four times, sixteen treatment combinations, involving four levels of lime rates, 0, 1.0, 1.5 and 2.0 tons/ha were used. Four local varieties of cocoyam (*nach, nworoko, ugwuta* and *odogolo*) that were sourced from small holder farmers in the locality was used as test crop.

2.4. Crop Establishment

Planting was done in the main cropping season of 2022. The four levels of lime were applied through broadcast method evenly on the allocated plots one month before planting. One cormel was planted per hole, giving about twenty-four plants per plot. Missing stands were supplied at 2 weeks after planting (WAP). Manual weeding was applied to keep all plots weed free.

2.5. Data Collection

Growth parameters measured were plant height at 1, 3 and 5 MAP, number of suckers was also taken at 3 MAP. Yield parameters measured were number of tubers per plant and total tuber yield (t/ha). These were measured at physiological maturity of the crop. Twelve plants were randomly selected and tagged at 1 MAP from each of the plots and used for the growth and yield parameter measurements.

2.6. Data Analysis

Statistical Analysis of Variance (ANOVA) was done on the field data collected using Genstat 7.1 second edition according to Obi (2002). Fishers Least Significant Difference (P=0.05) was used to detect significant difference between two treatment means.

3. RESULTS AND DISCUSSIONS

The results shown in the Table 1 below indicated that the soil of the experimental area was slightly acidic (pH 5.10 and 4.00, in water and potassium chloride respectively). The textural class of the soil was sandy loam which contained 35% fine sand, 33% coarse sand, 13% silt and 17% clay. The organic carbon, organic matter and total nitrogen contents were 1.05%, 1.70% and 0.040% respectively. The exchangeable bases [sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg)] were 0.311 meq/100g, 0.301 meq/100g, 3.20 meq/100g, and 0.39 meq/100g respectively. The cation exchange capacity (CEC) of the soil was 7.20 meq/100g and 65.18% for the base saturation. Hydrogen content was found to be 2.20 meq/100g and the available phosphorus was 10.35 parts per million (ppm).

Table 1: Some Physical and Chemical Properties of the Soil before the Application of Lime.

Parameters	Level
Physical Properties	
Particle size distribution (%)	
Fine Sand	35.00
Coarse Sand	33.00
Silt	13.00
Clay	17.00
Textural Class	Sandy Loam
Chemical Properties	
Soil pH (H_2O)	5.10
Soil pH (kcl)	4.00
Total Nitrogen (%)	0.04
Organic Carbon (%)	1.05
Organic Matter Content (%)	1.70
Exchangeable Cations (meq/100g)	
Sodium	0.31
Potassium	0.30
Calcium	3.20
Magnesium	0.39
Cation Exchange Capacity (meq/100g)	7.20
Base Saturation (%)	65.18
Exchangeable Acidity (meq/100g)	2.20
Available Phosporus (ppm)	10.35

Growth Parameters

Table 2 below shows the effect of Lime rates on the plant height (cm) of four varieties of Cocoyam at 1 MAP, 3 MAP and 5 MAP respectively. The results obtained showed that as the rates of Lime increased from 0 t/ha to 2 t/ha, the plant height of the four varieties of cocoyam also showed a consistent increase indicating a significant effect ($p<0.05$).

At 1, 3 and 5 MAP, *odogolo* variety gave the tallest plant height (14.30 cm, 65.02 cm and 70.01 cm respectively) at 2 t/ha of Lime rate when compared to the *ugwuta* variety that produced the shortest plant height (13.03 cm, 58.03cm and 56.30 cm) at the same Lime rate of 2 t/ha. It was also observed that the control plots (0 t/ha) of the four varieties of cocoyam at 1, 3 and 5 MAP produced short plant heights when compared with the increased rates of lime application (1 t/ha, 1.5 t/ha and 2 t/ha respectively).

Table 2: Effects of Liming on Plant Height (cm) of Four Varieties of Cocoyam at One, Three and Five months after planting (MAP)

Lime (t/ha)	Four Varieties of Cocoyam				
	nkpong	*nworoko*	*ugwuta*	*odogolo*	**Mean**
			At 1 MAP		
0.00	13.00	12.30	12.32	13.30	**12.73**
1.00	13.03	13.00	12.60	13.43	**13.02**
1.50	13.09	13.08	13.01	13.55	**13.18**
2.00	14.00	13.90	13.03	14.30	**13.81**
Mean	**13.28**	**13.07**	**12.74**	**13.65**	
			At 3 MAP		
0.00	47.00	47.05	46.61	48.01	**47.17**
1.00	48.05	48.80	47.01	53.67	**49.38**
1.50	57.01	58.76	52.00	60.00	**56.94**
2.00	62.60	63.00	58.03	65.02	**62.16**
Mean	**53.67**	**54.40**	**50.91**	**56.68**	

			At 5 MAP		
0.00	51.00	48.00	48.00	53.05	**50.01**
1.00	52.81	53.65	51.50	57.20	**53.79**
1.50	59.22	59. 91	53.71	65.43	**59.57**
2.00	63.00	65.00	56.30	70.01	**63.58**
Mean	**56.51**	**56.64**	**52.38**	**61.42**	

