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Biological Implications of Cassava Waste Peels on the Physico-Chemical and Antioxidant Properties of Mazie Seedlings

Augustine Osasemeaga Okpiabhele[1]*, Usunomena Usunobun[2]

[1]Department of Biological and Chemical Sciences, Faculty of Natural and Applied Sciences, Michael and Cecilia Ibru University, Ughelli, Delta State, Nigeria Email: okpiabheleaustin405@gmail.com

[2]Department of Biochemistry, Faculty of Basic Medical Sciences, College of Medical Sciences, Edo State University Uzairue, Edo State, Nigeria. Email: Usunsquare@yahoo.com

*Corresponding Author, Department of Biological and Chemical Sciences, Faculty of Natural and Applied Sciences, Michael and Cecilia Ibru University, Ughelli, Delta State, Nigeria. Email: okpiabheleaustin405@gmail.com

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Abstract

Objective: The beneficial effect of cassava processing effluents and solid waste materials on plants is generating scientific interest in researches and this issue continues to draw significant attention specifically in maize plant. Therefore, this study is focusing on the biological implications of cassava waste peels on the physico-chemical and antioxidant properties of maize seeds.

Materials & Methods: Maize seedlings (Zea mays) were purchased from uselu market in Benin City, Edo state, Nigeria. The seedlings were sorted, cleaned, and tested for viability using the method of floatation. The soil samples for planting the maize were collected from five (5) different points (A, B, C, D and E) close to a local cassava mill. The maize plants were grown for four weeks and subjected to the same atmospheric condition in the greenhouse located in the premises. Laboratory analysis of the growth parameters, biomass activities, soil profile, and antioxidant properties were carried out each week for a period of four (4) weeks on the growing maize plants of the various soil samples.

Results: Results obtained recorded significant changes ($p>0.05$) in the growth parameters, biomass activities, soil analysis, and antioxidant properties among the various groups during a period of four (4) weeks.

Conclusion: It is believed that the effluent from cassava processing site/plant when discharged on agricultural land causes biological and physiochemical changes as well as an increase in growth rate and biomass activities which are beneficial to the soil.

Introduction

Nigeria is by far the largest cassava (Manihot esculanta crantz) producing nation in the world with approximately 45 million tons in 2009, which was almost 19% of production in the world [1]. Cassava is the cheapest source of carbohydrate presently and majority of the tubers are processed into food such as garri, fufu, tapioca, starch, lafun with limited availability for industrial use [2]. Processing of cassava before consumption is a means of detoxification, preservation and modification due to the presence of toxic cyanogenic glucosides which is a potential for the production of poisonous hydrogen cyanide (HCN). Linamarin, a

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cyanogenic glucoside present in cassava roots when hydrolyzed, produces hydrogen cyanide and acetone [3]. The basic processes involved in processing of cassava to garri includes; sorting, peeling and washing, grating, de-watering and fermenting, granulating, roasting, sieving and packaging. During cassava processing, large amounts of liquid (cassava processing effluent) and solid (cassava waste peels and some discarded tubers) residues are generated [4]. In Nigeria alone, about 20-30% of cassava peels are generated from cassava tuber processing every year, most of which become solid municipal wastes which contribute significantly to environmental pollution causing great challenges to the environment [5]. The peels contain large amounts of cyanogenic glucoside that may cause surface water and soil pollution if stored under rain [6].

Maize (*Zea mays*) ranks one of the major staple foods in Nigeria as a result of it high production rate in corn, ethanol, animal feed and other maize products. It is extensively grown in areas where cassava is cultivated as a method of intercropping which makes the plant susceptible to soil contaminated by cassava processing waste products [7]. The beneficial effect of cassava processing effluents and solid waste materials on plants is generating scientific interest in researches, and this issue continues to draw significant attention specifically in maize plant. Thus, this current study is therefore focused on the biological implications of cassava waste peels on the physico-chemical and antioxidant properties of maize seedlings.

Materials and Methods

Study Location

This study commenced on October 21st 2021 and ended on November 18th 2021 (i.e. a period of four (4) weeks). The planting activity was carried out at the green house premises of Metro Research and Biotechnology Africa in Benin City, Edo state, Nigeria. The region experiences moderate rainfall and humidity for most part of the year. The climate is marked by two distinct seasons; the dry season and the rainy season. The natural vegetation is dense tropical rain forests with swamp forests in some areas and also it is characterized by tropical equatorial climate with mean annual temperature of 32.8^{o}C and annual rainfall of about 2673.8mm.

Preparation of Maize (*Zea mays*) Seeds

Maize seedlings (*Zea mays*) were purchased from uselu market in Benin City, Edo state, Nigeria. The seedlings were sorted, cleaned and tested for viability using the method of floatation. The seeds were placed in water for 5 minutes after which they were collected and used for the experiment, while the seeds that remained afloat were discarded. The viable seeds were then stored in polythene bags in the laboratory and used within few days of collection.

Soil Sampling

The soil samples to be used in planting the maize were collected from five (5) different points close to a local cassava mill located at sapele road, Benin-city, Edo state. The different points of collection include; where cassava peel waste are heaped (A) , 10m south (B), 10m east (C), and 10m west (D) away from the first point of collection (A). This is in order to examine how cassava peels might have affected the soil quality at different points of the environment. Control soil sample (E) was collected 100 meters away from the point of cassava peels heap (A). All soil samples were collected from the location at a depth of 20 – 25cm and handpicked in order to get rid of large particles and debris and also to obtain a homogenous mixture, the soil were mixed thoroughly. The representative samples were thereafter loaded in well labeled large plastic buckets, properly covered and transported to the laboratory for analysis and planting.

Experimental Design

Cultivation/Planting of Maize Seedlings

Viable maize seedlings were cultivated in perforated polythene bags containing 4kg of soil samples. A total of 50 bags were used with each soil sample having 10 bags each. Five (5) different groups of soil samples (A,B,C,D and E) were represented with seven (7) seeds in each planted in a depth of 1 – 2cm and well watered daily with about 100 – 300ml of water throughout the period of the experiment depending on the texture of the soil. The maize plants were grown for four weeks and subjected to the same atmospheric condition in the green house located in the premises. Laboratory analysis on the growth parameters, biomass activities, soil analysis and antioxidant properties were carried out each week for a

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period of four (4) weeks on the growing maize plants of the various soil samples.

