Biochemical and Morphological Response of Maize (Zea May) Planted in Rubber Effluents Contaminated Soil

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Abstract: This study investigated the effect of Rubber effluents impacted soil on physio morphological and biochemical properties of maize plant (Zea May). Fifteen polythene pots with drainage holes at the bottom, each containing 10 kg of surface soil, were randomly placed on a table in a screen house in a factorial combination of five treatment levels (20%, 15%, 10%, 5% and 0%w/w) of rubber effluent. The soil inside the pots was homogenized by stirring using a glass rod, wetted with distilled water and allowed to equilibrate for two weeks. Two weeks after the application of rubber effluent, three seeds of maize corn per pot were planted. Result revealed a significant decrease ($p<0.05$) in girth length of maize corn planted rubber effluent-impacted soil relative to the control. The relative water content RWC ranged between 80% and 89%. Biochemical analysis which includes both assay of enzymes and antioxidant enzymes like, Ascorbic acid (ASB), Alanine transferase (ALT), Superoxide Dismutase (SOD), Catalase (CAT), Malondialdehyde (MDA) was carried out on the maize plant after four Weeks of Planting. From the analysis, generally, it was observed that the MDA values of stem of corn planted in rubber effluent-contaminated soil was significantly ($p<0.05$) lower than that of control but later increased at the higher concentration while their SOD, CAT, ASP was significantly higher than the control ($p<0.05$). The activities of antioxidant of the stem of experimental corn studied followed a definite pattern in root, stem and leave of the plant in which the activities increased as the percentage concentration of rubber effluent increased in the soil. Although activities of enzymes (ALT) in of the stem in corn for the concentration B, C and D were significantly ($p<0.05$) higher than that of control (A), but those of B, C and E were not significantly different from one another ($p>0.05$).The results obtained reported that soil nutrient had been to be less mobile in contaminated soil and this condition had also been reported to adversely alter the growth pattern in plants. The assessment of antioxidative enzymes and non-enzymatic antioxidative parameters following contamination with a greater level of rubber effluent revealed that the plant's defense system against the harmful impact of the rubber effluent is overwhelmed, putting the plant at risk of oxidative stress.

Keywords: Rubber effluent-contaminated soil, SOD, CAT, MDA, ALT, ASB, Toxicity.

I. INTRODUCTION

Maize (Zea mays L.), sometimes known as corn, is a versatile cereal crop produced in a variety of agro-ecological settings across the world. Maize is the most significant grain crop in Sub-Saharan Africa (SSA) and a staple meal for over 1.2 billion people in the region [1]. After sorghum and millet, maize is the most significant staple crop in Nigeria, having the largest geographical range in terms of production and use among the cereals [2]. Maize is produced across the nation; however, it is significantly more prevalent in the savannah region. There are about 50 species, which come in a variety of colors, textures, grain forms, and sizes. The most frequent colors are white, yellow, and red. Food and non-food items can be made from any component of the crop [1]. The development of high yielding, drought resistant, early and extra early maturing cultivars (e.g. 80 – 90 days) has improved maize production and consumption in Nigeria in recent years. Maize is a fast-growing, robust, tall (2–3 m) grain crop with wide (5–10 cm) and long (50–100 cm) leaves. Both adventitious and brace roots are produced by maize. After the plant emerges from the earth, the brace roots develop above ground. Brace roots are essential for preventing lodging. These roots may not form properly if the plant is suffering from drought. Maize has only one stem and very few tillers. Each plant of maize produces 16 to 22 leaves. At each node, leaves form and alternate. The pollen for fertilizing the ear is collected by the tassel, which grows at the top of the plant. Maize grows in a single ear most of the time. Early in the spring, maize is best grown in a hotbed, but it will germinate in regular soil in May. During peak growing season, a vigorous growing plant like maize requires about 2 – 3 litres of water per day, or an average water consumption of 2.5 to 4.3 litres per day. For accelerated photosynthetic activity and plant growth, maize requires bright sunny days. Long periods of cloudy weather are harmful to the crop, but intermittent sunlight and rain clouds are ideal for its growth. Deep fertile soils rich in organic matter and well-drained soils are preferred in terms of soil requirements; however, maize can be grown on a variety of soils. The soil should have a medium texture and be able to hold a lot of water. The ideal soil types are loam or silt loam surface soil and brown silt clay loam with a fairly permeable sub soil. Crop is very sensitive to water logging. The pH should be 6.5 – 7.5 along with cation exchange capacity of 20 meq/100g and base saturation of 70 to 90 per cent, bulk density of 1.3 g cm-3 water holding capacity of about 16 cm per meter depth.