	1 map	3 map	5 map
F-LSD $_{(0.05)}$ Lime (L)	1.00	3.50	4.80
F-LSD $_{(0.05)}$ Varieties (V)	0.25	2.00	3.01
F-LSD $_{(0.05)}$ L x V	0.25	1.27	2.52

Number of Suckers

At 3 MAP, *odogolo* variety gave the highest number (6.87) of suckers at 2 t/ha of lime application rate when compared to other varieties. Although the *nkpong* and *nworoko* varieties were significantly the same, *ugwuta* variety gave the least number of suckers as shown in Table 3 below. Getachew *et al.,* 2017 reported that application of 1.65 t/ha lime combined with 20 kg/ha phosphorus fertilizer increased barley grain yield by 274% compared with the control treatment.

Table 3: Effects of Liming on Number of Suckers of Four Varieties of Cocoyam at three months after planting (MAP)

Lime (t/ha)	**Four Varieties of Cocoyam**				
	nkpong	*nworoko*	*ugwuta*	*odogolo*	**Mean**
0.00	3.00	3.30	3.00	3.50	**3.20**
1.00	4.03	4.05	3.87	4.62	**4.14**
1.50	5.08	5.10	4.07	5.66	**4.98**
2.00	6.20	6.21	5.01	6.87	**6.07**
Mean	**4.58**	**4.67**	**3.99**	**5.16**	

F-LSD $_{(0.05)}$ Lime (L)	0.34
F-LSD $_{(0.05)}$ Varieties (V)	0.38
F-LSD $_{(0.05)}$ L x V	0.42

Yield Parameters

As shown in Table 4 below, *odogolo* variety of Cocoyam produced the highest number of tubers (17.84) at 2 t/ha of lime rate at harvest when compared to control at 0 t/ha. Other varieties of cocoyam also showed a significant increase in the number of tubers as the lime rate increased when compared with their control at 0 t/ha. Agegnehu *et al*., 2006 also found that lime addition at the rates of 1–5 t h/a showed about 45–81% faba bean yield increments over the control.

Table 4: Effects of Liming on Number of Tubers per Plant of Four Varieties of Cocoyam at Harvest

Lime (t/ha)	**Four Varieties of Cocoyam**				
	nkpong	*nworoko*	*ugwuta*	*odogolo*	**Mean**
0.00	15.00	15.03	15.01	15.50	**15.14**
1.00	15.61	15.80	15.58	15.93	**15.73**
1.50	16.53	16.89	16.60	16.99	**16.75**
2.00	17.01	17.50	17.30	17.84	**17.41**
Mean	**16.04**	**16.31**	**16.12**	**16.57**	

F-LSD $_{(0.05)}$ Lime (L)	1.34
F-LSD $_{(0.05)}$ Varieties (V)	0.56
F-LSD $_{(0.05)}$ L x V	0.43

Table 5 below shows the effect of Lime rates on the total tuber yield (t/ha) of four varieties of Cocoyam at harvest. The results obtained showed that as the rates of Lime increased from 0 t/ha to 2 t/ha, the total tuber yield (t/ha) of the four varieties of cocoyam also showed a consistent increase indicating a significant effect ($p<0.05$).

Odogolo variety produced the highest total tuber yield (18.90 t/ha) at 2 t/ha of Lime rate application when compared to other varieties that were significantly the same. This is in line with Agegnehu *et al*., 2006 also found that lime addition at the rates of 1–5 t h/a showed about 45–81% faba bean yield increments over the control.

Table 5: Effects of Liming on Total Tuber Yield (t/ha) of Four Varieties of Cocoyam at Harvest

Lime (t/ha)	Four Varieties of Cocoyam				
	nkpong	*nworoko*	*ugwuta*	*odogolo*	**Mean**
0.00	12.50	12.48	12.37	13.01	**12.59**
1.00	14.00	13.93	13.50	15.25	**14.17**
1.50	15.67	15.79	14.99	17.21	**15.92**
2.00	16.30	16.45	16.23	18.90	**16.97**
Mean	**14.62**	**14.66**	**14.27**	**16.09**	

F-LSD $_{(0.05)}$ Lime (L)	1.95
F-LSD $_{(0.05)}$ Varieties (V)	2.01
F-LSD $_{(0.05)}$ L x V	2.03

4. Conclusion

The study shows that lime application is effective in mitigating soil acidity, enhancing available nutrients and crop yields compared to broadcast lime application. The result showed that the highest cocoyam yields were achieved from the application of 2 t/ha lime due to the mitigation of soil acidity. We conclude that applying 2 t/ha lime is the best option for small holder cocoyam farmers to reduce soil acidity, improve nutrient availability and crop yields in the study area and others having similar environment. However, to determine the reapplication of lime and residual effects, the long-term effects of lime rates on soil acidity and crop yields need to be investigated through further research.

Declaration of interest's statement

The authors declare no conflict of interest.

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