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Microbiological and Physicochemical Characteristics of Cassava Cultivated Soils

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Abstract: Sixteen soil samples were collected from four different plots of cassava plantation and analyzed for their microbiological and physicochemical characteristics. A total of twelve microorganisms were isolated consisting four bacteria, seven fungi and one actinomyces. The bacteria were *Bacillus cereus*, *B. megaterium*, *B. polymyxa*, *B. subtilis*, while the fungi included *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *A. repens*, *Botrytis cinerea*, *Neurospora sitophila*, *Varicosporium elodea* and *Actionmyces reticuli*. Plot A recorded the highest microbial counts of 7.95×10^5 cfu g^{-1} and 4.18×10^3 sfu g^{-1} for bacteria and fungi respectively, while the control (uncultivated soils) had the lowest microbial counts of 1.73×10^5 cfu g^{-1} and 1.50×10^3 sfu g^{-1} for bacteria and fungi, respectively. Actinomycetes were found only in plots B and D. The colour of the soils varied from black, brownish black, yellowish brown to complete brown, while the texture ranged from very coarse, through granular to very fine. Chemical analysis revealed pH range of 5.67 to 6.70, moisture content of 10.08 to 14.70%, organic matter content of 8.48 to 13.90% oxidizable organic carbon of 0.11 to 0.41% and ash content of 8.37 to 13.40%. Mineral analysis showed the presence of N, P, K^+, Na^+, Ca^{2+}, Mg^{2+} ppm in varying proportions. Therefore, cassava cultivated soils has not suffered any significant depletion of nutrients.

Key words: Microbiological, physicochemical characteristics, cassava, cultivated soils, uncultivated soils

INTRODUCTION

Soils are particulate materials of the outer crust of the earth surface formed from the continuous weathering of the underlying parental rocks (Brady and Weild, 1999; Adekayode, 2003). Therefore, the type of soil is a function of the nature of the underlying rocks. Soil formations have been reported to be combination of interdependent factors of parental materials, climate, organisms, topography and time (Adekayode, 2003). Functionally, soil constitutes the substratum on which plants and other vegetation grow, providing essential nutrients required for their survival. In addition, soil harbors quite a number of other living organisms including microorganisms (Ijah and Abioye, 2003). Hence, the interactions of the living organisms and plants in the soil cannot be underscored.

Cassava (*Manihot esculenta* Crantz) is a root tuber crop that is widely cultivated in the tropical regions of the world (Cock, 1982; Oboh and Akindahunsi, 2003). Of the global production of cassava (138 metric tones per annum), approximately 57 million tones produced in Africa, Nigeria accounted for 14 million tones (FAO, 1988). Currently, Nigeria is the highest producer of cassava in the world. In West Africa and part of Caribbean, an angular food known as gari and farinlia (Oboh and Akindahunsi, 2003) constitute common staple food. Other products such as lafun and pupuru have readily commanded the delight of many peoples diet. Agricultural value of cassava as an alternative

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source of carbohydrate and energy in livestock nutrition (Areghore, 1992) together with its various industrial applications (Kay, 1987; Nweke *et al*., 1989; Ofuja and Nwaijukuba, 1990; Pontoh and Low, 1995) may no doubt make cassava a noble crop of the millennium.

In recent past, researches are being focused on the cassava plant early maturation, diseases resistant varieties and its application in various industrial processes. This study examined the microbiological and physicochemical characteristics of cassava cultivated soils, with a view to ascertain the effect of cassava plant cultivation on the soil characteristics compared with uncultivated soils.

MATERIALS AND METHODS

Sources of Sample

Soil samples were collected from cultivated farm plantation of cassava plots A, B, C and with the uncultivated soils as control of the Teaching and Research Farm of Federal University of Technology. Akure Nigeria. Samples were collected in cellophane bags that have been previously exposed to ultraviolet radiation for 1 h in the inoculating chamber.

Collection of Samples

Surface of the soil sample locations was cleared and triplicates samples were obtained at four locations in a plot using soil augar at the depth of 15 cm (Osho and Fawole, 2001; Ekundayo, 2004).

Isolation, Enumeration and Identification of Associated Microorganisms

Microbial isolation was carried out on the various soil samples using serial dilution pour plate method (Arotupin and Akinyosoye, 2001). Ten-grams of the sample were mixed with 90 mL of sterile distilled water. The suspension was thorough mixed, serial diluted and 0.1 mL of dilutions 10^{-5} and 10^{-3} was used for the isolation of associated bacterial and fungi, respectively. Colonies, which developed on the plates, were counted and recorded as colony farming unit per gram (cfu g^{-1}) of soil. The isolates were subcultured to obtained pure cultures. The pure bacterial isolates were characterized and identified using the method of Holt *et al*. (1994). The pure cultures of the fungal isolates were identified based on cultural and morphological characteristics according to Barnett and Hunter (1972).

