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Soil Physico-Chemical Properties and Growth Responses of C3 and C4 Crops in Rivers State, Nigeria

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ABSTRACT

This study examined thesoil physico-chemical properties andgrowth responses of C3 and C4 crops in Rivers State, Nigeria. The C3 crop refers to Pumpkin and Cucumber while C4 crop refers to Amaranthus in this study. The study made use of three crops (Pumpkin, Cucumber and Amaranthus in some selected sites in Rivers State and the study was carried out both in the dry and wet seasons. Soil samples were collected from both topsoil (0-15cm) and subsoil (15-30cm).The crops and soil samples were taken to the laboratory for further analysis. Mean values and standard deviations were used to describe the analysis while analysis of variance (ANOVA), Duncan, and Kruskal Wallis were used to test the hypotheses. All analyses were carried out using Statistical Package for Social Sciences (SPSS) 21.1 Version. Findings showed that sand content in Oyigbo had the highest in the topsoil at 95.37% while Etche had highest in silt content at 1.87%. For the subsoil, Oyigbo also had the highest sand content at 93.30% while Ikwerre had the highest clay content at 6.63% in subsoil. For chemical properties of soil, total organic carbon and magnesium were highest in Oyigbo at 1.91% and 24.00% respectively for topsoil while for subsoil potassium was highest in Ikwerre at 8.30%. It was also discovered C3 and C4 crops planted in Oyigbo, Etche and Ikwerre varied from the nutrients standards recommended by USDA (2014). The following nutrients and minerals were considered: energy, carbohydrates, protein, total fat, cholesterol, dietary fiber, vitamins,folates ,niacin,pantogenic acid, pyridoxine, riboflavin, thiamin, Electrolytes, sodium, potassium, calcium, iron, magnesium, manganese phosphorus, and zinc. For standards recommended by (USDA 2014), only energy, iron, zinc, manganese, vitamin E, riboflavin, pyridoxine, niacin and pantothenic acid at Oyigbo met the standards, also Riboflavin and iron at Ikwerre met the (USDA 2014) standards while only folates at Etche met the (USDA 2014) standards. The study recommended that the soil nutrients and pH should be improved across the three locations and the acidic nature of both topsoil and subsoil should be improved by neutralizing the soil with lime.

Keywords: Soil, Amaranthus, Cucumber, Pumpkin, C3 crops and C4 crops.

I. INTRODUCTION

Soil physico-chemical properties in our environment contribute to the growth of major crops in terms of physiological appearances and nutrients content(Marco, 2012). Globally,this has become a major concern because when the soil in the environment does not meet up the standards required for such crop the effort of many farmers becomes unfruitful because such crop becomes unsafe for human consumption.Most crops generates their nutrients from the soil and the soil contains both the physical and chemical properties such as: the clay, sand, and the silt while the chemical properties such as the total organic carbon, available potassium, total nitrogen, exchangeable magnesium, exchangeable calcium, TEA are also found in the soil. There is a recommended standard for both C3 and C4 crops as indicated by USDA 2014. As comprehensively reviewed by Sage and Kubien (2003);there could be an alteration in crops when there is an instrumental change insoils environment. Such alteration canaffect the reduction in sugar and nutrient contents of plants, susceptibility for less development in the leaf, changes in stomata conductance, vegetative growth effect, plant's variations in several locations, consumption of crops should be based on recommended standards as seen in several countries where food production is controlled by a Federal Agency like in the case

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of Nigeria, we have National Agency for Food, Drug, Administration and Control (NAFDAC) the same is also applicable to crops produced in our environment. Because of changes in the climate variation such as evapotranspiration variation, temperature variation, carbon dioxide variation and other greenhouse gases there is need to measure the standards of farm produce before human consumption. This is what this study intends to achieve with USDA 2014 standards on crops produced in three locations in Rivers State.