Phytoremediation is a term that refers to the process of using plants to clean up chemical hazards such as heavy metals (lead, chromium, arsenic, zinc, cadmium, copper, mercury, and nickel) may be ingested by humans and ecosystems through direct ingestion of contaminated soils, consumption of crops and vegetables grown on contaminated lands, or drinking water that has percolated through contaminated soils. [3] for example, concluded that subsistence farmers who consume rice grain cultivated on polluted areas for the rest of their lives are at danger of cadmium poisoning. With governments and the general public becoming more conscious of the effects of a degraded environment on human and animal health, the scientific community has been more interested in developing solutions to repair polluted areas. Low-cost and environmentally sustainable technologies are needed to remediate contaminated lands in developing countries with high population density and limited funds for environmental restoration in order to reduce associated risks, make the land resource available for agricultural production, improve food security, and reduce land tenure issues. Heavy metal contamination is particularly difficult to remediate because, unlike organic pollutants that are reduced to carbon (IV) oxide by microbial activity, most metals are poisonous and their total content in soils remains for a long period after their introduction [4].

In this present study, the rubber effluent sample from the factory run off pipe, its physicochemical properties and effects on soil and maize plant planted in the soil are investigated are to determine the changes in the morphological properties of the maize plant that was planted in a rubber effluent contaminated soil and to determine the biochemical response of the maize plant when germinated from a rubber processing effluent contaminated soil.

II. MATERIALS AND METHODS

Reagents and solvents were of analytical grade and are products of British Drug House, Poole, England. Rubber effluent was collected from the official effluent discharge point of the rubber processing factory located at Sapele via Sapele/Benin expressway, Delta State Nigeria. The 25 liters of rubber effluent was collected in plastic keg and stored under normal room temperature. The physicochemical properties of the rubber effluent were carried out following standard method (APHA, 1985) at Clefas Ventures Laboratory services and also the Atomic Absorption Spectrophotometer was used for the determination of heavy metals.

Rubber effluent was diluted with distilled water in the order of 5ml of effluent to 95ml of distilled water ,10ml of effluent to 90ml of distilled water ,15ml of effluent to 85ml of distilled water and lastly 20ml of effluent to 80ml of distilled water. All these dilution was carried out according to the methods stated by Adeyemi (2016) and were stored in different plastic sample bottles.

The experiment was conducted in a screen house of the College of Science, Federal University of Petroleum Resources Effurun, Delta State Nigeria. The method described by Adewole and Aboyeji (2013) though slightly modified was used. Bulk surface soil samples (0–15 cm) were collected from an area in the University with a coordinate of; Elevation 33ft, N 05º34¹, E 05º51¹S, air-dried for seven days, sieved using 2mm sieve and analyzed using standard methods. Fifteen polythene pots with drainage holes at the bottom, each containing 10 kg of surface soil, were randomly placed on a table in the screen house in a factorial combination of four treatment levels of watering with (20%,15%,10%, 5% and 0% v/v) Rubber effluent and the soil was designated E, D, C, B and A respectively. The soil inside the pots, homogenized by stirring using a glass rod, wetted with distilled water and allowed to equilibrate for two weeks. Three seeds of maize (obtained from Oyo State Agricultural Agency Agodi Ibadan, Nigeria) per pot were planted.

The maize stands were regularly watered throughout the growing stage. The maize plants were thinned to three stands per group at two weeks after planting (WAP). Biochemical marker: tissue homogenate was evaluated for enzyme Alanine aminotransferase (ALT) by the method of Reitman and Frankel (1957) modified by Schmidt and Schmidt (1963). And antioxidant enzyme activities; superoxide dismutase (SOD) was assayed by the method of Misra and Fridovich (1972), while catalase (CAT) was by the method of Sinha (1971). Lipid peroxidation concentration in the organ tissues homogenate and serum was by malondialdehyde (MDA) and Ascorbic acid (ASB) determination by the methods of Varshney and Kale (1990); Roe and Kurethor (1943) respectively. Analytical grade reagents (products of British Drug House, Poole, England) were used. The absorbance of the test was measured spectrophotometrically using HAICE®, DR 3000 (Germany). The statistical analysis of data was done using SPSS11.5, Mean ± SEM. Post-hoc comparison using Duncan Multiple Range Test (DMRT) was employed for statistical data. The significance of the test result was observed at P<0.05 level.

