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AN APPRAISAL OF THE EFFECTS OF DIFFERENT PETROLEUM CHEMICALS ON SELECTED FOOD CROP SEEDLINGS

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ABSTRACT

Effluence of agricultural lands with petroleum and allied substances is rife. The aim of this study was to appraise the influence of kerosene, diesel, engine oil and petrol-polluted soil at varying concentrations on the activities of plant enzymes, peroxidase, α-amylase and starch phosphorylase in selected crops (cowpea and maize seedlings). The results revealed that treatment of soil with petroleum chemicals decreased the activities of peroxidase, α-amylase and starch phosphorylase compared to their control values. Kerosene-treated soil inhibited the activities of the enzymes compared to the other petroleum chemicals. Similarly, cowpea seedlings exhibited pronounced negative response to the petroleum chemicals relative to maize seedlings.

Key words: Enzymes, Petroleum, Pollution, Seedlings, Soil

INTRODUCTION

Plant development is influenced by so many factors which could be exterior and interior-based resources [1]. Pollutants such as petroleum in the exterior environment lead to changes in the growth and physiology of plants. Petroleum compounds are rife and inundate plant's environment with highly toxic chemicals that are detrimental to their growth and overall metabolic activities [2, 3]. One toxic consequence of petroleum on plant is the depression of seed germination. Previous works reported that crude oil and its derivatives inhibited seed germination, a physiological process that is predicated on petroleum-stimulated decrease in available air, water and inhibition of soil enzymes [3, 4].

The biochemistry of plants are also affected in myriads of ways which include alteration in the production of pigments such as chlorophyll; alterations of metabolites such as glucose, total carbohydrate as well as proteins and amino acids; and alterations in plant enzyme activities [5,6], oxidative stress markers and other metabolic enzymes [7-9].

Crops cultivation is one major occupation of Niger Delta people. These crops are cultivated on polluted soil, thereby creating metabolic perturbations in these crops. Environmental imports of organic solvents (kerosene, diesel, engine oil and petrol) are scarce in literature and need to be given detailed treatment, hence, this study.

MATERIALS AND METHODS

Warri Refining and Petrochemical Company, Warri, Nigeria, supplied the petroleum solvents of known specific gravities (kerosene = 0.81; diesel = 0.85; engine oil=0.87; petrol = 0.75). Improved varieties of maize (*Zea mays*) and cowpea seedlings were supplied by Delta Agricultural Development Project (DTADP), Ibusa, Delta State, Nigeria and International Institute of Tropical Agriculture IITA, Ibadan, Nigeria, respectively. The physicochemical properties of the soil were published earlier [9].

The experiment was done in laboratory at conditions of temperature 28 °C and 12-hr day/night regime. Soil treatment and seed planting was done as described previously [10].

The extract for peroxidase activity was prepared as previously described [9]. Peroxidase activity was assayed as reported in Rani et al. [11]. Five pairs of the cotyledons of the germinated plants in each group were collected for amylase and phosphorylase activities of after four days germination. The enzyme, α-amylase, assay was done by the combined methods of Gupta et al [12] and Xiao et al [13]. Phosphorylase activity was evaluated according to the method of Singh and Steinnes [14].

RESULTS AND DISCUSSION

The activity of peroxidase wasreduced in the leaves of cowpea and maize seedlings grown in soil treated with refined petroleum chemicals (Table 1). Comparatively, higher concentrations of petroleum chemicals in soil inhibited peroxidase activity more relative to lower concentrations. Also, peroxidase activity was affected more by kerosene compared to petrol, diesel and engine oil. Peroxidases are a family of enzymes involved in a diversity of functions in plant, most especially cell wall elongation and growth [15]. This may be the basis why seedling exposed to petroleum hydrocarbon exhibited a retarded growth [3, 5].

