



Effect of crude oil and palm bunch ash on maize growth

Emmanue Ogboma Dania*, Temitayo Fayehun, Osemhengbe Ruth Akhabue

Biochemistry Department, University of Benin Nigeria, Benin City, Nigeria

ARTICLE INFO

Article history:

Received 12 Aug 2016

Received in revised form 5 Sep 2016

Accepted 12 Sep 2016

Available online 19 Sep 2016

Keywords:

Crude oil

Palm bunch ash

Maize

Growth parameters

Contamination

ABSTRACT

Objective: To investigate the effect of different crude oil fractions (whole crude and water soluble fraction) at 2% contamination (98% distilled water) and the effect of 2 g of palm bunch ash (PBA) on the phytotoxicity of crude oil fraction on growth parameters such as percentage of seedling emergence, plant height, number of leaves, length of root, length of radical and leaf area in maize (*Zea mays*).

Methods: A total of 180 bags containing 500 g of loamy soil each were used for this study, of which 30 bags containing loamy soil each served as control, 60 bags of soil were added each 2% crude oil fraction and 60 bags of soil were added each 2% crude oil fraction and 2 g PBA each, while 30 bags of soil contained each 2 g of PBA only. The maize grown on the soil was harvested after 7, 14 and 21 days of seedling emergence and assessed for growth parameters.

Results: The growth parameters (plant height, length of root, length of radicle, number of leaves, and leaf area) in maize were significantly reduced in the crude oil fraction treatment ($P \leq 0.05$). The treatment containing PBA was found to have significant improvement compared to the crude oil fraction contaminated treatment.

Conclusions: The study has revealed the deleterious effect of crude oil at 2% on maize and its effect was ameliorated using PBA.

1. Introduction

Nigeria is one of the oil producing countries with exportation of crude oil being the mainstay of her economy[1]. Crude oil is a colloidal mixture of different hydrocarbons and non-hydrocarbon components. Crude oil pollution is an inevitable phenomenon in oil producing and consuming areas worldwide[2]. It stems from human error, accidental discharge and other sources[3]. The severity of oil pollution varies with the quantity, plant species, age of the plant, adequacy of the responses as well as other factors[4]. Crude oil poses serious threats to organisms and farmland[5]. Many studies have been carried out and reported the effect of crude oil on growth and performance of plants which makes the soil unsatisfactory for plant growth[6-8]. Although crude oil is immiscible with water, there is a small portion of it called the water soluble fraction (WSF) that can dissolve in water. The toxicity of this fraction has also been reported by Olubodun and Eriyamremu[1] at different percentages of contamination.

Palm bunch ash (PBA) is obtained from the empty fruit bunches

of *Elaeis guineensis* (Arecaceae). It has been reported that it mainly contains potassium carbonate and potassium hydroxide[9] and is recognized as a 100% organic fertilizer, serving as a cheap source of potassium oxide[10,11]. Research has been carried out on how bioremediation can be carried out naturally, or by the use of nutrients (organic or inorganic fertilizer) or by the use of chemical or mechanical means. Anderson *et al.*[12] and Onyelucheya *et al.*[10] reported that the rate of bioremediation varies with the soil and the kind of environment, compound to be degraded and concentration of the compound in the environment.

Maize (*Zea mays*) is a major staple food grown and consumed in Nigeria. It is grown in most agro-ecological areas, especially areas where oil industrial activities are predominant in the Niger Delta[13]. The effect of crude oil and its WSF on growth parameters like height, root length and leaf area of maize at various percentages of contamination has been reported by Olubodun and Eriyamremu[1]. Therefore, the aim of this study was to evaluate the phytotoxicity response of maize to crude oil and its WSF at 2% contamination and investigate the reduction in phytotoxicity following PBA stimulated remediation.

2. Materials and methods

Garden soil used for this study was collected from the Nursery Unit of the Department of Botany, University of Benin, Nigeria.

*Corresponding author: Emmanuel Ogboma Dania, Biochemistry Department, University of Benin Nigeria, Benin City, Nigeria.

Tel: +234 7036538201

E-mail: Emmainet@yahoo.com

The journal implements double-blind peer review practiced by specially invited international editorial board members.

The empty palm bunches were obtained from palm oil mill at Oluku in Ovia North East Local Government, Edo State. The crude oil was obtained from Warri Refining and Petrochemical Company, Warri, Delta State, Nigeria. The maize seeds were bought from Ediaken Market in Benin City and identified at the Department of Plant Biology and Biotechnology, University of Benin.

2.1. Methods

The maize seeds were placed in a beaker containing water and stirred. Those that did not float were regarded as viable seeds. The garden soil of pH 6.55 was weighed into 180 polythene bags with each bag containing 500 g of soil. A portion of the crude oil was fractionated by the method of Anderson *et al.*[12] into WSF and water insoluble fraction by putting 200 mL of crude oil and 400 mL of water in 1 L conical flask was constantly stirred for 48 h. The WSF was then obtained using separating funnel. The oil palm empty fruit bunches were sun-dried for one week before they were ashed in the oven at 100 °C and stored in air tight containers at room temperature.

2.2. Soil treatment

The soil was divided into six treatments with each treatment having 30 polythene bags with 500 g of soil (Table 1).

Whole crude (WC), WSF, whole crude and ash (WCA) and water soluble fraction and ash (WSFA) treatment were given 2% contamination using their respective fractions and 2 g of PBA was added to the soil of CA, WCA, and WSFA. The contamination of the soil was repeated twice per week and PBA was added to the appropriate treatment.