III. RESULTS

Calculated values for superoxide dismutase (SOD), catalase (CAT), alanine aminotransferase (ALT), ascorbic acid (ASB) and malondialdehyde (MDA), along with standard deviations are given in tables 1-4. Table 1 presented specific activity of Superoxide Dismutase (SOD) and Catalase (CAT) of stem of *Zea may* administer with effluent from rubber production. Specific activity of antioxidant SOD in the stem revealed a definite pattern in that there was a decrease in activity in all experimented groups with increase in concentration of effluent (rubber). Specifically, in Groups B to E, the specific activity of SOD was a significantly ($p <$ 0.05) lower when compared to Group A (control) which Group B showing more reduced activity. In the stem, CAT specific activity showed alteration. Generally, there was decrease in specific activity in all experimented groups except one (Group D). Specifically, in Group B, C and E, the specific activity of CAT was significantly ($p < 0.05$) lower but significantly ($p < 0.05$) higher in Group D when compared to Group A (control) with Group B showing more reduced activity.

Result for Enzymes and Antioxidant activities in Stem

The MDA, SOD, CAT and ASB content of stem of experimental corn are shown in Table 4.1, 4.3 and 4.4 respectively. Generally, it was observed that the MDA values of stem of corn planted in rubber effluent-contaminated soil was significantly (p<0.05) lower than that of control but later increased at the higher concentration while their SOD, CAT, ASB was significantly higher than the control (p<0.05).

The activities of antioxidant enzymes of the stem of experimental corn studied followed a definite pattern in which the activities increased as the percentage concentration of rubber effluent increased in the soil (Table 3.1, 3.3, 4.4).

Although activities of enzymes (ALT) in (Table 3.2) of the stem in corn for the concentration B, C and D were significantly (p <0.05) higher than that of control (A), but those of B, C and E were not significantly different from one another (p>0.05).

TABLE 3.1: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ANTIOXIDANT SUPEROXIDE DISMUTASE (SOD), CATALASE (CAT) OF A MAIZE STEM ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	SOD	CAT

Mean of group A	134.97± 0.20[a]	0.23± 0.00[a]
Mean of group B	135.19 ± 0.12[b]	0.25 ± 0.00[b]
Mean of group C	132.09 ± 0.15[c]	0.26 ± 0.00[c]
Mean of group D	136.01 ± 0.15[d]	0.28 ± 0.00[d]
Mean of group E	138.89 ± 0.15[e]	0.29 ± 0.00[e]

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.2: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ALT OF A MAIZE STEM ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	ALT
Mean of group A	0.03 ±0.00[a]
Mean of group B	0.09±0.00[b]
Mean of group C	0.09±0.00[b]
Mean of group D	0.07±0.00[c]
Mean of group E	0.09±0.00[b]

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.3: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ASCORBIC ACID (ASB) OF A MAIZE STEM ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	ASB
Mean of group A	0.89±0.00[a]
Mean of group B	0.97±0.00[b]
Mean of group C	0.89±0.00[a]
Mean of group D	1.05±0.00[c]
Mean of group E	0.09±0.00[a]

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.4: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME MALONDIALDEHYDE (MDA) OF A MAIZE STEM ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	MDA
Mean of group A	13653.85 ± 15.48[a]
Mean of group B	13365.38 ± 19.33[b]
Mean of group C	15416.67 ± 70.17[c]
Mean of group D	13910.26 ± 56.39[d]
Mean of group E	16025.64 ±68.88[e]

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

Result for Enzymes and Antioxidant activities in Root

The MDA, SOD, CAT and ASB content of root of experimental corn is shown in Table 4.5, 4.6, 4.7. Generally, it was observed that the MDA values in Root of the corn planted in rubber effluent-contaminated soil was significantly ($p<0.05$) lower than that of control even at the higher concentration while their CAT, ASB, SOD was significantly higher than the control ($p<0.05$).

The activities of antioxidant enzymes of the root of experimental corn studied followed a definite pattern in which the activities increased as the percentage concentration of rubber effluent increased in the soil (Table 4.5, 4.6, 4.7) except for antioxidant MDA. Although activities of enzymes (ALT) in (Table 4.8) of the root in corn for the concentration B, C, D and E were not significantly different ($p <0.05$) but higher than that of control (A) ($p>0.05$).

