http://dx.doi.org/10.4314/gjas.v14i1.7

GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL 14, 2015: 51-59
 ISSN 1596-2903
www.globaljournalseries.com; Info@globaljournalseries.com

CORRELATION STUDIES OF MINERAL NUTRIENTS' CONCENTRATIONS IN SOILS AND PINEAPPLE (*ANANAS COMOSUS*) PLANTS IN THE SOUTHERN AGRICULTURAL ZONE OF CROSS RIVER STATE

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(Received 5 February 2015; Revision Accepted 11 May 2015)

ABSTRACT

Nutrient deficiencies were observed to be the primary factor affecting pineapple (*Ananas comosus*) plants growth and development in the southern agricultural zone of Cross River State. Fields experiment were conducted to evaluate the relationships existing between mineral nqutrients in the soils and pineapple plants. Thirty - two Soil samples were collected within the experimental plots at the depth of 0-30 cm using a soil auger. Thirty- two pineapple plants of 18 months old were equally collected within the same experimental plots. Randomization method was used for soil and pineapple plants samplings. Samples were labeled and processed for soil and plant laboratory analyses. The parameters analyzed were: Total nitrogen, Available phosphorus, potassium, calcium and magnesium. Their mean concentrations in the soils and pineapple plants were: 0.59 % and 1.22 g kg^{-1} Total N; 15.53 mg kg^{-1} and 0.42 g kg^{-1} Available P and 0.11 cmol kg^{-1} and 1.3 g kg^{-1} Potassium. Others means value were 2.86 cmol kg^{-1} and 0.86 g kg^{-1} Calcium and 0.75 cmol kg^{-1} and 0.52 g kg^{-1} Magnesium respectively. Moreover, the concentrations of other chemical properties in soils were : 0.77 % organic carbon, 4.5 of Soil p H, 0.08 of Exchangeable Sodium and 65.9 cmol Kg^{-1} base saturation. The results further revealed that total N , K and Mg associated positively but weakly correlated, while Calcium associated positively but strongly correlated .Available Phosphorus associated negatively but strongly correlated between the soils and pineapple plants. The levels of mineral nutrients' concentration in the soils at the experimental plots were low, which reflected remarkable in the pineapple plants. Inorganic fertilizers such as N. P. K 15:15:15 should be cautiously applied to enhance soil nutrients' concentration.

KEYWORDS: Soils, Pineapple plants, Mineral nutrients, relationship, Correlation.

INTRODUCTION

Pineapple is one of the world's favourite tropical fruits. The plant was initially called Ananas" a Caribbean word for "excellent fruit". The name "Pineapple" came from European explorers who thought the fruit looked like a pine cone with flesh like an apple. However, pineapple (*Ananas comosus*) is a perennial, monocotyledonous and ornamental fruit plant. This plant had its origin from tropical South America, but presently is widely grown in all tropical and sub-tropical areas of the world (Malo and Campbell, 2003). In Nigeria, the cultivation of pineapple has spread from the sea coast to quite a large part of the upland agricultural areas of the country. A fully matured pineapple grows up to one meter high and 0.5 m wide, while a particular species called smooth cayenne grows up to 1.5 m and one meter wide (Okimoto, 1998). There are five recognized species of pineapple cultivated in Southern Agricultural Zone of Cross River State. These are Smooth cayenne, Spanish red, Queen, Pernambuco and perolera. Pineapple is cultivated primarily for its fruit which is consumed fresh or processed into juice. Economically, this fruit provides jobs to the jobless, and huge income are received from the sale of its products by farmers while government foreign exchange increases annually . Medicinally, a ripe pineapple has anti-bacterial, anti-inflammatory and diuretic actions in human body (Nakasone, 1998).

Globally, pineapple is cultivated in different types of the soil, but tropically, especially in Nigeria, the soils are well drained, having a pH range of 4.5 to 6.5 which is the ideal level for pineapple productions (Coppens, 1998). In the tropics, pineapple is cultivated in any planting seasons of the year provided there is a good irrigational system. Optimal growth temperatures for pineapple are between 20 ^{o}C to 29 ^{o}C (Kochhar, 2006). However, according to Malo and Campbell (2003), pineapple grows well on sandy loam soils with sandy clay textures, having good physical properties. Pineapple requires a lot of nutrients for effective growth and development. The major nutrients pineapple plant requires are: nitrogen, phosphorus, potassium, calcium and magnesium. Pineapple plant also requires micro nutrients such as Manganese, Zinc, Copper and Boron, but in low concentrations. When in excess, they become toxic

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to the plants (Loison,1992). Major minerals nutrient require by the pineapple plants existed in the soils, are also found in the plants, but have different rates of interaction. Therefore, the objective of this study was to evaluate the probable relationships existing between mineral nutrients' concentrations in the soils and pineapple plants in the Southern Agricultural Zone of Cross River State.