Mode of Data Collection of Growth Parameters

The following growth parameters were measured;

Plant height

Shoot length

Number of Leaves

Leaf length

Leaf width

Area of leaf

Shoot girth

Root length

Data collection of growth parameters was carried out at the end of every week within the four (4) weeks of growth of the maize (*Zea Mays*) plant. Number of leaves was determined by merely counting the leaves on each plant. With the aid of a metre rule, the longest part of each leaf was measured as leaf length, while the widest part was measured as leaf width. Shoot length was determined by measuring from the base to the point of attachment of the leaf to the plant. Plant height was measured from the base to the highest point of the plant and shoot girth was measured with the aid of a thread tied around the shoot and placed on a metre rule. Lastly, the root length of every plant after each week's harvest was also measured with the aid of a metre rule placed from its highest point of attachment to the shoot to the longest root.

Leaf area (cm^2) of individual leaves was calculated as follows;

$A = 0.75 \times L \times W$ for fully expanded leaves

$A = 0.5 \times L \times W$ for expanding leaves

Where, 0.75 and 0.5 are constants; L- Leaf length (cm); and W- Leaf width (cm).

The individual leaf areas per plant were summed up to get the total leaf area per plant [8].

Determination of Plant Biomass

The biomass was obtained by summation of the dry weight of the individual plants after oven drying at 105° C to obtain a constant weight for each group. Biomass content was expressed in grams (g) [9].

Soil Analysis

Soil pH

About 10g of air-dried fine soil was weighed into a 50ml beaker. Exactly 20ml of distilled water was added. This mixture was stirred for 30 minutes intermittently. The content was allowed to stand for a while. The pH was then read using a pH meter that was standardized with a buffer at pH 4.0 [10].

Total carbon and Organic Matter Determination (Wet oxidation method)

This was determined using the method described by Juliana et al. (2014) [11]. This procedure measures the active or decomposable organic matter and carbon in the soil. The carbon in plant residues and humus is oxidized but the carbon present as graphite or charcoal is not oxidized. From 90-95% of total carbon is oxidized and measured using this procedure. In the determination of total carbon and organic matter, carbon is oxidized by potassium dichromate (K2Cr2O7) in the presence of sulphuric acid (H2SO4) leading to the formation of carbon dioxide (CO2) according to the equation given shown below;

$$2\ K_2Cr_2O_7 + 8H_2SO_4 \longrightarrow 2K_2\ SO_4 + 2Cr_2\ (SO_4)_3 + 8\ H_2O + 3O_2$$

$$3C + 3O_2 \longrightarrow 3CO_2$$

While organic carbon is oxidized, $K_2Cr_2O_7$ is reduced. The amount of oxygen consumed during the oxidation of organic carbon is calculated from the difference between the amount of potassium dichromate ($K_2Cr_2O_7$) taken and the amount remaining after oxidation which is determined by titration with 0.5N ferrous sulphate in the presence of ferroin indicator [12]. Air-dried soil sample (1.0g) was weighed into 250ml conical flask, and then 10ml of 0.5N potassium dichromate ($K_2Cr_2O_7$) solution was added. The mixture was swirled for proper mixing and 15ml of concentrated sulphuric acid (H_2SO_4) was added violently but carefully. The mixture was left to stand for 30minutes, and then 100ml of distilled water was added to increase the volume, following which eight (8) drops of ferroin indicator was added. The content was titrated using 0.5N ferrous sulphate to obtain a wine red or dirty brown end-point. A blank titration was done alongside with the sample but without sample.

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Percentage Nitrogen Determination (Macro Kjeldahl Method)

One gram of soil was weighed into 250ml conical flask and a catalyst tablet was added then, 20ml of conc. H_2SO_4 extracted was added violently but carefully. A bent-tailed funnel was placed at the mouth of the flask. The mixture was heated for 3 hours to digest till the mixture was clear. The digest was allowed to cool and the content poured into 100ml volumetric flask then made up to mark. To distil, 10ml aliquot was taken into 500ml Kjeldahl flask and 30ml of distilled water was added followed by 15ml of 40% NaOH (excess). Heat was applied and the distillate was trapped using 5ml boric acid (4%) containing mixed indicators (methyl orange and bromocresol green), then 30ml distillate collected and titrated using 0.1N HCl [13].

Determination of Phosphorus

Five grams (5g) of soil sample was weighed into 250ml plastic soil shaking bottle and 30ml of 1M ammonium fluoride (NH4F) was shaken for 1 minute and filtered using whatmann filter paper into 100ml sample bottle. Phosphorus was determined using colorimetric method using the molybdate-ascorbic acid method and absorbance was measured at 882nm wavelength [14].

Statistical Analysis

Investigations were carried out in triplicate (n=3), and data were presented as mean ± standard error of mean (SEM) using descriptive statistics. One-way Analysis of Variance (ANOVA) was used to compare mean difference between samples and least significant difference.

Results

Growth of maize plant on cassava waste peels

The result shown in Table 1 for the growth of maize over a period of four weeks indicate a significant increase ($p>0.05$) in the growth parameters (Plant height, Number of leaves, Leaf width, Leaf length, Shoot length, Root length and Girth) between the various groups.

Table 1. *Changes in growth parameters of maize plant exposed to cassava waste peels*

WEEK 1					
GROUPS	A	B	C	D	E
Plant height (cm)	35.2 ± 2.40^{c}	29.1± 4.33^{a}	36.0±1.00^{c}	29.6 ± 1.09^{b}	29.0 ± 2.81^{a}
Number of leaves(cm)	4.0 ± 0.99^{b}	3.0 ± 0.00^{a}	4.0 ± 0.78^{b}	4.0 ± 1.11^{b}	2.9 ± 1.90^{a}
Leaf width (cm)	3.6 ± 0.10^{b}	4.9 ± 0.91^{c}	1.9 ± 0.00^{a}	1.9 ± 0.09^{a}	1.8 ± 0.11^{a}
Leaf length (cm)	31.0 ± 1.10^{b}	36.2 ± 1.33^{d}	32.1 ± 1.73^{c}	31.0 ± 0.00^{b}	19.2 ± 1.00^{a}
Shoot length (cm)	15.1 ± 1.00^{b}	15.7 ± 1.90^{b}	15.9 ± 1.04^{b}	14.2 ± 0.53^{a}	14.0 ± 0.00^{a}
Root length (cm)	30.0 ± 0.05^{e}	29.3 ± 1.00^{d}	26.7 ± 1.85^{b}	21.6 ± 6.00^{c}	20.9 ± 0.00^{a}
Girth (cm)	4.1 ± 0.00^{d}	3.7 ± 0.03^{c}	1.9 ± 0.00^{b}	1.8 ± 1.02^{b}	1.4 ± 1.00^{a}
WEEK 2					
GROUPS	A	B	C	D	E
Plant height (cm)	48.8 ± 3.00^{c}	34.8 ± 1.99^{b}	34.5 ± 5.2^{b}	34.1 ± 1.07^{b}	30.1 ± 1.00^{a}
Number of leaves	6.0 ± 0.00^{c}	5.2 ± 0.77^{b}	5.0 ± 0.76^{b}	5.0 ± 0.32^{b}	4.0 ± 0.00^{a}
Leaf width (cm)	2.4 ± 0.55^{c}	2.0 ± 6.66^{b}	2.0 ± 0.00^{b}	1.9 ± 0.77^{b}	1.9 ± 0.01^{a}
Leaf length (cm)	36.0 ± 0.09^{c}	35.2 ± 8.06^{b}	34.1 ± 2.00^{d}	30.9 ± 1.11^{a}	28.3 ± 0.99^{a}