Determination of Physicochemical Characteristics of Soil Samples

The colour of the various soil samples was determined in comparison with Munsel colour chart. Soil texture was determined by rubbing few quantities of each samples in-between finger tips. Five-man panel carried out the exercise. The consistency of each sample was determined according to Amusan and Ashaye (1989) and Ashaye *et al*. (1990). The pH of the soil was determined by mixing 5 g of soil with 20 mL of distilled water in a 50 mL beaker. The mixture was placed in a rotatory shaker at 100 rpm for 1 h at 28±2°C. The pH values were measured using Jenway Model 3015 pH meter, which was standardized with appropriate buffers. Moisture content was determined using the method of Ijah and Abioye (2003). Organic matter content was measured with the method of Amund *et al*. (1993). The total nitrogen was measured using the macro Kjeldahl digestion method (Black, 1965). Exchangeable bases (Na, K, Ca and Mg) were determined using Atomic Absorption spectrophotometer (Chapman, 1965).

RESULTS AND DISCUSSION

Plot A recorded the highest bacterial count of 7.95×10^{5} cfu g^{-1}, while uncultivated soils recorded the lowest counts of 1.75×10^{5} cfu g^{-1}. The fungal count was highest in plot A and least in uncultivated soils with 4.18×10^{3} sfu g^{-1} and 1.50×10^{3} sfu g^{-1}, respectively (Table 1). The high microbial count may be due to the adequate nutritional status of the soils which are available and accessible to the

microorganisms. In addition, are the favorable physicochemical properties of the soils (Table 3 and 4). Bacterial counts were higher than the fungal counts. This is not unexpected, as bacteria have been reported as the most numerous of the microorganisms in the soil. (Druce and Thomas, 1970). The nutritional versatility of bacteria may also be responsible for their ecological success. However, the isolation of bacteria, fungi and actinomyces in the soil sample attested to the mutualisms of these organisms in the soil habitat (Table 1 and 2).

Table 1: Microbial load of cassava soil samples

	Microbial load		
Samples (plot)	Bacteria $\times 10^5$cfu g^{-1}	Fungi $\times 10^2$ sfu g^{-1}	Actinomyces $\times 10^3$ cfu g^{-1}
A	7.95	4.18	ND
B	5.15	3.20	2.99
C	3.20	3.75	ND
D	5.33	3.33	2.81
Control	1.75	1.50	ND

Cfu: Colony Forming Unit, sfu: Spore forming unit, ND: Not Determined, Control: Uncultivated soils. Values are means of triplicate readings

Table 2: Occurrence of microbial isolates of cassava soil samples

	Plots				
Microbial isolate	A	B	C	D	Control
Bacteria					
Bacillus cereus	+	+	+	+	+
B. megaterium	+	-	+	+	-
B. polymyxa	+	+	+	+	+
B. substilis	+	+	+	+	-
Fungi					
Aspergillus flavus	+	+	-	-	+
A. fumigatus	+	+	+	+	-
A. niger	+	+	+	+	+
A. repens	-	+	+	-	-
Botrytis cenerea	+	-	+	-	-
Neurospora sitophila	+	+	-	-	+
Vericosporium elodea	-	+	-	+	-
Actinomyces reticuli	-	+	-	+	-

+: Present, -: Absent, Control: Uncultivated soils

Table 3: Physicochemical characteristics of cassava soil samples

	Physicochemical parameters							
Sample (plot)	CL	TT	CT	pH	MC (%)	OM (%)	OOC (%)	AC (%)
A	yb	fi,gr	m,s	6.70	11.61	11.23	0.17	13.40
B	db	fi,cl	m,s,fr	5.67	14.70	13.90	0.25	11.47
C	bl	fi,l	m,s,fr	6.10	13.55	10.87	0.41	10.95
D	br	vc	m,s	5.68	12.56	11.39	0.38	13.05
Control	bb	fi,l	m,s,fr	5.31	10.08	8.48	0.11	8.37

CL: colour, bb: brownish black; bl: black; br: brown; db: dark brown; yb: yellowish brown. TT: Texture: C: Clay; fi: fine; gr: granular; l: loam; CT: Consistency: fr: fibriable; m: moist; s: sticky, MC: Moisture Content, OM: Organic Matter, OCC: Oxidizable Organic Carbon; AC: Ash Content, Control: Uncultivated soil. Values are means of triplicate readings