MATERIALS AND METHODS

The study was carried out at the Southern Agricultural Zone of Cross River State. The zone lies between 5^0 32` and 04 $^0$ 27` North and Longitude 07^0 15` and 0 $9^0$ 28` East (Bulk trade and Investment company Limited, 1989). The state has an area of about 2100 km^2 and is bounded in the North by Benue State and in the East by Akwa Ibom , Anambra and Imo States. The southern boundary follows the Cross River state into the Bight of Bonny, while the Eastern boundary is the International boundary between the Federal Republic of Nigeria and the United Republic of Cameroon . The Southern Agricultural Zone comprises of Akamkpa, Akpabuyo, Odukpani and Calabar South Local Government Areas in Cross River State of Nigeria. Based on the Federal Department of Agriculture and Land Resources (1998) report, that the soils in Odukpani, Calabar South and Akpabuyo Local Government Areas are derived from the sedimentary sandstones and coastal plain sand. Whereas, soils in Akamkpa Local Government Area are derived from the basement complex parent materials. Each of the local government area represented the experimental plot. From each of the experimental plot, two sampling units were located. Within the sampling unit, 4 sub- sampling points were identified. Eight Soil samples were randomly collected, mixed together to form a Soil composite sample from each of the sub –sampling unit. At the same sampling unit, a well developed, un fruiting Pineapple plant of 18 months old was randomly collected entirely, immediately, within the same circumference of sampling unit. Four Soil composite samples and pineapple plant samples were collected from the sampling unit, and Eight Soil samples and pineapple plants were collected from each of the experimental plot. Soil samples were collected at the depth of 0-30 cm using a soil auger. Thirty -two Soil composite samples and pineapple plant samples were collected from the entire zone. All the samples were labeled and processed for Soil and plant nutrients analyses.

LABORATORY ANALYSES

Soil samples were air - dried, and passed through a 2 mm sieve to remove materials greater than 2 mm in diameter. The fined earth fractions (< 2 mm) were subjected to the following analysis: The particle size analysis was determined by the Bouyocous (hydrometer method) as outlined by Jackson (1969) using sodium hexametaphosphate as a dispersant. The pH of each soil was determined with 1:2.5 soil / water ratio using electrometric method (glass electrode model 3051 pH meter). Organic carbon was determined by the Walkley and Black wet oxidation method, as modified by Nelson and Sommers (1982). Total nitrogen was determined on samples (sieved through 0.5 mm Mesh) by the macro-Kjeldahl method (Jackson, 1969). Available phosphorus (P) was extracted by the Bray P-1 extraction (0.025 ml HCl and 0.03 ml NH_4F) and the content of P in each extract was determined colorimetrically using a Technicon AAII Auto analyser. Determination of exchangeable bases was by neutral ammonium acetate extraction and read with an atomic absorption spectrophotometer (ASS). Exchangeable acidity was determined by the 1 N K chloride (KCl) extraction method (McLean 1965) and titrated with 1 M sodium hydroxide (NaOH) using phenolphthalein as an indicator. The effective cation exchange capacity was the summation of total exchangeable bases and exchangeable acidity .Base saturation percentage was obtained by calculation using the formula:

$$\% \text{ B S} = \frac{\text{Sum of exchangeable bases}}{\text{Exchangeable cation exchange capacity}} \times 100$$

Plant analysis involved pineapple plant samples, which were sliced into smaller particles, oven dried and crushed with pestle, and mortar into finer particles before subjected to the following analysis: Total nitrogen in plant samples was determined by the macro Kjeldahl method (Jackson, 1969). Available phosphorus (P) was extracted using perchloric acid digestion of plant materials. Exchangeable cations (Ca, Mg, K and Na) were extracted with 1 N neutral of NH_4OAc. Exchangeable K^+ and Na^+ contents in the filtrate were determined by the flame photometer. Ca^{2+} and Mg^{2+} were estimated by atomic absorption Spectrophotometer. The results were analyzed using descriptive statistics and Pearson correlation coefficients (Webster, 2001).