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Shoot length (cm)	20.9 ± 5.00[d]	18.0 ± 0.33[c]	17.0 ± 2.00[b]	11.9 ± 0.00[a]	9.0 ± 0.33[a]
Root length (cm)	33.2 ± 2.00[d]	32.4 ± 1.11[c]	32..9 ± 0.11[c]	30.8 ± 1.90[a]	30.1 ± 5.00[a]
Girth (cm)	1.1 ± 1.66[d]	1.0 ± 0.22[a]	1.0 ± 0.02[a]	1.0 ± 0.09[a]	1.0 ± 0.00[a]
WEEK 3					
GROUPS	A	B	C	D	E
Plant height (cm)	44.0 ± 2.17[d]	36.8 ± 2.46[c]	36.1 ± 5.18[c]	34.9 ± 2.03[b]	32.6 ± 2.63[a]
Number of leaves	5.0 ± 0.67[c]	4.0 ± 0.36[b]	4.0 ± 0.26[b]	4.0 ± 0.20[b]	3.0 ± 0.20[a]
Leaf width (cm)	2.0 ± 0.18[d]	1.5 ± 0.12[b]	1.7 ± 0.13[c]	1.4± 0.06[a]	1.4 ± 0.05[a]
Leaf length (cm)	37.4 ± 3.85[c]	38.3 ± 3.08[d]	41.1 ± 2.35[e]	33.7 ± 2.34[b]	30.5 ± 3.13[a]
Shoot length (cm)	19.0 ± 1.22[c]	20.5 ± 1.91[d]	21.1 ±0.57[d,e]	16.3 ± 0.69[b]	15.3 ± 0.90[a]
Root length (cm)	29.4 ± 3.17[b]	38.5 ± 2.46[a]	38.9 ± 2.00[a]	25.8 ± 2.94[c]	38.3 ± 3.30[a]
Girth (cm)	3.0 ± 0.18[d]	1.5 ± 0.15[b]	1.8 ± 0.20[c]	1.5 ± 0.12[b]	1.4 ± 0.12[a]
WEEK 4					
GROUPS	A	B	C	D	E
Plant height (cm)	50.3± 5.00[e]	44.9 ± 2.66[c]	48.0 ± 8.11[d]	40.4 ± 0.0[b]	39.0 ± 2.9[a]
Number of leaves	8.0 ± 0.00[c]	8.0 ± 0.10[c]	3.0 ± 3.00[a]	5.0 ± 0.00[b]	3.0 ± 0.01[a]
Leaf width (cm)	4.1 ± 2.01[e]	3.2 ± 1.99[d]	3.2 ± 1.29[c]	2.9 ± 0.20[b]	1.5 ± 0.07[a]
Leaf length (cm)	50.9 ± 2.22[e]	39.0 ± 2.82[c]	44.2 ± 1.00[d]	49.1 ± 4.22[d]	39.1 ± 2.39[a]
Shoot length (cm)	30.1 ± 3.22[e]	29.4 ± 0.00[d]	18.0 ± 1.99[c]	13.2 ± 3.22[b]	11.3 ± 1.22[a]
Root length (cm)	29.9 ±0.00[c]	25.0 ± 1.88[d]	30.1 ±2.10[e]	21.2 ± 1.92[b]	19.2 ± 1.00[a]
Girth (cm)	1.2 ± 1.22[e]	1.1 ± 1.12[c]	1.1 ± 1.20[d]	1.0 ± 1.00[b]	1.0 ± 0.00[a]

Values are expressed as Mean ± SEM of seven seeds in each group; [a, b, c, d] significantly different from the values of control from the 1st week to the 4th week ($p > 0.05$).

Plant biomass of maize plant

As shown in Table 2, there was a significant increase ($p>0.05$) in the values of maize seeds grown on the sample collected from other groups (A, B, C and D) when compared with maize seeds collected 100metres away from the site of cassava heap (group E) starting from week one to week four.

Table 2. *Effect of cassava waste peel on the biomass production of the maize plant*

WEEKS	A	B	C	D	E
WEEK 1	1.22 ± 1.99[d]	1.34 ± 2.80[e]	1.20 ± 1.24[c]	0.99 ± 0.22[b]	0.78 ± 2.00[a]
WEEK 2	1.11. ± 1.18[d]	1.12 ± 0.00[e]	1.10 ± 1.13[c]	1.00 ± 1.00[b]	1.00 ± 0.00[a]
WEEK 3	3.50 ± 0.22[e]	3.22 ± 1.00[d]	2.99 ± 1.67[c]	1.22 ± 1.00[b]	1.00 ± 0.99[a]

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WEEK 4	3.00 ± 3.00[e]	2.88± 1.00[d]	2.12 ± 1.33[c]	1.83 ± 1.12[b]	1.22. ± 1.11[a]

Values are expressed as Mean ± SEM of seven seeds in each group; [a, b, c, d] significantly different from the values of control from the 1st week to the 4th week ($p > 0.05$).

Soil analysis and heavy metals in maize plant

The present result obtained from the soil analysis carried out as shown in the first part of Table 3 indicates that there was no significant difference ($p>0.05$) between the soil pH of the various samples, and also they are below 7.0 which signifies that they are acidic. Also results shown in the second part of Table 3 revealed a significant increase ($p>0.05$) in values of the exchangeable bases (Na, Ca, Mg, K, Pb, Ni and Cd) and other soil nutrients (organic carbon, organic matter, phosphorus and total nitrogen) of the samples of groups A, B, C and D when compared with group E.