Petroleum solvents in experimental soil altered the activities of α-amylase and starch phosphorylase in the cotyledons of cowpea as well as in maize seedlingsas observed afterfour days post sowing (Table 1).This observation agrees with earlier report of petroleum-induced changes in the activity of plant enzymes[16, 17]. The two enzymes, α-amylase and starch phosphorylase, are essential for mobilizing stored starch in plants to eventually produce acetyl CoA for thetricaboxylic acid cycle reaction, a pathway useful for aerobic energy production in living systems [18]. This implies that the inhibition of these enzymes could disturb respiratory activities of germinating cowpea and maize seedlings and predisposes the seedlings to a variety of metabolic problems [9, 16]. Most importantly, this study revealed the higher toxic potency of kerosenerelative to petrol, diesel and engine oil, which is due to the harmfulness of keroseneon soil enzymes [9]. Again, this study is similar to the report of Coskun and Zihnioglu [19] that showed that starchy seeds are less affected by toxicants than proteinous seeds.

CONCLUSION

Petroleum chemicals-mediated toxicity in exposed plants is achieved via inhibition of crucial metabolic enzymes such as starchphosphorylase, amylase and peroxidase activities in the seedlings. The harmfulness of kerosene is more severe than the other studied petroleum substances, namely, petrol, diesel and engine oil.

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Table 1: Peroxidase activities in leaves of cowpea (*Vignaunguiculata*) and maize (*Zea* mays) seedlings after four days of germination in soil treated with different concentrations of petroleum chemicals

	Peroxidase activities (Unit/min gfw)							
Concentration	Kerosene		Diesel		Engine oil		Petrol	
of petroleum chemicals in soil (% v/w ml/g)	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize
0.00	153 ± 6.0	147 ± 6.0	153 ± 6.0	147 ± 6.0	153 ± 6.0	147 ± 6.0	153 ± 6.0	147 ± 6.0
0.10	167 ± 15.0[bc]	140 ± 0.0[a]	183 ± 6.0[bc]	140 ± 0.0	210 ± 10.0 [c]	163 ± 6.6 [b]	213 ± 6.1[bc]	167 ± 6.2 [b]
0.25	147 ± 6.0 [ac]	103 ± 6.0 [a]	157 ± 6.0 [c]	110 ± 0.0 [a]	140 ± 14.0[a,c]	113 ± 6.1 [a]	170 ± 2.6[bc]	113 ± 6.5 [a]
0.50	140 ± 10.0 [a]	137 ± 6.0 [a]	163 ± 6.0[bc]	147 ± 6.0	170 ± 2.6[b]	163 ± 12.0 [b]	150 ± 10.0	153 ± 6.0
1.00	83 ± 6[a,d]	147 ± 25 [c]	117 ± 6.0[a,d]	163 ± 6.0[bc]	140 ± 0.00[a,d]	173 ± 12 [b]	113 ± 6[a,d]	160 ± 10 [b]
1.50	80.0 ± 0.00[a,d]	120 ± 10 [ac]	113 ± 12[a,d]	121 ± 17 [ac]	120 ± 1.86[a]	123 ± 6.0 [a]	110 ± 10[a,d]	130 ± 10 [ac]
2.00	80.0±0.00 [a]	77±60 [a]	113±11 [a]	100±0.00	117±6.8[a]	113 ± 6.4 [a]	87 ± 6 [a]	90 ± 10 [a]

[a] significantly lower at $p < 0.01$ compared to control. [b] Significant higher at $p < 0.01$ compare to control c = significantly higher when cowpea is compared to maize d = significantly lower when cowpea is compared to maize Results are expressed asmean $\pm$ SD; N=5 for each control and test.

Table 2: α-amylase activities in cotyledon of cowpea (*Vignaunguiculata*) and maize (*Zea mays*) seedlings after four days of germination in soil treated with different concentrations of petroleum chemicals.