RESULTS AND DISCUSSION

The particle sizes analysi showed that the experimental soils were predominantly, Sand, Silt and Loamy clay. The soil pH had the mean of 4.5. The average value of 4.5 of soil pH fell above the range of soil pH in the southern part of Nigeria Soils which was reported by Solubo *et al.,* (1981) that, the soil p H critical limits ranged from 5.5 to 8.5 which is good for maximum pineapple productions. The Exchangeable Cation Exchange Capacity and Base Saturation Percentage were moderate at the experimental sites (Table.1). The Southern Agricultural Zone, has organic carbon mean of 0.77 % . This value was appreciably higher than the report of Enwezor and Solubo (1981) that organic carbon in the Southeastern Nigeria selected soils had a mean of 0.55 % ,thus lower than the critical limits of 1.5 to 2.0 %. Soil nitrogen, according to Bationo *et al*., (2003), reported that greater percentage (%) of nitrogen was derived from the decomposed organic matter in most tropical soils. The total nitrogen in the Soil of Southern Agricultural Zone of Cross River State has a mean of 0.59 % which was slightly higher than the critical limit of 0.1 to 1.0 % which was reported by Enwezor et al., (1981) in the

Southeastern Nigeria soils (Table. 1) .The total nitrogen in pineapple plants at the experimental zone has a mean of 1.22 g kg^{-1} (Table. 2). But Bartholomew *et al*., (2003), reported that the average concentration of total nitrogen in a pineapple plant was 0.774 g Kg^{-1} . . The total nitrogen in the soils at the experimental sites associated positively but weakly correlated with pineapple plants. There was a correlation coefficient (r) of 2.8473 for total nitrogen (N) with a regression function of 0.2736X+0.2536 (Y)….equation...1 (Fig.1). Among the soil fertility factors, lack of available phosphorus is a major limiting factor militating against the production of pineapple in this region. In the soils, the value of available P in the southern agricultural zone of Cross River State has a mean of 15.57 mg kg^{-1}. This level of available P was comparably higher than what was reported by *Enwezor et al,*. (1981), that the value of available P in the Southeastern soils of Nigeria was 12.67 mg kg^{-1}. The mean value was also greater than the critical limits value of 15.0 mg kg^{-1} in the soils . The mean value of available Phosphorus in the pineapple plants was 0.42 g kg^{-1} . This value was greater than what was reported of Bartholomew *et al.,* (2003) as 0.015 g kg^{-1} . However, there was negatively but strongly correlation of available P in the soils and in the pineapple plants, which showed a correlation coefficient (r) of 1.6822 with a regression function of -6.438X +18.24 (Y)…Equation …ii. (Fig .2). The exchangeable K in the soil was observed to have a mean of 0.10 cmol kg^{-1} . The mean value of exchangeable K obtained from the zone was greater than what was obtained from the South eastern Nigeria soils which was reported by Sobulo *et al.,* (1981), but lower than the range of 0.01 to 1.25 cmol kg^{-1} reported by Akinyede (1988) for selected soils of Nigeria. The exchangeable K in the pineapple plants had a mean value of 1.30 g kg^{-1} but the critical limits of exchangeable K concentration was higher compare to the exchangeable K in the soils of the zone. The exchangeable K in the soils was positive, but weakly correlated with the pineapple plants. There was a correlation coefficient (r) of 2.8690 with a regression function of 0.0146x +0.0123 (Y)…Equation…iii (Fig .3). Among the exchangeable bases, calcium has high absorption rate in the experimental soils. From the analyzed soil samples, calcium has a mean of 2.90 cmol kg^{-1} which was higher than the critical limit reported by Enwezor and Sobulo (1981) in the soils of South eastern Nigeria. The mean value of calcium in the pineapple plants was 0.86 g kg^{-1} .The result of this report revealed that there was appreciable increase in the concentration of calcium in the pineapple plants in the cultivated soils of Southern Cross River State compared to the value obtained from the tropical agricultural zone. Calcium ions interacted positively and were highly correlated between soils and pineapple plants in the cultivated zone. There was a correlation coefficient (r) of 1.5055 with regression function of 2.428x +0.225 (Y)….Equation IV (Fig. 4). Magnesium presence in the soils had manifested greatly in the pineapple plant. Magnesium distribution in the soils had a mean of 0.84 cmol kg^{-1} . The concentrated mean value in the cultivated soils was depreciably lower than the critical limits of 2.25 cmol kg^{-1} as reported by Enwezor and Sobulo (1981) in the soils of South eastern Nigeria. The concentration of Magnesium ions in the pineapple plants had a mean value of 0.52g kg^{-1} . The Magnesium ions were positive but weakly correlated within the pineapple plants and soils at cultivated zone. Magnesium showed a correlation coefficient of 1.6822 (r) with a regression function of 0.4129x +0.5524 (Y)…Equation ….V (Fig 5). However, the data further revealed that the concentration of nutrients in the soils, are inversely proportional to their concentration in the pineapple plants. The amount of nutrients in the soil will determined the fertility of that soil and their corresponding effects in the plants (Agboola,1986)