Table 3. *Soil properties and exchangeable bases of maize plant exposed to cassava waste peels*

SOIL	pH	Organic Carbon (%)	Organic Matter (%)	Total N (%)	Phosphate	Calcium
A	5.2 ± 0.6[c]	2.11 ± 1.22[e]	1.00 ± 2.05[d]	0.001 ± 0.000[b1]	1.11 ± 0.22[e]	131.00 ± 0.00[d]
B	5.6. ± 0.0[c]	1.29 ± 1.11[b]	0.33 ± 0.11[b]	0.002 ± 0.002[b]	0.92 ± 1.50[b]	130.10 ± 0.00[c]
C	6.7 ± 1.0[b]	1.36 ± 0.02[d]	0.99 ± 0.00[c]	0.011 ± 0.000[c]	1.07 ± 0.11[d]	139.30 ± 0.00[e]
D	6.9 ± 0.5[b]	1.30 ± 0.22[c]	2.32 ± 0.00[e]	0.017 ± 0.000[d]	1.00 ± 1.00[c]	129.11±19.21[b]
E	6.1 ± 0.7[a]	1.22 ± 0.01[a]	0.99 ± 1.01[a]	0.000 ± 0.003[a]	0.90 ± 0.22[a]	120.10 ± 3.20[a]
SOIL	**Mg**	**Na**	**K**	**Pb**	**Cd**	**Ni**
A	13.22 ± 0.25[d]	150.00 ± 2.00[e]	119.10 ±9.20[b]	1.09 ±1.22[e]	1.15 ± 1.00[e]	2.40 ± 2.00[e]
B	12.10 ± 0.01[c]	131.30 ± 2.51[d]	122.22± 1.22[d]	1.08 ± 2.11[d]	0.13 ± 0.00[c]	2.33 ± 1.25[c]
C	12.00 ± 0.11[b]	132.00±22.10[c]	130.29± 1.00[e]	0.09 ± 1.00[b]	1.10 ± 1.00[c]	2.39 ± 0.00[d]
D	19.75 ± 4.55[c]	132.00 ±19.00[b]	120.00± 1.01[c]	1.00 ± 1.00[c]	1.01 ± 0.02[b]	1.20 ± 1.01[b]
E	11.00 ± 1.00[a]	130.22±42.10[a]	111.10± 2.10[a]	0.05 ± 1.11[a]	1.00 ± 9.01[a]	1.00 ± 1.90[a]

Values are expressed as Mean ± SEM of seven seeds in each group; [a, b, c, d] soil pH values not significantly different from the values of control ($p > 0.05$); [a, b, c, d] exchangeable bases and soil nutrient values significantly different from the values of control ($p > 0.05$).

Catalase Activities of Maize Plant

The result for the activities of catalase on maize plant for a period of four weeks is shown in Table 4. In the first, second and third week, the leaf, shoot and root of groups A, B, C and D recorded low values and were significantly different ($p>0.05$) from control (group E). In the last week, the leaf, shoot and root of groups A and B recorded high values ($p>0.05$) when compared with groups E, C and D.

Table 4. *The effect of catalase on maize plants exposed to cassava waste peels*

WEEK 1					
GROUPS	A	B	C	D	E
LEAF	0.1100 ± 0.0038[e]	0.7653 ± 0.0012[a,b]	0.5565 ± 0.0012[c]	0.9296 ±0.0089[d]	0.7941 ±0.0080[a]
SHOOT	0.1186 ± 0.0126[d]	0.0290 ± 0.0131[e]	0.2441 ± 0.0451[c]	0.8379 ±0.0423[b]	1.0446 ±0.0156[a]
ROOT	0.1817 ± 0.0232[d]	0.0470 ± 0.0241[e]	0.5106 ± 0.0980[c]	0.9902 ±0.0334[b]	1.0925 ±0.0102[a]
WEEK 2					

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GROUPS	A	B	C	D	E
LEAF	0.4335 ± 0.0118^{b}	0.5353 ± 0.0043^{a}	0.3662 ± 0.0025^{c}	0.1908 ±0.0067^{d}	0.5279 ±0.0081^{a}
SHOOT	0.5357 ± 0.0133^{b}	0.5960 ± 0.0029^{b,c}	0.5577 ± 0.0093^{b}	0.8312 ±0.0087^{d}	0.6087 ±0.0555^{a}
ROOT	0.5734 ± 0.0336^{c}	0.4277 ± 0.0237^{d}	0.6459 ± 0.0339^{b}	0.5972 ±0.0054^{c}	0.7760 ±0.0193^{a}
WEEK 3					
GROUPS	A	B	C	D	E
LEAF	0.2462 ± 0.0205e	0.5795 ± 0.0244^{d}	0.8942 ± 0.0149^{c}	0.9281 ±0.0056^{b}	1.0419±0.0285^{a}
SHOOT	0.9088 ±0.0115a,b	0.6438 ± 0.0296^{c}	0.9253 ± 0.0337^{a}	0.9593±0.0082^{a}	0.9725±0.0392^{a}
ROOT	0.3502 ± 0.0048^{d}	0.9779 ± 0.0016^{b}	0.9684 ± 0.0007^{b}	0.9071±0.0107^{b,c}	1.0402±0.0442^{a}
WEEK 4					
GROUPS	A	B	C	D	E
LEAF	1.0191 ± 0.0098^{e}	0.1328 ± 0.0000^{b}	0.0965 ± 0.0014^{c}	0.0655 ±0.0079^{d}	0.2966 ±0.0228^{a}
SHOOT	0.9482 ± 0.0482^{e}	0.1619 ± 0.0123^{b}	0.1011±0.0204^{b,c}	0.2895 ±0.0111^{d}	0.1575 ±0.0367^{a}
ROOT	1.0077 ± 0.0024^{e}	0.4662 ± 0.0011^{a,b}	0.1305 ± 0.0277^{d}	0.3932 ±0.0024^{c}	0.4848 ±0.0212^{a}

Values are expressed as Mean ± SEM of seven seeds in each group; $^{a,\,b,\,c,\,d}$ significantly different from the values of control in the 1st, 2nd and 3rd week ($p > 0.05$) respectively; $^{a,\,b,}$ significantly different from the values of control, group C and D ($p > 0.05$) in the 4th week.