Mabel (2011) maintained that many crops have lost its values and standards in our environment in terms of its nutrients and minerals. Several works have been done on the soil physical and chemical properties and the crops growth which works vice versa but a few was done on C3 and C4 crops in which the present study is taking care of. Thus this study is focusing at the effect of soil physico-chemical properties and the growth responses of C3 and C4 crops in Rivers State, Nigeria.

II. MATERIALS AND METHODS:

The study area is Etche ,Ikwerre and Oyigbo Local Government aresa of Rivers State in the Niger Delta Region of Nigeria. It is located in the southern region, and has been reported to be one of the major biodiversity hotspots in the world (Izah et al., 2017a; Izah and Seiyaboh, 2018). The ecosystem is home to several Crops such as Cucumber, Pumpkin and Amaranthus potentials. The three Local governments contains coal plain terrace soil that are recommended by the FAO (2011) for C3 and C4 crops. The prominent season for these locations is dry and wet seasons. The wet seasons starts from March to November while the dry seasons starts from November ending to February.The temperature (28 ±8 ºC) and relative humidity (50 - 95%) is within the estimated range of the area (Izah et al., 2017b).Primary data were generated during the field data gathering using Atmometer for land level, GPS for location, soil analyzer for soil,fertometer and crops collected where subjected to lab analysis.Soil samples were taken in various periods like the 43rd period, 49th periods, 56th period, 63rd period and 70thperiods in both dry and wet seasons. Topsoil sample was from 0-15cm while subsoil sample was from 15cm-30cm. The research design adopted in this work has a treatment combinations in Randomized Complete Block Design (RCBD) in factorial experiment .

Factors considered are:

1. Factor A (Main Factor): Amaranth, Pumpkin and Cucumber = **Crop.**
2. Factor B (sub-factor i) soil=**Environment.**
3. Factor C (sub-factor ii) Wet and Dry= **Season**
4. Factor D (sub-factor iii) Etche, Oyibo and Ikwerre = **Location**

NB: Each treatment combination was replicated 3times. This implies that treatment combination =AxBxCxDxRep(3x3x2x3x3)=**162.**

Table1.Schematic Presentation of Treatment Combination

AxB	Amaranth (Ok)	Pumpkin (Pu)	Cucumber (Cc)
Evapotranspiration (Ep)	AmEp	PuEp	CcEp
Temperature (Tp)	AmTp	PuTp	CcTp
Carbon dioxide (Co)	AmCo	PuCo	CcCo

Table 2.ABxC

ABxC	AmEp	AmTp	AmCo	PuEp	PuTp	PuCo	CcEp	CcTp	CcCo
Ambient (S1)	AmEpS1	AmTpS1	AmCoS1	PuEpS1	PuTpS1	PuCoS1	CcEpS1	CcTpS1	CcCoS1
Chamber (S2)	AmEpS2	AmTpS2	AmCoS2	PuEpS2	PuTpS2	PuCoS2	CcEpS2	CcTpS2	CcCoS2

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Table 3.ABCxD

Ikwerre (Ik)	OYIBO (OY)	ECTHE (ETC)
AmEpAbIk	AmEpAb OY	AmEpAbETC
AmTpAbIk	AmTpAb OY	AmTpAbETC
AmCoAbIk	AmCoAb OY	AmCoAbETC
PuEpAbIk	PuEpAb OY	PuEpAbETC
PuTpAbIk	PuTpAb OY	PuTpAbETC
PuCoAbIk	PuCoAb OY	PuCoAbETC
CcEpAbIk	CcEpAb OY	CcEpAbETC
CcTpAbIk	CcTpAb OY	CcTpAbETC
CcCoAbIk	CcCoAb OY	CcCoAbETC
AmEpChIk	AmEpCh OY	AmEpChETC
AmTpChIk	AmTpCh OY	AmTpChETC
AmCoChIk	AmCoCh OY	AmCoChETC
PuEpChIk	PuEpCh OY	PuEpChETC
PuTpChIk	PuTpCh OY	PuTpChETC
PuCoChIk	PuCoCh OY	PuCoChETC
CcEpChIk	CcEpCh OY	CcEpChETC
CcTpChIk	CcTpCh OY	CcTpChETC
CcCoChIk	CcCoCh OY	CcCoChETC