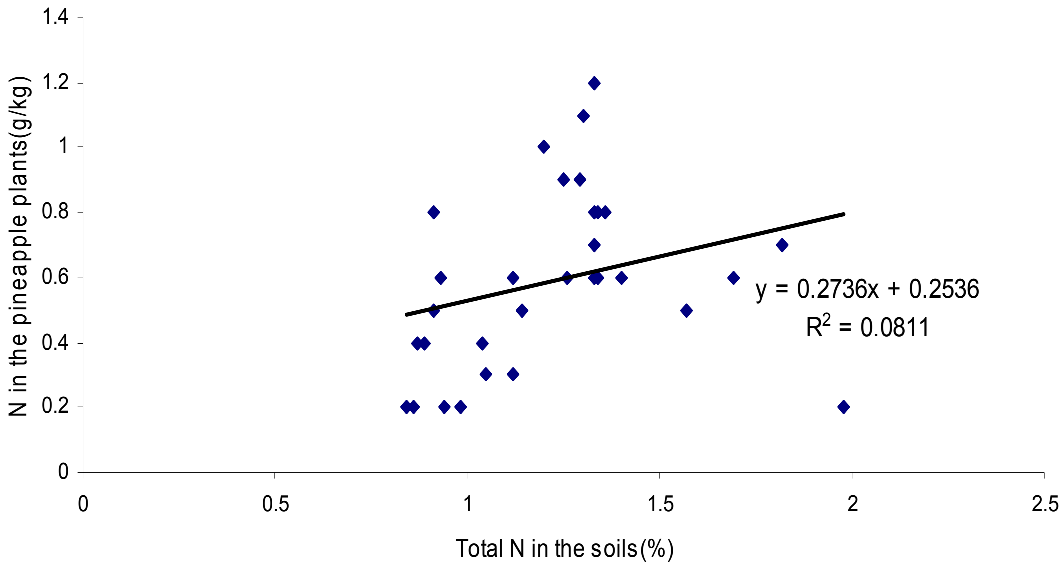

Fig. 1: Relationship between nitrogen (N) content in the soils and pineapple plants in the Southern Agricultural Zone of Cross River State.

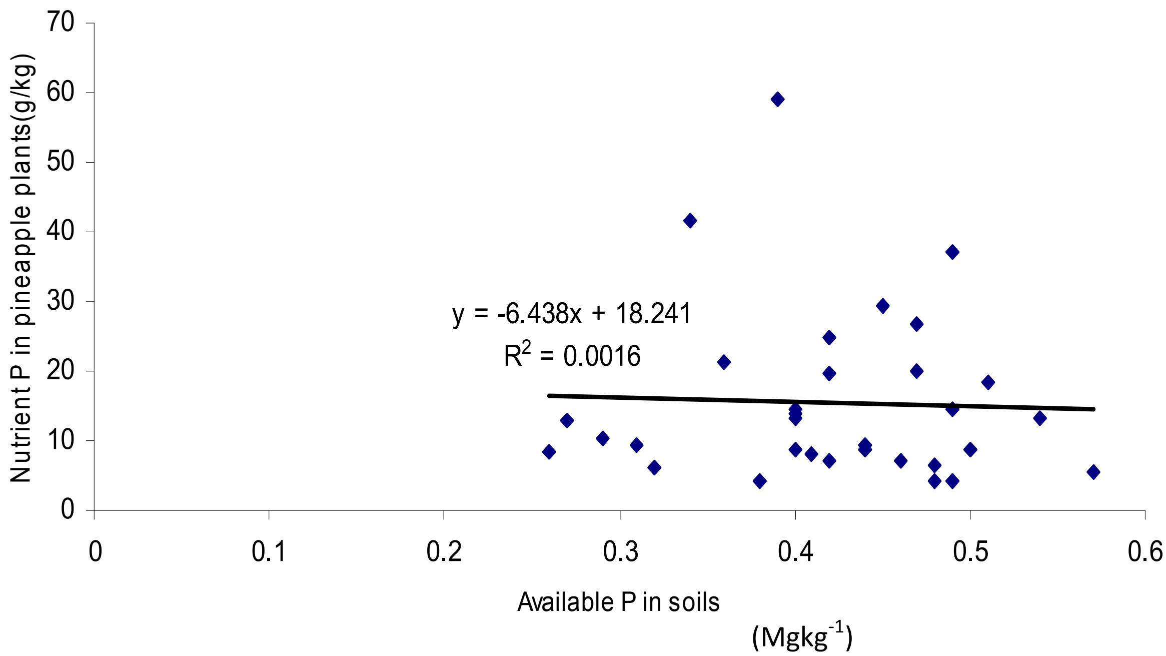

Fig. 2: Relationships between available phosphorus (P) content in the soils and pineapple plants in the Southern Agricultural Zone of Cross River State.