Chlorophyll Content in Maize Plant

Table 5. *Chlorophyll activities of maize plant on cassava waste peels*

WEEK 1					
GROUPS	A	B	C	D	E
Chlorophyll a	0.7749 ± 0.0039^{b}	0.7937 ±0.0059^{b}	0.8770 ±0.0018^{a}	0.9173 ±0.0013^{c}	0.8096 ±0.0094^{a}
Chlorophyll b	0.4337 ± 0.0026^{a}	0.4926±0.0043^{a,b}	0.5417± 0.0093^{c}	0.8629 ±0.0173^{d}	0.4622 ±0.0044^{a}
Total Chlorophyll	1.2219 ± 0.0014^{a}	1.3000 ± 0.0027^{b}	1.4338 ±0.0078^{c}	1.7965 ±0.0162^{d}	1.2762 ±0.0073^{a}
WEEK 2					
GROUPS	A	B	C	D	E
Chlorophyll a	0.9770 ± 0.0067^{c}	0.9386 ±0.0037^{b}	0.9449 ± 0.0021b	0.8168 ±0.0068^{a}	0.8331 ±0.0015^{a}
Chlorophyll b	0.7853 ± 0.0086^{a}	0.8258 ±0.0035^{b}	0.8304 ± 0.0049^{b}	0.7649 ±0.0015^{a}	0.7608 ±0.0066^{a}
Total Chlorophyll	1.8565 ± 0.0388^{d}	1.7709 ±0.0140^{c}	1.7920 ± 0.0070^{c}	1.5962 ±0.0066^{b}	1.6086 ±0.0077^{a}
WEEK 3					
GROUPS	A	B	C	D	E
Chlorophyll a	0.9780 ± 0.0033^{c}	0.9235 ±0.0036^{b}	0.9105 ± 0.0075^{d}	0.9251 ±0.0010^{b}	0.9541 ±0.0046^{a}
Chlorophyll b	0.7206 ± 0.0087^{c}	0.5951 ±0.0147^{a}	0.4678 ± 0.0045^{b}	0.4841 ±0.0059^{b}	0.5729 ±0.0152^{a}

The effect of chlorophyll activities on maize plant for a period of four weeks is shown in Table 5. In the first, second and fourth week, the total chlorophyll numbers of groups A, B, C and D recorded significant increase (p>0.05) in values when compared with the control (group E), but in the third week the total chlorophyll numbers of the various groups were close to the control group.

Total hlorophyll	1.7190 ± 0.0073^{d}	1.5334 ±0.0207^{a}	1.3971 ± 0.0061^{c}	1.4397 ±0.0151^{b}	1.5440 ±0.0199^{a}
WEEK 4					
GROUPS	**A**	**B**	**C**	**D**	**E**
Chlorophyll a	0.9836 ± 0.0012^{b}	0.9866 ±0.0013^{b}	0.9780 ± 0.0022^{b}	0.9609 ±0.0059^{b}	0.8914 ±0.0001^{a}
Chlorophyll b	0.6490 ± 0.0144^{c}	0.6774 ±0.0074^{c}	0.8585 ± 0.0059^{d}	0.5383 ±0.0211^{b}	0.4228 ±0.0058^{a}
Total hlorophyll	1.6497 ± 0.0133^{c}	1.6811 ±0.0064^{c}	1.8538 ± 0.0057^{d}	1.5583 ±0.0504^{b}	1.3294 ±0.0058^{a}

Values are expressed as Mean ± SEM of seven seeds in each group; $^{a, b, c, d}$ significantly different from the values of control in the 1st, 2nd and 4th week (p > 0.05) respectively; $^{a, b, c, d}$ not significantly different from the values of control (p > 0.05) in the 3rd week.

Cyanide Content in Maize Plant

In this study, the result obtained from the cyanide content of maize for a period of four weeks is presented in Table 6. In the first and second week, the cyanide content of the leaf, shoot and root of groups A, B, C and D recorded significant changes (p>0.05) in values when compared with control (group E). In the third and fourth week, the values of groups A, B, C and D were significantly reduced (p>0.05) when compared with the control (group E).

Table 6. *The effect of cyanide content of maize plant on cassava waste peels*

WEEK 1					
GROUPS	**A**	**B**	**C**	**D**	**E**
LEAF	0.0417 ± 0.0002^{b}	0.0444 ± 0.0023^{b}	0.1051 ± 0.0020^{d}	0.0725 ±0.0019^{c}	0.0566±0.0013^{a}
SHOOT	0.0042 ± 0.0020^{d}	0.0119 ± 0.0002^{a}	0.0147±0.0002^{a,c}	0.0128±0.0008^{a,b}	0.0118±0.0005^{a}
ROOT	0.0073 ± 0.0018^{c,e}	0.0024 ± 0.0005^{c,d}	0.0209 ± 0.0006^{b}	0.0143 ± 0.0016^{a}	0.0188±0.0005^{a}
WEEK 2					
GROUPS	A	B	C	D	E
LEAF	0.3881 ± 0.0010^{d}	0.3391 ± 0.0022^{c}	0.3190±0.0038^{a,b}	0.3190±0.0010^{a,b}	0.3162±0.0008^{a}
SHOOT	0.2985 ±0.0011^{a,b}	0.3014 ± 0.0011^{c}	0.3147 ± 0.0102^{e}	0.3048±0.0017^{c,d}	0.2924±0.0014^{a}
ROOT	0.3049 ± 0.0017^{c}	0.3056 ± 0.0022^{c,d}	0.2949 ± 0.0011^{a}	0.2970±0.0012^{a,b}	0.2926±0.0010^{a}
WEEK 3					
GROUPS	**A**	**B**	**C**	**D**	**E**
LEAF	0.0350 ± 0.0095^{d}	0.0447 ± 0.0003^{e}	0.0596 ± 0.0001^{b}	0.0555±0.0009^{b,c}	0.0821±0.0007^{a}
SHOOT	0.0115 ± 0.0013^{b}	0.0087 ± 0.0004^{d}	0.0115 ± 0.0002^{b}	0.0155 ± 0.0004^{c}	0.0130±0.0013^{a}
ROOT	0.0156 ± 0.0014^{e}	0.0168 ± 0.0006^{d}	0.0177 ± 0.0003^{c}	0.0183 ± 0.0012^{b}	0.0223±0.0012^{a}
WEEK 4					
GROUPS	A	B	C	D	E
LEAF	0.1509 ± 0.0069^{e}	0.1415 ± 0.0033^{a,b}	0.1396 ± 0.0003^{c}	0.1504 ±0.0013^{d}	0.1490±0.0016^{a}
SHOOT	0.1158 ±0.0005^{b,c}	0.1236 ± 0.0025^{a}	0.1144 ± 0.0003^{c}	0.1190 ±0.0014^{b}	0.1232±0.0007^{a}
ROOT	0.0811 ± 0.0406^{e}	0.1249 ± 0.0011^{a,c}	0.1179 ± 0.0014^{d}	0.1289±0.0026^{a,b}	0.1297±0.0027^{a}

Values are expressed as Mean ± SEM of seven seeds in each group; $^{a, b, c, d}$ significantly different from the values of control in the 1st and 2nd week (p > 0.05) respectively; $^{a, b, c, d}$ significantly different from the values of control (p > 0.05) in the 3rd and 4th week.

Glutathione Peroxidase Activities in Maize Plant

Results obtained for the glutathione peroxidase activities on the leaf, shoot and root of maize plants for a period of four weeks are shown in Table 7. In the first and second week, the glutathione peroxidase activity of groups A, B, C and D did not record significant changes (p>0.05) when compared with control (group E). In the third and fourth week, the activity of glutathione peroxidase in groups A, B, C and D was significantly increased (p>0.05) when compared with control (group E).