Data that was taken include but not limited to:

1. Agronomic data such as plant height, leaf number, 50% days flowering, maturity and total yield etc.
2. The soil sample was taken from the surface down to 15cm, that is from 0-15cm and from 15cm to 30cm, it was also sent for laboratory test and the result is stated in chapter four. We took the soil temperature of the three plants starting from 0-2cm depth. This is because in planting amaranth and pumpkin, 2cm is recommended while that of cucumber 3 cm FAO(2011)
3. Land equivalent ratio to plant was also calculated, we have 5 by 5 for cucumber and pumpkin crops per bird and a total of 9 birds in a location. This gives each bird a 25.
4. Geo-ecological data such as: evapotranspiration rates, carbon assimilates, temperature reading, physio-chemical properties, relative humidity data and day length were also taken for the various locations studied etc.

All data were subjected to analysis in a RCBD in factorial experiment where interactions were tested for AxB; AxC,AxD,BxC,BxD,DxC, DxB others were on ABxC,ABxD,ACx D and ABCxD, they were subjected to ANOVA and Duncan analysis with error mean square.

III. RESULTS AND DISCUSSIONS

Analysis ofphysico-chemical properties of soil and the comparison of the nutrients values with USDA Standards (2014)

The chemical analysis of soil properties shown in Table 4 reveals that pH in the three locations was weakly acidic ranging from 5.28 in Oyigbo to 6.10 in Etche. The total organic carbon was highest in Oyigbo (1.91%) while Etche recorded the lowest (1.40%). Furthermore, the available P varied slightly with the highest in Ikwerre (13.42 mg/kg) and the least in Etche (10.73 mg/kg). Among the exchangeable cations, Mg was the highest which ranged from 1.36 mg/kg in Etche to 29.98 mg/kg in Etche. Total N was very low in the study locations ranging from 0.11% in Etche to 0.17% in Ikwerre. The total exchangeable acidity was highest in Etche (1.77 mg/kg) and lowest in Ikwerre (1.35 mg/kg). This also reflected on why there was poor growth in mostly Pumpkin across the three locations.Table 5 explains the chemical properties of soil in Etche, Oyigbo and Ikwerre and from the table, total organic carbon in the topsoil was highest at Oyigbo with 1.91%, available potassium recorded was most in Oyigbo at 13.05mg, the pH was also more in Etche at 6.10 while total exchangeable acidity was highest in Etche at 1.77mg. while at the subsoil, Total Exchangeable Acidity recorded 2.01mg in the same Etche and Total Organic carbon was more at Oyigbo with a value of 0.92. This implies that some chemical properties in the study area did not meet up to the requirement for C3 and C4 crops.

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Table 4. Physical Properties of Soil in the Study Locations

Soil Parameters	Soil Depth	Etche	Oyigbo	Ikwerre
Sand (%)	Topsoil	94.97±1.3	95.37±1.5	93.93±1.3
Silt (%)		1.87±0.8	1.5±0.9	1.67±0.3
Clay (%)		3.17±1.4	3.13±0.6	4.40±1.0
Sand (%)	Subsoil	91.70±1.8	93.30±1.4	91.50±1.8
Silt (%)		2.13±0.8	2.07±0.4	1.87±0.4
Clay (%)		6.17±2.2	4.70±1.0	6.63±2.2