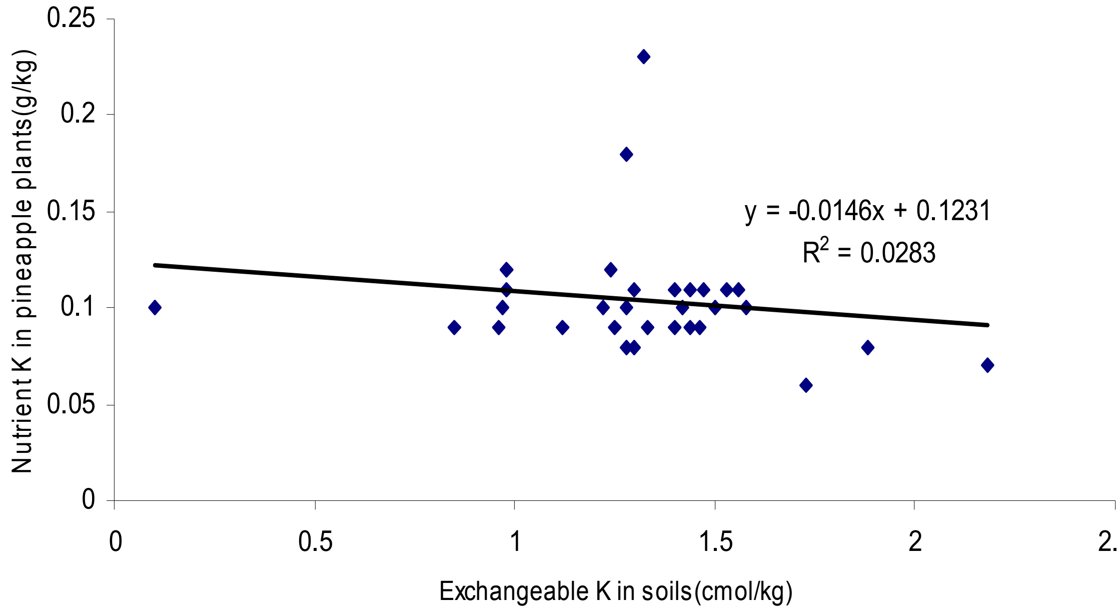

Fig. 3: Relationships between potassium (K) content in the soils and pineapple plants in the Southern Agricultural Zone of Cross River State.