Table 4: Mineral compositions of cassava soil samples

	Minerals (ppm)					
Sample (plot)	N	P	K^+	Na^+	Ca^{2+}	Mg^{2+}
A	3425.0	8627.5	237.5	197.5	2205.0	617.5
B	1892.5	9205.0	262.5	172.5	1947.5	1050.0
C	4482.5	11857.5	545.0	205.0	2442.5	1835.0
D	3955.0	10287.5	410.0	175.0	2420.0	1495.0
Control	1665.0	6655.0	195.0	107.5	2015.0	400.0

ppm: par per million; values are means of triplicate readings

A sum total of twelve microorganisms were isolated from the soil. The bacterial isolates were *Bacillus cereus*, *B. megaterium*, *B. polymyxa*, *B. subtilis*, while the fungal isolates included *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *A. repens*, *Botrytis cinerea*, *Neurospora*, *sitophila*, *Varicosporium elodae* and *Actinomyces reticuli* (Table 2). Fungi appeared to be the dominant and frequently occurring microorganisms in the soil samples. This is in conformity with the Ekunmdayo (2004), in addition to the fairly dry nature of the soil. Arotupin and Akinyosoye (2001) and Ekundayo (2004) separately reported most of these microbial isolates to be an autochthonous inhabitant of soil. The bacterial isolates are well adapted to persist in the soils, while the fungi produce spores of conidia which are more resistant and adapt to changing conditions. Notably, the survival of these microorganisms in the cassava cultivated soil lucidly showed that, the soil constitutes suitable substratum for the growth of microorganisms (Table 3 and 4).

The colour of the cassava soils ranged from yellowish brown, brown dark brown, brownish black to black when dry and dark grayish brown when moist (Table 3). This is in consonance with the findings of Isaka *et al*. (1996) who revealed that water logging tend to impart dark brown to dark grayish brown colour to soils. Similar range in colour of soil have been reported by Usman and Shall (2003). Also, the colour differences observed have been reported to be as a result of the organic matter contents, which accounted for the dark colouration (Buol *et al*., 1980). The soils varied from coarse, fine to clay loam in texture. The seasonal depositions in addition to microbial and human activities on the farm soil lend credence to this observation. The consistency of the soil samples ranged from moist, sticky to friable especially when fairly dried (Table 3).

The pH of the soils ranged from 5.31 to 6.70. Therefore, based on the classification by Eus (1991), the soils are classified as slightly acidic for plots A and C, moderately acidic for samples of plots B, D and control plot (Table 3). This trend may not be unconnected with the nature of the soil and occasional washing away of the exchangeable bases down soils. The incorporation of manures rather than inorganic fertilizers which are known to have liming effects on soil (Bache and Heathcote, 1969; Olayinka, 1990) and to improve the soil structure and fertility may readily be useful. There was no significant difference in moisture content of the plots, which is a function of close similarity in the nature of the soils. High organic matter content observed in the soil (Table 3) was as a result of the biodegradative activities of the microorganisms (Table 2) on the weed residues as well as fall off leaves cum ease of incorporation into the soils. Oxidizable organic matter ranged from 0.11 to 0.41% (Table 3). The regular application of inorganic fertilizers as confirmed by the farm manger no doubt accounted for the high ash content that ranged from 10.95 to 13.40% compared to the control (uncultivated soils) with 8.37% (Table 3).

The exchangeable divalent cations (Ca^{2+} and Mg^{2+}) ranged from low to medium. The moderate exchangeable calcium content of the soils was in agreement with the reports of Usman and Shall (2003), who revealed was as a result of the inherent calcium content of the soils. However, high exchangeable magnesium content of the soils may be attributed to the non-leaching of cation. The potassium content ranged from 195 to 545 ppm, showing moderate exchangeable K content in the cultivated soils, while the control had low exchangeable K content (Mustapha *et al*., 2003). The high rainfall spanning nine months of the year, thus dissolving the sodium content tend to justify the low to medium sodium content in the soils. In addition, is probably the washing away during flood as reported by Isaka *et al*. (1996).

The available phosphorous content of the soils ranged from 6655 to 11857.5 ppm. The medium P content of soil may probably be due to the high organic matter content (Table 3 and 4). The decomposition of organic matter by the activities of microorganisms leading to the release of P content is adduced for the present level of P, in addition to the application of chemical fertilizers. This latter reason is also true for the high nitrogen content of the soils. Other reasons included the mulching of the soils and the incorporation of the plant residual before the next planting season which was the practice.

CONCLUSION

This study lucidly showed the array of microorganisms in cassava-cultivated soils. Also, the physicochemical characteristics of the soils were not in anyway adversely affected. There is therefore, the dare need to study the ecological interactions of these microorganisms and the cassava plant. This will no doubt provide information on the critical role of microorganisms in the growth and yield of quality cassava plant cum tubers.

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