TABLE 3.5: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ANTIOXIDANT SUPEROXIDE DISMUTASE (SOD), CATALASE (CAT) OF A MAIZE ROOT ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	SOD	CAT
Mean of group A	135.80 ± 0.16^{a}	0.24 ± 0.00^{a}
Mean of group B	138.27 ± 0.19^{b}	0.27 ± 0.00^{b}
Mean of group C	135.29 ± 0.34^{a}	0.28 ± 0.00^{c}
Mean of group D	131.79 ± 0.05^{c}	0.28 ± 0.00^{d}
Mean of group E	141.56 ± 0.08^{d}	0.29 ± 0.00^{e}

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.6: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ASCORBIC ACID (ASB) OF A MAIZE ROOT ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	ASB
Mean of group A	0.91 ± 0.00^{a}
Mean of group B	0.98 ± 0.00^{b}
Mean of group C	0.99 ± 0.00^{c}
Mean of group D	1.00 ± 0.00^{d}
Mean of group E	1.10 ± 0.00^{e}

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.7: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME MALONDIALDEHYDE (MDA) OF A MAIZE ROOT ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	MDA
Mean of group A	14070.51 ± 20.67^{a}
Mean of group B	13621.78 ± 41.57^{b}
Mean of group C	14455.13 ± 48.42^{c}
Mean of group D	14615.38 ± 64.19^{d}
Mean of group E	13910.26 ± 32.69^{e}

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.8: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ALT OF A MAIZE ROOT ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	ALT
Mean of group A	0.02 ± 0.00^{a}
Mean of group B	0.09 ± 0.00^{b}
Mean of group C	0.08 ± 0.00^{c}
Mean of group D	0.07 ± 0.00^{d}
Mean of group E	0.08 ± 0.00^{e}

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

Result for Enzymes and Antioxidant activities in Leaf

The MDA, SOD, CAT and ASB content of root of experimental corn is shown in (Table 4.9, 4.10, 4.11). Generally, it was observed that the SOD values in leaf for group C and D were significantly low (p<0.05) relative to the control value of the corn planted in

rubber effluent-contaminated soil, it was also observed that, at the increased concentration the value were significantly higher than that of the control value ($p<0.05$), while their CAT, ASB, MDA was significantly higher than the control ($p<0.05$).
The activities of antioxidant of the root of experimental corn studied followed a definite pattern in which the activities increased as the percentage concentration of rubber effluent increased in the soil (Table 4.9, 4.10, 4.11) except for antioxidant SOD.
Although activities of enzymes (ALT) in (Table 4.12) of the root in corn for the concentration B, C, D and E were not significantly different ($p <0.05$) but higher than that of control (A) ($p>0.05$).

TABLE 3.9: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ANTIOXIDANT SUPEROXIDE DISMUTASE (SOD), CATALASE (CAT) OF A MAIZE LEAF ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE)

GROUPS	SOD	CAT
Mean of group A	136.52 ± 0.17^a	0.23 ± 0.00^a
Mean of group B	136.63 ± 0.13^a	0.24 ± 0.00^b
Mean of group C	133.13 ± 0.17^b	0.24 ± 0.00^c
Mean of group D	130.04 ± 0.06^c	0.26 ± 0.00^d
Mean of group E	142.28 ± 0.08^d	0.28 ± 0.00^e

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).
Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.10: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ASCORBIC ACID (ASB) OF A MAIZE LEAF ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	ASB
Mean of group A	0.90 ± 0.00^a
Mean of group B	0.93 ± 0.00^b
Mean of group C	1.16 ± 0.00^c
Mean of group D	0.87 ± 0.00^d
Mean of group E	1.18 ± 0.00^e

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).
Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 3.11: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME MALONDIALDEHYDE (MDA) OF A MAIZE LEAF ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	MDA
Mean of group A	13750.00 ± 28.22^a
Mean of group B	14519.23 ± 65.92^b
Mean of group C	14070.51 ± 34.36^c
Mean of group D	13974.36 ± 52.52^d
Mean of group E	15608.97 ± 26.69^e

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15% - 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).
Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

TABLE 4.12: SPECIFIC ACTIVITY (u/mg protein) OF ENZYME ALT OF A MAIZE LEAF ADMINISTERED WITH EFFLUENT FROM RUBBER PRODUCTION (RUBBER RESEARCH INSTITUTE SAPELE, DELTA STATE).