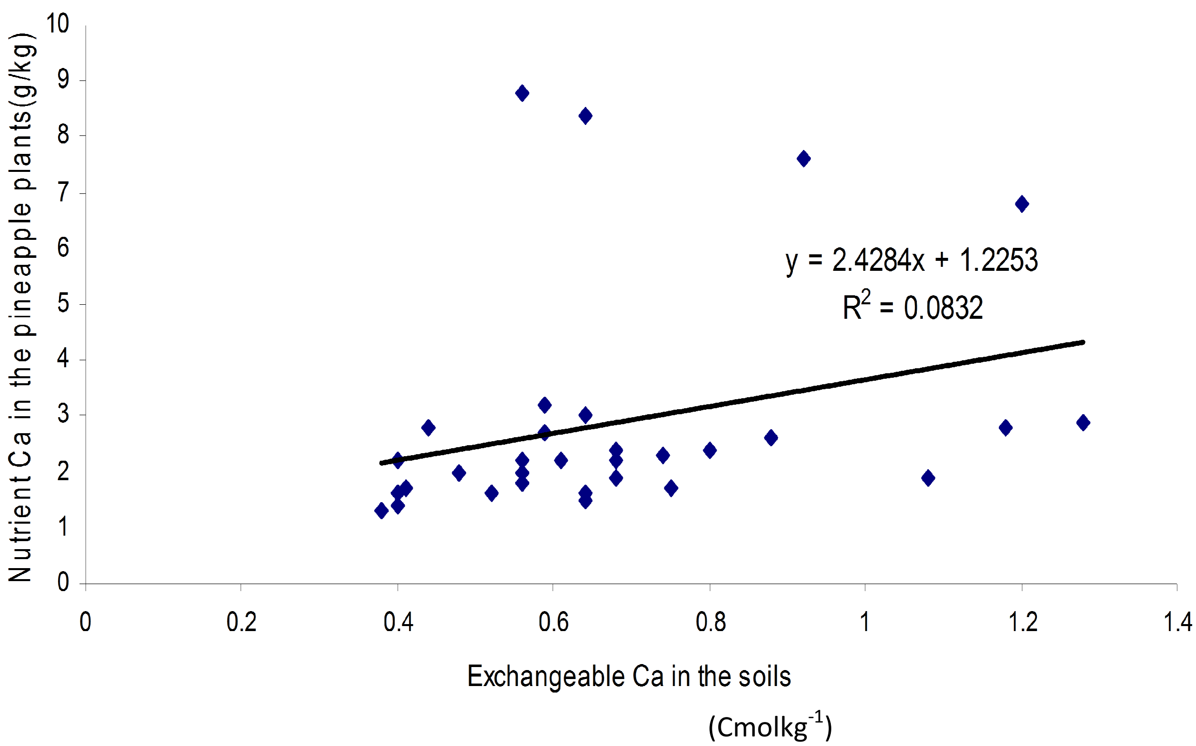

Fig. 4: Relationships between calcium (Ca) content in the soils and pineapple plants in the Southern Agricultural Zone of Cross River State.

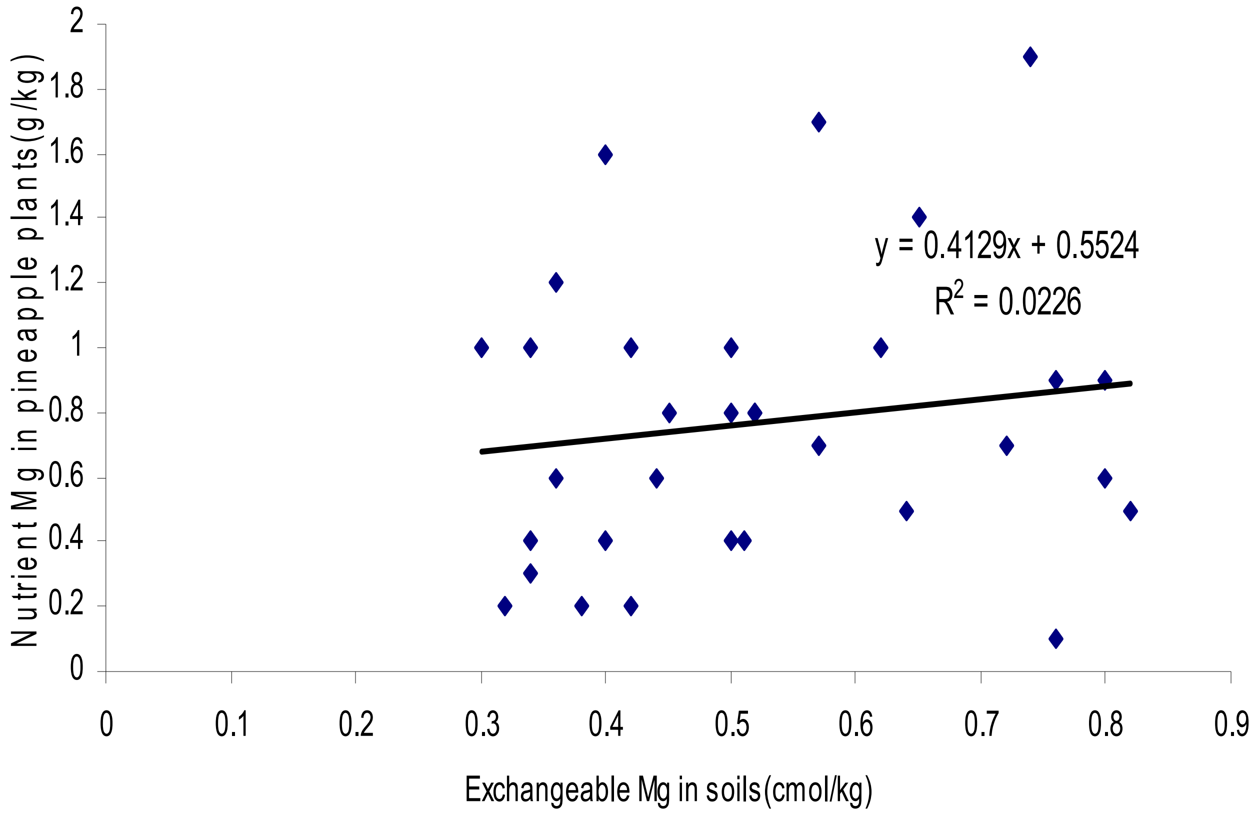

Fig. 5: Relationships between Magnesium (Mg) content in the soils and pineapple plants in the Southern Agricultural Zone of Cross River State.

Table 1: Chemical properties of the soils at 0-30 cm depth at the Southern Agricultural Zone of Cross River State.