Table 7. *Assessment of glutathione peroxidase activities of maize plants on cassava waste peels*

WEEK 1					
GROUPS	A	B	C	D	E
LEAF	$0.0028 \pm 0.0000^{a,d}$	$0.0028 \pm 0.0001^{a,d}$	$0.0027 \pm 0.0000^{a,c}$	$0.0026 \pm 0.0001^{a,b}$	0.0025 ± 0.0000^{a}
SHOOT	0.0030 ± 0.0001^{d}	0.0026 ± 0.0000^{a}	$0.0027 \pm 0.0001^{a,c}$	$0.0025 \pm 0.0001^{a,b}$	0.0026 ± 0.0000^{a}
ROOT	0.0027 ± 0.0001^{a}	$0.0026 \pm 0.0000^{a,b}$	0.0027 ± 0.0000^{a}	0.0027 ± 0.0000^{a}	0.0027 ± 0.0000^{a}
WEEK 2					
GROUPS	A	B	C	D	E
LEAF	$0.0029 \pm 0.0000^{b,c}$	0.0020 ± 0.0000^{b}	0.0009 ± 0.0000^{d}	0.0009 ± 0.0000^{d}	0.0011 ± 0.0000^{a}
SHOOT	0.0026 ± 0.0001^{c}	0.0021 ± 0.0001^{a}	0.0021 ± 0.0000^{a}	0.0022 ± 0.0000^{b}	0.0021 ± 0.0000^{a}
ROOT	0.0029 ± 0.0001^{c}	0.0021 ± 0.0000^{b}	0.0021 ± 0.0000^{b}	0.0021 ± 0.0001^{b}	0.0023 ± 0.0000^{a}
WEEK 3					
GROUPS	A	B	C	D	E
LEAF	$0.0038 \pm 0.0001^{a,b}$	$0.0033 \pm 0.0001^{a,d}$	$0.0039 \pm 0.0000^{a,c}$	$0.0039 \pm 0.000^{a,c}$	0.0037 ± 0.0000^{a}
SHOOT	0.0041 ± 0.0000^{e}	0.0034 ± 0.0002^{c}	0.0033 ± 0.0001^{b}	0.0039 ± 0.0001^{d}	0.0025 ± 0.0000^{a}
ROOT	0.0041 ± 0.0000^{c}	0.0040 ± 0.0000^{a}	0.0041 ± 0.0001^{c}	0.0039 ± 0.0000^{b}	0.0040 ± 0.0000^{a}
WEEK 4					
GROUPS	A	B	C	D	E
LEAF	0.0034 ± 0.0001^{a}	$0.0031 \pm 0.0000^{a,b}$	$0.0035 \pm 0.0001^{a,c}$	$0.0037 \pm 0.0000^{a,d}$	0.0034 ± 0.0001^{a}
SHOOT	0.0034 ± 0.0000^{d}	0.0034 ± 0.0001^{d}	0.0016 ± 0.0001^{c}	$0.0028 \pm 0.0001^{a,b}$	0.0027 ± 0.0001^{a}
ROOT	$0.0038 \pm 0.0000^{a,c}$	$0.0038 \pm 0.0000^{a,c}$	0.0040 ± 0.0000^{d}	$0.0037 \pm 0.0001^{a,b}$	0.0035 ± 0.0000^{a}

Values are expressed as Mean $\pm$ SEM of seven seeds in each group; $^{a, b, c, d}$ not significantly different from the values of control in the 1st and 2nd week (p > 0.05) respectively; $^{a, b, c, d}$ significantly different from the values of control (p > 0.05) in the 3rd and 4th week.

Malondialdehyde (MDA) Concentration in Maize Plant

The effect of MDA activities on the leaf, shoot and root of maize plant for a period of four weeks is shown in Table 8. In the first, third and fourth week, groups A, B, C and D recorded low values which were not significantly different (p>0.05) from the control (group E). Consequently in the second week, the leaf, shoot and root of groups B, C, D and E recorded high values and also showed no significant changes (p>0.05) when compared with each other.

Table 8. *Evaluation of malondialdehyde activities in maize plant exposed to cassava waste peels*

WEEK 1					
GROUPS	A	B	C	D	E
LEAF	0.0020 ± 0.0000^{e}	0.0033 ± 0.0001^{b}	0.0030 ± 0.0004^{d}	0.0031 ± 0.0001^{c}	0.0034 ± 0.0001^{a}
SHOOT	0.0008 ± 0.0001^{c}	0.0011 ± 0.0000^{a}	0.0012 ± 0.0000^{b}	0.0011 ± 0.0000^{a}	0.0011 ± 0.0000^{a}
ROOT	0.0013 ± 0.0000^{b}	0.0021 ± 0.0000^{c}	0.0025 ± 0.0001^{e}	0.0023 ± 0.0001^{d}	0.0017 ± 0.0000^{a}
WEEK 2					

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GROUPS	A	B	C	D	E
LEAF	0.0024 ± 0.0001^{e}	0.0137 ± 0.0000^{b}	0.0139 ± 0.0001^{c}	0.0144 ±0.0000^{d}	0.0138 ±0.0000^{a}
SHOOT	0.0135 ± 0.0005^{d}	0.0132 ± 0.0002^{c}	0.0129 ± 0.0001^{b}	0.0132 ±0.0001^{c}	0.0130 ±0.0000^{a}
ROOT	0.0010 ± 0.0000^{d}	0.0137 ± 0.0000^{c}	0.0134 ± 0.0001^{a}	0.0131 ±0.0001^{b}	0.0134 ±0.0000^{a}
WEEK 3					
GROUPS	A	B	C	D	E
LEAF	0.0022 ± 0.0001^{a}	0.0014 ± 0.0000^{c}	0.0021 ± 0.0001^{b}	0.0031 ±0.0002^{d}	0.0022 ±0.0000^{a}
SHOOT	0.0023 ± 0.0003^{e}	0.0010 ± 0.0001^{c,d}	0.0009 ± 0.0000^{b}	0.0013 ±0.0000^{c}	0.0008 ±0.0000^{a}
ROOT	0.0002 ± 0.0000^{e}	0.0015 ± 0.0000^{d}	0.0014 ± 0.0001^{c}	0.0027 ±0.0001^{b}	0.0023 ±0.0002^{a}
WEEK 4					
GROUPS	A	B	C	D	E
LEAF	0.0015 ± 0.0000^{e}	0.0016 ± 0.0001^{d}	0.0023 ± 0.0001^{c}	0.0019 ±0.0001^{b}	0.0021 ±0.0001^{a}
SHOOT	0.0014 ± 0.0000^{e}	0.0007 ± 0.0001^{b}	0.0012 ± 0.0000^{c}	0.0013 ±0.0000^{d}	0.0009 ±0.0001^{a}
ROOT	0.0010 ± 0.0000^{d}	0.0011 ± 0.0001^{c,d}	0.0016 ± 0.0001^{b}	0.0016 ±0.0000^{b}	0.0015 ±0.0002^{a}

Values are expressed as Mean ± SEM of seven seeds in each group), $^{a, b, c, d}$ not significantly different from the values of control in the 1st, 3rd and 4th weeks ($p > 0.05$) respectively; $^{b, c, d, e}$ significantly different from the values of group A ($p > 0.05$).