N=3

Table 5. Chemical properties of soil in the study locations

Soil Parameters	Soil Depth	Etche	Oyigbo	Ikwerre
pH	Topsoil	6.10±0.2	5.28±0.3	5.60±0.3
Total Organic Carbon (%)		1.40±0.2	1.91±0.2	1.71±0.5
Avail P (mg/kg)		10.73±0.4	13.05±2.9	13.42±2.3
Total N (%)		0.11±0.1	0.12±0.1	0.17±0.1
Ex. Na (mg/kg)		0.95±0.1	1.07±0.2	1.00±0.1
Ex. K (mg/kg)		1.03±0.2	0.92±0.1	0.98±0.4
Ex. Mg (mg/kg)		29.98±5.0	24.00±3.9	1.36±0.8
Ex. Ca (mg/kg)		0.63±0.1	0.77±0.1	0.82±0.1
Total Exchangeable Acidity (mg/kg)		1.77±0.3	1.75±0.2	1.35±0.1
pH	Subsoil	5.57±0.2	5.27±0.4	5.37±0.1
Total Organic Carbon (%)		0.66±0.1	0.92±0.3	0.79±0.1
Avail P (mg/kg)		7.29±0.7	7.77±1.5	8.30±0.8
Total N (%)		0.05±0.1	0.06±0.1	0.11±0.1
Ex. Na (mg/kg)		0.85±0.3	1.05±0.5	1.10±0.3
Ex. K (mg/kg)		0.97±0.2	0.96±0.2	1.22±0.4
Ex. Mg (mg/kg)		0.97±0.3	0.82±0.1	1.05±0.3
Ex. Ca (mg/kg)		0.73±0.1	0.74±0.1	0.70±0.2
Total Exchangeable Acidity (mg/kg)		2.01±0.2	1.56±0.4	1.26±0.3

Table 6: General Physical Properties of Soil

Soil Parameters	Topsoil (0-15cm)	Subsoil (15-30cm)
Sand (%)	94.76±1.3	92.17±1.7
Silt (%)	1.68±0.6	2.02±0.5
Clay (%)	3.57±1.1	5.83±1.9

N=9

Table 7. General Chemical Properties of Soil

Soil Parameters	Topsoil (0-15cm)	Subsoil (15-30cm)
pH	5.66±0.4	5.40±0.3
Total Organic Carbon (%)	1.67±0.4	0.79±0.3
Avail P (mg/kg)	12.40±2.2	7.79±1.0
Total N (%)	0.13±0.1	0.07±0.1
Ex. Na (mg/kg)	1.00±0.2	1.00±0.3
Ex. K (mg/kg)	0.98±0.2	1.05±0.3
Ex. Mg (mg/kg)	18.45±4.6	0.95±0.3
Ex. Ca (mg/kg)	0.74±0.1	0.73±0.1
TEA (mg/kg)	1.62±0.3	1.61±0.4

N=9

The measurements of nutrients and minerals Contents in Amaranthus, Pumpkin and Cucumber with USDA 2014 Standards

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Table 8 shows the comparison between the nutrients and mineral values obtained in the study area with that of the USDA 2014. From the table below, energy (kcal) recommended by USDA was 12kcal while none of the locations had up to that value, the same applied in carbon hydrates, protein, total fat, dietary fiber in Nutrients alone.In vitamin, the three locations met the standards for Folates (µg), vitamin E, while the rest did not, in minerals only manganese and zinc inOyigbo met the standards while the rest did not. For electrolyte, sodium and potassium did not meet the required standards. This by implication means that cucumber, pumpkin and Amaranthuscrops planted in these areas should be carefully consumed because of the less nutrients, minerals and electrolytes contents in them.