GROUPS	ALT
Mean of group A	0.02 ± 0.00^a
Mean of group B	0.09 ± 0.00^b
Mean of group C	0.08 ± 0.00^c
Mean of group D	0.07 ± 0.00^d
Mean of group E	0.09 ± 0.00^e

Notes: Tabulated results are means (mean ± SEM) of six determinations (n=6). Plant placed on 1000ml distilled water (control). 1=Plants placed on water contaminated with effluent (5% - 50ml EAL / 950ml distilled water), 2=Plant placed on water contaminated with effluent (10% - 100ml EAL / 900ml distilled water), 3=Plant placed on water contaminated with effluent (15%

- 150ml EAL / 850ml distilled water), 4=Plant placed on water contaminated with effluent (20% - 200ml EAL / 800ml distilled water).

Values on the same column carrying different superscripts are significantly different ($p < 0.05$).

IV. DISCUSSION

The present study explicates the technique by which effluents from rubber production affects the biochemistry and physiology underlying the growth of *Zea mays*. The study is the first catalogued report on the biochemical and morphological response of corn to rubber effluent-contaminated soil. The physicochemical characteristics analysis suggested that the rubber effluents were found within the discharge limit prescribed by WHO and the soil is good to support the growth of corn while the experimental soil indicated that it is loamy sand.

Soil pollution and soil contamination leads to nutrients imbalance and also reduces mobility of soil nutrients [5] and this circumstances have shown a reduction in growth, performance and yield of the experimental plants. The SOD value of the leave reduced substantially following the increase in concentration of rubber effluent (Table 4.9). This could be due to difficulty in getting appropriate nutrient by the root of corn created by the rubber effluents contamination. Reduced soil aeration due to thin film layer formation on the top soil by the applied rubber effluent could have reduced the air passage through the soil pores, thereby leading to the inadequate air supply to the maize plants [6]. Factor like, low temperature, stable soil PH, helps the condition created by the rubber effluents may also be responsible for the increased lipid peroxidation products, MDA, of leaves, root and stem of experimental corn.

Corn planted in rubber effluents showed a significant increase in CAT activity in the leaves, root and stem respectively which resulted in increased lipid peroxidation and oxidative stress in the plant (Table 3.1,3.5.3.9). Plant stress may also lead to stomata closure, thereby reducing CO_2 availability in the leaves and inhibiting carbon fixation. This exposes the chloroplast to excessive excitation energy, which could in turn increase the generation of free radicals and induce oxidative stress [7]. The corn plant which is considered moderately drought tolerant might have inadequate ROS scavenging system in addition to other tolerance mechanisms to cope with stress.

There is still not much available information about the significance of some commonly analyzed enzymes as markers of stress reactions in plants. In several papers, it has demonstrated that some enzymes (like aminotransferases) can participate in plant stress reactions [8**]**. Thus, we focused our attention on the activity of alanine transaminase (ALT). Transaminases catalyze the transfer of the amino groups of amino acids to 2-oxoacids. In plants, transaminases participate very effectively in transformations of nitrogen compounds. They are important for the synthesis of amino acids from Oxo-acids in the citrate cycle and for other crucial biochemical pathways [9]. They also play key roles in the synthesis of secondary metabolites as well as chlorophyll. In roots, stem and leave respectively, ALT activities were increased during the experiments in comparison to control plants (Table 4.2, 4.8, 4.12). This increase corresponds well with the higher metabolic activity.

The activity of ascorbic acid (ASB) increased during the application of rubber effluent. This fact indicates that during the plant growth stage may involve the removal of free radicals through a system using ascorbic acid as an antioxidant by ascorbate. It has been demonstrated in corn leaves that a rise of the ascorbic acid-level group with an increase in flavonols is implicated in the degradation of H2O2[10]. This agrees ascorbic acid has also been described as being related to the ABA-gibberellin (GA) balance, implicated in seed germination [11]. In fact, an ABA increase with a concomitant decrease in GA produced a drop in ascorbic acid, keeping the seed dormant [12].

V. CONCLUSION

From the results, corn (Zea mays) responded to rubber effluent – contaminated soil, thereby affecting the biochemical and morphological properties of the plant and also altering the properties of the soil. Experimental evidence from this study further underscores the importance of caution when channeling run-off from industrial wastes to avoid contact with crops. I hereby recommend that the federal government should revisit the issue of waste management in our country, and farmers should be enlightened about the presence of rubber effluent in the water bodies. Also rubber production companies should treat their effluents that are generated during production processes very well before disposal.

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