Reduced Glutathione Content in Maize Plant

The results obtained for Reduced Glutathione on the various parts (leaf, shoot and root) of maize plants in the various samples for a period of four weeks are shown in Table 9. In the first, second and third week, the leaves, shoots and roots of group A, B, C and D recorded a significant decrease (p>0.05) in value when compared with group E (control). Finally, there was a significant decrease (p>0.05) in value of the leaves, shoots and roots of group E (control) when compared with the other groups.

Table 9. *The effect of reduced glutathione activities of maize plant exposed to cassava waste peels*

WEEK 1					
GROUPS	A	B	C	D	E
LEAF	0.0954 ± 0.0071^{d}	0.0393 ± 0.0131^{b,c}	0.0154 ± 0.0014^{c}	0.0344 ±0.0128^{b}	0.0807 ±0.0081^{a}
SHOOT	0.0442 ± 0.0021^{c}	0.0232 ± 0.0063^{d}	0.0105 ± 0.0012^{e}	0.0842 ±0.0000^{a}	0.0832 ±0.0116^{a}
ROOT	0.0547 ± 0.0021^{b}	0.0554 ± 0.0091^{b}	0.0463 ± 0.0024^{c}	0.0379 ±0.0049^{d}	0.0768 ±0.0137^{a}
WEEK 2					
GROUPS	A	B	C	D	E
LEAF	0.5231 ± 0.0178^{b}	0.1538 ± 0.0308^{c}	1.0231 ± 0.0231^{d}	0.6385±0.0846^{a,b}	0.6231±0.0077^{a}
SHOOT	0.3590 ± 0.0401^{c}	0.2359 ± 0.0401^{d}	0.5077 ± 0.0154^{b}	0.1846 ± 0.0308^{e}	1.0846±0.1154^{a}
ROOT	0.2154 ± 0.0000^{b}	0.1692 ± 0.0308^{c}	0.2154 ± 0.0154^{b}	0.1538 ± 0.0355^{d}	0.4615±0.0308^{a}
WEEK 3					
GROUPS	A	B	C	D	E
LEAF	0.1583 ± 0.0648^{e}	0.4000 ± 0.0500^{b}	0.2278 ± 0.0147^{d}	0.3000 ±0.0825^{c}	0.7000 ±0.0285^{a}
SHOOT	0.3056 ±0.0455^{a,b}	0.2556 ± 0.0294^{c}	0.1500 ± 0.0167^{e}	0.4833 ±0.0333^{d}	0.3583 ±0.0392^{a}
ROOT	0.0611 ± 0.0278^{d}	0.3000 ± 0.0289^{b}	0.1833 ± 0.0192^{c}	0.3167 ±0.0500^{b}	0.4333 ±0.0833^{a}
WEEK 4					
GROUPS	A	B	C	D	E

LEAF	0.5238 ± 0.0265^{b}	0.1222 ± 0.0016^{c}	0.0730 ± 0.0206^{d}	0.4500 ±0.0071^{a}	0.4286±0.0429^{a}
SHOOT	0.4643 ± 0.0071^{c}	0.1619 ± 0.0048^{a}	0.0571 ± 0.0082^{e}	0.2429 ±0.0218^{b}	0.1333±0.0333^{a}
ROOT	0.3190 ± 0.0423^{c}	0.2143 ± 0.0660^{a}	0.1762 ± 0.0033^{b}	0.3214±0.0214^{c,d}	0.2238±0.0454^{a}

Values are expressed as Mean ± SEM of seven seeds in each group), $^{a, b, c, d}$ significantly different from the values of control in the 1st, 2nd and 3rd weeks (p > 0.05) respectively; ^{e} significantly different from the values of the other groups (p > 0.05).

Rhodanase Concentration in Maize Plant

In this present study, the result obtained from rhodanese activities of maize plant grown on soil samples for a period of four weeks is shown in Table 10. There was a significant increase (p>0.05) in the leaf, shoot and root values of group A, B, C and D when compared with group E (control) in the first, third and fourth week. Also in the second week, the shoot and root of group E recorded significant increase (p>0.05) in values especially when compared with those of A and B.

Table 10. *Changes in Rhodanese activities in maize plant exposed to cassava waste peels*

WEEK 1					
GROUPS	A	B	C	D	E
LEAF	1.7133 ± 0.3869^{c}	2.7266 ± 0.1197^{d}	2.0776 ± 0.0645^{b}	4.3109 ±0.6172^{e}	1.9743 ±0.1330^{a}
SHOOT	2.6529 ± 0.1013^{e}	2.5930 ± 0.1059^{d}	2.1739 ± 0.0985^{c}	1.9943 ±0.0322^{b}	1.6626 ±0.1336^{a}
ROOT	1.7317 ± 0.0737^{b}	2.4809 ± 0.0427^{d}	2.3581 ± 0.1105^{c}	2.4917 ±0.2257^{d}	1.8423 ±0.0281^{a}
WEEK 2					
GROUPS	A	B	C	D	E
LEAF	3.0490 ± 0.0184^{e}	1.1054 ± 0.0281^{b}	1.3295 ± 0.0480^{d}	1.2159 ±0.0141^{c}	1.0915 ±0.0691^{a}
SHOOT	1.0040 ± 0.0000^{c}	1.0086 ± 0.0415^{c}	1.1652 ± 0.0046^{b}	1.0271 ±0.0230^{c}	1.2251 ±0.0276^{a}
ROOT	0.9979 ± 0.0403^{b}	0.9211 ± 0.0130^{c}	1.0225 ± 0.0000^{a}	1.1883 ±0.0192^{d}	1.0317 ±0.0368^{a}
WEEK 3					
GROUPS	A	B	C	D	E
LEAF	0.2702 ± 0.0433^{c}	0.5481 ± 0.0046^{b}	1.6488 ± 0.3592^{d}	1.3587 ±0.0046^{e}	0.7553 ±0.1934^{a}
SHOOT	0.9718 ± 0.1244^{c}	1.5153 ± 0.0138^{b}	0.5680 ± 0.1416^{d}	0.9948 ±0.1658^{c}	1.3940 ±0.2553^{a}
ROOT	1.1054 ± 0.3961^{d}	0.8981 ± 0.0691^{a}	0.7185 ± 0.2671^{c}	0.9764 ±0.1566^{b}	0.8382 ±0.1658^{a}
WEEK 4					
GROUPS	A	B	C	D	E
LEAF	6.7888 ± 0.0092^{e}	2.4410 ± 0.2026^{d}	1.2067 ± 0.1934^{c}	1.3955 ±0.0138^{b}	0.4514 ±0.0368^{a}
SHOOT	1.6795 ± 0.0938^{e}	1.3449 ± 0.0368^{d}	1.2527 ± 0.1105^{c}	0.4974 ±0.0276^{b}	0.2026 ±0.0829^{a}
ROOT	4.1267 ± 0.2487^{d}	1.4830 ± 0.2211^{c}	0.5849 ± 0.2441^{b}	0.5343 ±0.1013^{b}	0.2579 ±0.1614^{a}