Table 8: Average Nutrients, Vitamins, Electrolytes and Mineral Contents in Cucumber, Pumpkin and Amaranthus in the Study Locations in the Wet Season

Parameters	Etche	Ikwerre	Oyigbo	USDA
Nutrients				
Energy (Kcal)	8	15	21	12
Carbohydrates (g)	0.16	0.18	1.23	2.16
Protein (g)	0.27	0.57	0.2	0.59
Total Fat (g)	0	0	0	0.16
Cholesterol (mg)	0	0	0	0
Dietary Fiber (g)	0.3	0.2	0.6	0.7
Vitamins				
Folates (µg)	14	17	19	14
Niacin (mg)	0.037	0.2	0.03	0.037
Pantothenic acid (mg)	0.27	0.38	0.27	0.259
Pyridoxine (mg)	0.034	0.4	0.07	0.051
Riboflavin (mg)	0.01	0.1	0.05	0.025
Thiamin (mg)	0.23	0.34	0.26	0.031
Vitamin A (IU)	4	3	2	12
Vitamin C (mg)	1.2	1.4	1.2	3.2
Vitamin E (mg)	0.03	0.03	0.03	0.03
Vitamin K (µg)	3.1	2.0	2.1	7.2
Electrolytes				
Sodium (mg)	1	1.1	1.01	2
Potassium (mg)	11	11.3	1.7	136
Mineralss				
Calcium (mg)	3.2	4.5	3.3	14
Iron (mg)	0.11	1.11	1.10	0.22
Magnesium (mg)	4	5	3	12
Manganese (mg)	0.43	1.043	2.053	0.079
Phosphorus (mg)	11	11.1	8.9	21
Zinc (mg)	0.12	0.11	1.03	0.17

Table 9: Average Nutrient content in Cucumber, Pumpkin and Amaranthus in Dry Season in Etche, Ikwerre and Oyigbo LGAs

Parameters	Etche	Ikwerre	Oyigbo	USDA
Nutrients				
Energy (Kcal)	2	9	14	12
Carbohydrates (g)	0.6	0.11	0.2	2.16
Protein (g)	0.1	0.2	1.2	0.59
Total Fat (g)	0	0	0	0.16
Cholesterol (mg)	0	0	0	0.69
Dietary Fiber (g)	0.3	0.1	0.3	0.7
Vitamins				
Folates (µg)	14	12	12	14
Niacin (mg)	0.037	0.02	0.2	0.037

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Pantothenic acid (mg)	0.27	0.24	0.17	0.259
Pyridoxine (mg)	0.034	0.04	1.34	0.051
Riboflavin (mg)	0.01	1.01	0.4	0.025
Thiamin (mg)	0.23	0.24	0.12	0.031
Vitamin A (IU)	4	1	1	12
Vitamin C (mg)	1.2	0.1	0.1	3.2
Vitamin E (mg)	0.03	0.03	0.02	0.03
Vitamin K (µg)	3.1	1.0	1.2	7.2
Electrolytes				
Sodium (mg)	1	0.1	1.01	2
Potassium (mg)	11	9.2	0.2	136
Minerals				
Calcium (mg)	3.2	2.1	2.1	14
Iron (mg)	0.11	1.0	0.20	0.22
Magnesium(mg)	4	2	1.2	12
Manganese (mg)	0.043	0.043	1.3	0.079
Phosphorus (mg)	11	2	4.6	21
Zinc (mg)	0.12	1.12	0.1	0.17
Phyto-nutrients				
Carotene-ß (µg)	0	0	0	31
Crypto-xanthin-ß (µg)	0	0	0	18
Lutein-zeaxanthin (µg)	0	0	0	16
Water (g)	47	15.8	0	96.73
Energy (Kcal)	0	0	0	12
Protein (g)	0	0	0	0.59
Total lipid (fat) (g)	0	0	0	0.16
Carbon hydrate by difference(g)	0	0	0	2.16
Fiber, total dietary(g)	0	0	0	0.7
Sugars, total including NLEA(g)	0	0	0	1.38
Calcium (mg)	0	0	0	14
Iron (mg)	0	0	0	0.22
Magnesium (mg)	0	0	0	12
Phosphorus (mg)	0	0	0	21
Potassium (mg)	0	0	0	136