Locations	pH	Org. C (%)	TN (%)	Avail P. (mg/kg)	Exch K (cmol/kg)	Exch Ca (cmol/kg)	Exch Mg (cmol/kg)	Exch Na (cmol/kg)	Exch Acidity H+ (cmol/kg)	Exch Acidity AL3+ (cmol/kg)	ECEC (cmol/kg)	BS (%)
Akabo 1	4.3	0.74	0.60	59.12	0.11	1.8	1.0	0.09	0.56	0.40	3.96	76
"	4.9	0.84	0.60	21.37	0.12	3.0	0.4	0.09	0.48	0.00	4.10	88
"	4.3	0.88	0.40	41.62	0.10	2.4	0.8	0.08	0.52	0.46	3.11	82
"	4.7	0.79	0.50	19.62	0.09	2.7	0.4	0.07	0.54	0.43	3.72	79
Obufa Esuk	4.3	0.26	0.30	9.25	0.11	1.5	0.8	0.07	0.59	0.56	3.52	64
"	4.6	0.25	0.20	8.75	0.10	1.6	0.9	0.05	0.66	0.64	3.68	49
"	4.3	0.26	0.30	7.25	0.08	1.7	0.1	0.08	0.68	0.60	4.04	56
"	4.3	0.22	0.20	9.50	0.09	1.9	0.5	0.09	0.62	0.58	3.89	52
Iko Offiong Ambai	4.3	0.28	0.20	130	0.10	1.4	0.2	0.08	0.80	0.12	2.70	66
"	4.3	0.22	0.20	6.25	0.11	1.6	1.0	0.09	0.56	0.06	4.16	67
"	4.3	0.27	0.40	10.25	0.09	1.3	0.6	0.08	0.56	0.09	3.09	66.5
"	4.3	0.24	0.20	8.25	0.08	1.7	0.4	0.08	0.60	0.10	3.30	69
Ikot Enang	4.3	1.42	0.50	24.75	0.12	2.0	0.2	0.08	0.68	1.84	5.74	56
"	4.5	0.62	0.80	370	0.09	1.8	0.2	0.08	1.04	0.46	3.45	56
"	4.6	0.64	0.60	29.4	0.10	1.6	0.4	0.07	0.89	1.66	4.60	63
"	4.3	0.58	0.40	26.85	0.09	2.2	0.3	0.05	0.65	1.15	4.05	62
Inuakpa	4.6	0.82	0.60	4.26	0.11	2.4	1.0	0.09	1.20	0.00	4.80	82.5
"	4.8	0.80	0.60	8.12	0.10	2.0	1.0	0.08	0.40	0.00	3.58	80.0
"	4.4	0.76	0.80	6.37	0.11	2.2	0.8	0.10	0.80	0.00	4.19	81.5
"	4.3	0.83	0.60	7.25	0.09	2.3	0.7	0.09	0.96	0.00	4.50	78.3
Oduyama	4.5	0.83	0.70	13.25	0.07	2.9	0.6	0.09	0.46	0.36	3.20	80
"	4.6	0.87	0.60	14.50	0.10	2.6	0.5	0.08	0.50	0.39	3.60	84
"	4.5	0.85	0.50	18.36	0.08	1.9	0.7	0.07	0.49	0.42	3.90	78
"	4.3	0.89	0.60	19.89	0.06	2.8	0.9	0.09	0.57	0.38	3.82	74
Nsan	4.5	1.77	1.00	13.25	0.12	8.8	1.6	0.09	3.52	3.60	17.73	60
"	4.6	1.49	1.20	14.50	0.11	6.8	1.9	0.08	5.92	3.04	18.55	52
"	4.4	1.33	1.10	13.88	0.23	8.4	1.7	0.07	4.72	3.32	15.14	56
"	4.8	1.25	0.90	4.19	0.18	7.6	1.4	0.09	4.80	2.08	16.40	61
Uyanga	4.4	0.98	0.80	8.62	0.09	2.2	1.0	0.07	0.60	0.32	4.28	78
"	4.5	0.84	0.70	8.62	0.10	2.2	0.6	0.08	0.80	1.60	5.38	55
	4.3	0.91	0.80	5.60	0.09	3.2	0.8	0.05	0.50	0.96	4.83	33
"	4.7	0.87	0.90	4.11	0.11	2.8	1.2	0.09	0.90	0.38	4.56	55.5
Range	**4.3**	**0.22**	**0.20**	**4.11**	**0.06**	**1.3**	**0.1**	**0.05**	**0.40**	**0.00**	**2.70**	**33.0**
	4.9	**1.77**	**1.20**	**59.12**	**0.23**	**8.8**	**1.9**	**0.10**	**5.92**	**3.60**	**18.55**	**88.0**
Mean	**4.5**	**0.77**	**0.59**	**15.53**	**0.10**	**2.9**	**0.8**	**0.08**	**1.17**	**0.81**	**5.61**	**65.9**
***Critical limits**	**5.5-8.5**	**1.5-2.0**	**0.1-1.0**	**8.0-20.0**	**0.2-0.4**	**5.0-10.0**	**1.5-3.0**	**0.3-0.7**	**0.5-1.6**	**0.4-4.0**	**10.0-20.0**	**20.0-60.0**