Values are expressed as Mean ± SEM of seven seeds in each group), $^{a, b, c, d}$ significantly different from the values of control in the 1st, 3rd and 4th weeks (p >0.05) respectively; ^{e} significantly different from the values of group A and B (p >0.05) in the 2nd week

Discussion

As shown in Table 1, there was an appreciable increase in growth of the seeds in the soil of the different samples than that of the control from week one to week four. This can be attributed to the non-inhibitory properties of cassava waste peels on the growth of maize seedlings as described by Ikpe et

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al. (2009); Nwakaudu et al. (2012) who observed similar effects [15,16].

Biomass can be described as plant or animal materials used for energy production, heat production or in various industrial processes as raw materials for a range of products [17]. In this study, the result obtained from effect of cassava waste peel on the biomass production of the experimental plant as shown in Table 2, implies a possible economic value of cassava waste peel in the production of maize biomass as suggested by Kigho et al. (2021) [18].

Plant growth is influenced by the physical, chemical and biological properties of the soil, hence understanding soil properties is essential for nutrient planning and land-use decisions [19]. The present result obtained from the soil analysis carried out as shown in the first part of Table 3 indicates that there was no significant difference ($p>0.05$) between the soil pH of the various samples, and also they are below 7.0 which signifies that they are acidic. This no doubt is due to the high concentration of hydrogen cyanide present in the cassava waste peels of the soil samples which is in accordance with the study of Kasi et al. (2012) [20]. The occurrence of heavy metals in soil may be beneficial or toxic to the environment; hence excess of metals may produce some common effects of individual metals on different plants. The biota may require some of these elements in trace quantities, but at higher concentrations there may be toxicity problems [21]. Results shown in the second part of Table 3 can be linked to the discharge of cassava waste peels on the samples which led to the acidic nature and increase in the microbial population of the soil due to the available nutrients. This is in accordance with the study of Eze and Onyilide (2015) [22].

Anti-oxidative enzymes are important in preventing the oxidative stress in plants; hence the activity of one or more of these enzymes is generally increased in plants when exposed to stressful condition [23]. The result for the activities of catalase on maize plant for a period of four weeks as shown in Table 4, indicate that catalase activity is able to maintain hydrogen peroxide (H_2O_2) potential more at very low levels in extracellular space which makes it possible for its scavenging system to avoid the formation of high toxic hydroxyl radicals [24].

Chlorophyll is a natural plant pigment found in the chloroplast of algae and plants which play an important role in photosynthetic process [25]. Observations from this result shown in Table 5 imply that cassava waste peel does not inhibit chlorophyll synthesis in maize plant, hence the re-occurring increase in the number of samples of the different groups. This result can be attributed to the studies of Martinez and Ramos (2015) [26].

The term cyanide is used to describe compounds which contain in their structure the $-C\equiv N$ group. In the environment, cyanides can be found in many different forms [27]. In this study, the result obtained from the cyanide content of maize for a period of four weeks as presented in Table 6, obviously indicates the presence of hydrogen cyanide in the soil samples which is mostly found in cassava peels as described by Williams et al. (2021) [28]. The significant reduction observed in the third and fourth week may be attributed to some physical and natural factors that might have led to the fermentation of the discharged cassava waste peel thereby reducing the concentration of hydrogen cyanide in the soil as described by Igwe and Azorji (2018) [29].

The glutathione peroxidase (GPX) family consists of multiple isoenzymes with distinct sub-cellular locations which exhibit different tissue-specific expression patterns and environmental stress responses [30]. In this study, the resultant increase in glutathione peroxidase activities in the various groups from the third week to the fourth week as shown in Table 7 is due to the reduction of reactive oxygen species which occurred as a result of oxidative stress [31].

Lipid peroxidation can be described generally as a process under which oxidants such as free radicals or non-radical species attack lipids containing carbon-carbon double bond especially polyunsaturated fatty acids (PUFAs) [32]. In this study the effect of MDA activities on the leaf, shoot and root of maize plant for a period of four weeks is shown in Table 8. The massive increase in values in the second week might occur as a result of high levels of free radicals in the soil samples due to crude wax present in the cassava peel [33].

The results obtained for reduced glutathione on the various parts (leaf, shoot and root) of maize plants in the samples for a period of four weeks are shown in Table 9. The initial decrease in values of the various soil samples might be that the enzyme was able to withstand the stress condition caused by reactive oxygen species, but was unable to sustain it due to some physical and natural factors that might have affected the soil sample. This observation was found to be consistent with the study of Michael et al. (2004) who

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examined glutathione system as a stress marker in different plants [34].

Rhodanese is a ubiquitous enzyme which is widely distributed in all living organisms ranging from plants to bacteria to man. It is a multifunctional enzyme that plays a central role in cyanide detoxification [35]. In this present study, the observations obtained from the activity of rhodanese on maize plant grown on soil samples for a period of four weeks as shown in Table 10, clearly indicate that cyanide found in the cassava waste peels is inhibited by rhodanese due to the presence of thiosulphate or cysteine in the enzyme [36].

Conclusion

Plant growth is influenced by the physical, chemical and biological properties of the soil, hence understanding soil properties is essential for nutrient planning and land-use decisions From this study it can be concluded that the non-inhibitory properties and hydrogen cyanide concentraton of cassava waste peels on the growth of maize seedlings could bring about changes in the mineral and physico-chemical composition in the plant, as well as the antioxidant properties of some enzymes present in the soil of maize plant exposed to the effluent. In addition the effluents from cassava such as cassava waste peel are of great economic importance to the biofuel industry because it can help to improve the production of maize biomass.

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Conflict of Interest

The authors have no conflict of interest in this study.

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