IV. CONCLUSIONS

This study evaluated the growth responses of C3 and C4 crops to SoilPhysio-Chemical Properties in Rivers State. A C3 crop in this study refers to Cucumber and Pumpkin while the C4 crop refers to Amaranthus. Methodologically, three locations were selected in Rivers State namely: Etche, Oyigbo and Ikwerre this is because the three locations have the coal plain terrace soil as recommended by FAO (2011) in planting Cucumber, Pumpkin and Amaranthus. Agronomic data such as: plant height, leaf number, 50% days flowering, maturity, total yields and geo-ecological data such as: evapotranspiration rates, carbon assimilates, temperature reading were collected. The study made use of Randomized Complete Block Design in factorial experiment. From the discussions of findings, it was revealed Pumpkin, Cucumber and Amaranthus responded to soil physico-chemical variations at the 43^{rd},49^{th},56^{th}, 63^{rd} and 70^{th} periods of observations in the field. This variation in soil physico-chemical properties also affected the crops Nutrients and mineral such as: Vitamin A, Vitamin K, Energy, Phosphorous, Protein, Height, Leaf, D/Fiber, and Cholesterol. Some of the nutrients and minerals obtained from the study did not meet up the standards recommended by USDA in 2014. Such minerals and nutrients arecarbohydrates,protein, total fats, cholesterol, Vitamin A , Vitamin C, Vitamin K, Potassium, Calcium, Magnesium and Phosphorus.

REFERENCES

[1]. Barlow, K.M and B.P. Christy (2015) Simulating the impact of extreme heat and forest events on wheat crop production:

a review,Field crops Res.,171(2015),pp.109-119. Prague; Prague Publishing House.

[2]. Barnola, Jmfet all (1987) Historical CO_2 record from the Vostok ice core: Boden TA. StassFw.

[3]. Beppu, K. and Ikeda, T. (2011) Effect of high temperature exposure time during flower bud formation on the occurrence of double pistils in Satohnishik sweet cherry.Satohnishik; Double Publishing.

[4]. Bunce, J.A., (2013) Carbon Dioxide effect on stomatal responses to the Environment and water use by crops under field conditions. New Orleans; oecologia house centre.

[5]. Dupuis, L. and Dumas, C. (1990) Influence of Temperature Stress on invitro Fertilization and heat shock protein Synthesis in maize(zea mays L.) reproductive system, Plant Physio. Bucharist- Siatel Press.

[6]. Effect of nighttime temperature on physiology and growth of spring wheat crop. Sci., 48(2008),pp.2372-2372-2380

[7]. Egwuogu C. C, Okeke U. H, Alaga A.T and Eguaroje E. O (2016): Geo-Spatial Assessment of Changes in Vegetation in the Southern Delta Areas of Rivers State, Nigeria. International Journal of Trend in Research and Development, Vol. 3(6): 408-415.

[8]. Gilbert, P. (1955) The Carbon dioxide Theory of Climate Change Baltimore, md[s]; John Hoplans University.

[9]. Gosh, S.C.A. and Koh, I. (2011) Effects of temperature at different growth stages on non-structural carbohydrate, nitrate reduce case activity and yield of Potatos. US. Study house.

[10]. Hatfield et al. (1976) Evaluation of an electronic foliometre to measure leave area in Corn and Soybean. Agro.J.68(1976),pp.434-436.

[11]. Hatfield, J.L. and K.J. Boote (2008) The effects of Climate Change on Agriculture, Land Resources, Water Resources and Biodiversity in the United States; New York .

[12]. Mabel T.N. (2011) Conditions of man and its Environment: Copenhagen Heen: Stunted Press 243618. Tere Mass.

[13]. Marco, T.S. (2012) Understanding climate change through plants: yield Store 43627 limited. YkC Its processes and cultivation. London: Hartsfield Press Ltd.

[14]. Sage, N. T 7 Kubien R.T. (2003) Photosynthesis at low Temperature: A study using Transgenic Plants with Reduced Amounts of Rubisco. Toronto: Wilco S. Publishing.