* Enwezor (1981)

Table 2: Major nutrients content of pineapple plant at the Southern Agricultural Zone of Cross River State.

s/n	N g/kg	P g/kg	Ca g/kg	Mg g/kg	K g/kg	Na g/kg
1	1.26	0.39	0.56	0.50	1.30	0.66
2	1.12	0.36	0.64	0.50	0.98	0.46
3	1.04	0.34	0.68	0.52	0.10	0.68
4	1.14	0.42	0.59	0.51	1.12	0.57
5	1.05	0.31	0.64	0.50	0.98	0.46
6	0.98	0.40	0.64	0.80	1.28	0.70
7	1.12	0.42	0.75	0.76	1.30	0.69
8	1.98	0.44	0.68	0.82	1.25	0.56
9	0.84	0.27	0.40	0.32	1.22	0.64
10	0.94	0.32	0.40	0.34	1.44	0.60
11	0.89	0.29	0.38	0.36	1.33	0.62
12	0.08	0.26	0.41	0.34	1.28	0.62
13	0.91	0.42	0.48	0.38	0.98	0.48
15	0.93	0.45	0.52	0.40	0.97	0.51
16	0.87	0.47	0.61	0.34	0.85	0.56
17	1.33	0.49	0.80	0.62	1.56	0.80
18	1.40	0.41	0.56	0.42	1.50	0.76
19	1.36	0.48	6.80	0.52	1.53	0.78
20	1.34	0.46	0.74	0.57	1.46	0.81
21	1.82	0.54	1.28	0.80	2.18	0.98
22	1.33	0.49	0.88	0.64	1.58	0.68
23	1.57	0.51	1.08	0.72	1.88	0.83
24	1.69	0.47	1.18	0.76	1.73	0.82
25	1.20	0.40	0.56	0.40	1.24	0.86
26	1.33	0.40	1.20	0.74	1.40	0.88
27	1.30	0.40	0.64	0.57	1.32	0.89
28	1.25	0.38	0.92	0.65	1.28	0.80
29	1.33	0.44	0.40	0.30	1.44	0.76
30	1.33	0.50	0.56	0.44	1.42	0.80
31	**1,29**	0.57	0.59	0.45	1.40	0.81
32	1.34	0.48	0.44	0.36	1.47	0.83
Range	0.842-1.98 0.26-0.57		0.38-6.8	0.30-0.82	0.10-2.18	0.46-0.98
Mean	1.22	0.42	0.86	0.52	1.3	0.7

Table 3 : Correlation coefficient of extracted N, P, K , Ca, and Mg from the soils and pineapple plants uptake of N, P ,K, Ca and Mg mineral nutrients in the Southern Agricultural Zone of Cross River State.

Nutrients	Coefficient of determination(r^2)	Coefficient of correlation (r)	Regressional function(Y)
N	0.0811	2.8478	Y=0.2736x+0.2536
P	-0.0016	1.6822	Y=-6.4382x+18.241
K	0.0282	2.8690	Y=0.0146x+0.01231
Ca	0.0832	1.5053	Y=2.428x+0.2253
Mg	0.0226	1.6822	Y=0.4129x+ 0.5524

CONCLUSION

Major nutrients in the soils of Southern Agricultural Zone of Cross River State were found to be low for pineapple growth and development. The mean value of nutrients found in the pineapple cultivated soils fell below the critical levels required by the crops in the Southeastern soils of Nigeria . The effects further revealed that total nitrogen, potassium and magnesium were positive but had weak correlations between soils and pineapple plants .Available phosphorus was negative but strongly correlated whereas, calcium was positive and strongly correlated between soils and pineapple plants at the experimental sites. There are needs to sustain the soil nutrients ' concentration through the application of organic materials such as decomposed poultry waste and compost to the soils a month after land preparations. Fertilizers such as N. P. K 15:15:15 and Urea should be cautiously applied during the growing and before fruiting periods to supplement soil nutrients deficiencies, enhance soil physical and chemical properties for effective vegetative growth and fruit quality of pineapple plants.

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