Concentration of petroleum chemicals in soil (% v/w ml/g)	α-amylase activities (Unit/ ml)							
	Kerosene		Diesel		Engine oil		Petrol	
	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize
0.00	406.7 ± 1.5	405 ± 1.7	406.7 ± 1.5	405 ± 1.7	406.7 ± 1.5	405 ± 1.7	406.7 ± 1.5	405 ± 1.7
0.10	376 ± 2.6[a,d]	391.3 ± 1.5[a]	375.7 ± 4.0[a,d]	395 ± 1.7[a]	363.7 ± 20.6[a,d]	396.3 ± 0.6	374 ± 2.0[a,d]	398 ± 0.0[a]
0.25	352 ± 8.2[a,d]	384.3 ± 3.1[a]	357.3 ± 7.6[a,d]	385.3 ± 1.5[a]	366 ± 5.6[a,d]	394.3 ± 1.5	355.3 ± 7.6[a,d]	392 ± 1.5[a]
0.50	328 ± 19.3[a,d]	379 ± 4.6[a]	329 ± 19.9[a,d]	382.7 ± 1.2[a]	342 ± 11[a,d]	404.7 ± 1.2	395.3 ± 2.3	404 ± 2.6
1.00	292.7 ± 4.7[a]	353.7 ± 11.2[a]	301 ± 7.2[a,d]	373 ± 1.7[a]	339 ± 6.5[a,d]	390 ± 0.6[a]	302.3 ± 5.0[a,d]	387 ± 3.21[a]
1.50	267.3 ± 13.3[a,d]	329 ± 5.3[a]	273.3 ±13.4[a,d]	355 ± 1.0[a]	313 ± 14.1[a,d]	382 ± 2[a]	269 ± 12.5[a,d]	370 ± 7.6[a]
2.00	241.7 ± 3.5[a,d]	291 ± 8.1[a]	246 ± 5.8[a,d]	302 ± 2.5[a]	284.7 ± 6.0[a]	355.3 ± 4.5[a]	248 ± 6.2[a,d]	337 ± 9.2[a]

[a] significantly lower at $p < 0.01$ compared to control. [b] Significant higher at $p < 0.01$ compare to control c = significantly higher when cowpea is compared to maize d = significantly lower when cowpea is compared to maize. Results are expressed asmean ± SD; N=5 for each control and sample.

Table 3: Phosphorylase activities in cotyledon of cowpea (*Vignaunguiculata*) and maize (*Zea mays*) seedlings after four days of germination in soil treated with different concentrations of petroleum chemicals.

Concentration of petroleum chemicals in soil (% v/w ml/g)	Phosphorylase activities (mg/min gfw)							
	Kerosene		Diesel		Engine oil		Petrol	
	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize
0.00	3.6 ± 0.7	4.5 ± 0.6	3.6 ± 0.7	4.5 ± 0.6	3.6 ± 0.7	4.5 ± 0.6	3.6 ± 0.7	4.5 ± 0.6
0.10	2.7 ± 0.4^{a,d}	3.7± 0.8^{a}	2.9 ± 0.5^{b}	3.8 ± 0.8	3.5 ± 0.7	4.3 ± 0.6	3.2 ± 0.7	4.1 ± 0.3
0.25	1.8 ± 0.2^{a,d}	3.7± 0.1^{a}	2.1 ± 0.2^{a,b}	3.7 ± 0.2^{a}	2.8 ± 0.7^{a}	4.2 ± 0.5	2.5 ± 0.7^{a,d}	3.8 ± 0.3^{a}
0.50	1.2 ± 0.2^{a,d}	2.8± 0.2^{a}	2.6 ± 0.2^{a}	2.9 ± 0.2^{a}	3.1 ± 0.2	3.7 ± 0.1	2.8 ± 0.3^{a,d}	3.1 ± 0.3^{a}
1.00	1.2 ± 0.2^{a,d}	2.2± 0.2^{a}	1.8 ± 0.3^{a,d}	2.7 ± 0.2^{a}	2.7 ± 0.2^{a,d}	3.3 ± 0.2^{a}	1.9 ± 0.2^{a,d}	2.9 ± 0.3^{a}
1.50	1.2 ± 0.3^{a,d}	1.9± 0.2^{a}	1.4 ± 0.2^{a,d}	2.2 ± 0.3^{a}	2.2 ± 0.2^{a,d}	2.7 ± 0.3^{a}	1.9 ± 0.2^{a,d}	2.3 ± 0.3^{a}
2.00	1.0 ± 0.3^{a}	1.8± 0.2^{a}	1.1 ± 0.3^{a,d}	2.0 ± 0.2^{a}	2.0 ±0.1^{a,d}	1.9 ± 0.2^{a}	1.7 ± 0.1^{a,d}	2.2 ± 0.2^{a,b}

^{a}Significantly lower at $p < 0.01$ compared to control, ^{b} Significant higher at $p < 0.01$ when compared to control, c = significantly higher when cowpea is compared to maize, d = significantly lower when cowpea is compared to maize Results are expressed as mean ± SD; N=5 for each control and test.