2.3. Planting seeds

Four viable seeds were sown in the soil bag with a depth of 1–2 cm. The time and number of seedling emerged from each were noted and the percentage of seedling emergence in each treatment was calculated. The emerged seedlings were harvested at Day 7, Day 14 and Day 21 to assess growth parameters. Data for each parameter were analyzed separately using One-way ANOVA followed by Duncan's multiple range test. $P \leq 0.05$ was considered statistically significant.

Table 1

The various treatments and the number of bag of soil for each.

Treatments	Number of bags	Contamination (%)	PBA (g)
Control	30	0	0
WC	30	2	0
WSF	30	2	0
CA	30	0	2
WCA	30	2	2
WSFA	30	2	2

CA: Control and ash.

3. Results

Contamination of the soil with crude oil and its fraction

significantly reduced all the growth indices measured by this study (Tables 2–5). Percentage of emergence of the maize seeds in crude oil contaminated soil (WC and WSF) decreased compared to the control with WC having the least value (Table 2). Plant height, number of leaves, leaf area, length of root and length of radicle were significantly affected by the oil treatment when compared with seedlings grown in the uncontaminated soil ($P \leq 0.05$).

Table 2

Effect of different fractions of crude oil contamination and PBA on maize germination.

Items	Control	WC	WSF	CA	WCA	WSFA
No. of seeds planted/bag	4	4	4	4	4	4
Percentage of seedling emergence	100	65	80	100	72	88

Table 3

Effect of different fractions of crude oil contamination and PBA on growth parameters of maize at Day 7 after germination.

Growth parameters	Control	WC	WSF	CA	WCA	WSFA
Plant height	33.0 ± 0.3 ^a	18.9 ± 0.2 ^b	21.3 ± 0.4 ^b	33.1 ± 0.1 ^a	23.0 ± 0.3 ^{ab}	26.0 ± 0.1 ^a
Number of leaves	3.0 ± 0.2 ^a	3.0 ± 0.1 ^a	3.0 ± 0.2 ^a	3.0 ± 0.4 ^a	3.0 ± 0.1 ^a	3.0 ± 0.4 ^a
Length of root	28.5 ± 0.1 ^a	17.0 ± 1.5 ^b	23.5 ± 0.3 ^{ab}	29.0 ± 0.1 ^a	21.5 ± 0.4 ^c	26.5 ± 1.2 ^c
Length of radicle	4.0 ± 1.1 ^a	3.9 ± 0.2 ^{ab}	3.9 ± 0.1 ^b	4.0 ± 1.2 ^a	4.0 ± 0.1 ^a	4.0 ± 1.7 ^a
Leaf area	41.0 ± 0.3 ^a	20.5 ± 0.6 ^b	25.2 ± 0.2 ^b	42.0 ± 0.5 ^a	28.5 ± 1.2 ^{ab}	32.0 ± 0.1 ^a

Each value is the mean of 10 replicates. Values in rows followed by the different letters are significantly different at $P \leq 0.05$ according to Duncan's multiple range tests.

Table 4

Effect of different fractions of crude oil contamination and PBA on growth parameters of maize at Day 14 after germination.

Growth parameters	Control	WC	WSF	CA	WCA	WSFA
Plant height	65.5 ± 0.8 ^a	37.1 ± 0.3 ^c	42.1 ± 0.5 ^c	66.0 ± 0.2 ^a	48.1 ± 1.1 ^{ab}	53.2 ± 0.5 ^a
Number of leaves	6.1 ± 0.2 ^a	5.8 ± 0.1 ^c	5.8 ± 0.1 ^{bc}	6.5 ± 0.3 ^a	6.0 ± 0.2 ^a	6.0 ± 0.2 ^a
Length of root	40.0 ± 1.2 ^a	25.2 ± 0.1 ^b	31.0 ± 1.1 ^b	41.1 ± 0.2 ^a	29.3 ± 1.0 ^c	33.1 ± 1.6 ^c
Length of radicle	4.9 ± 0.5 ^a	4.0 ± 0.3 ^{bc}	4.2 ± 0.1 ^{ab}	4.9 ± 1.8 ^a	4.6 ± 1.5 ^a	4.6 ± 3.0 ^{bc}
Leaf area	60.3 ± 1.5 ^a	43.2 ± 1.0 ^b	46.0 ± 0.1 ^b	64.1 ± 0.2 ^a	53.2 ± 0.1 ^{ab}	58.2 ± 0.3 ^b

Each value is the mean of 10 replicates. Values in rows followed by the different letters are significantly different at $P \leq 0.05$ according to Duncan's multiple range tests.

Table 5

Effect of different fractions of crude oil contamination and PBA on growth parameters of maize at Day 21 after germination.

Growth parameters	Control	WC	WSF	CA	WCA	WSFA
Plant height	76.1 ± 1.2 ^a	45.3 ± 1.5 ^b	54.0 ± 0.3 ^a	77.0 ± 1.1 ^a	62.2 ± 0.3 ^a	63.3 ± 1.8 ^a
Number of leaves	7.2 ± 0.1 ^a	5.9 ± 0.3 ^b	6.0 ± 0.1 ^a	7.0 ± 0.1 ^a	6.1 ± 0.2 ^{ab}	7.0 ± 0.3 ^a
Length of root	56.2 ± 0.5 ^a	39.1 ± 0.1 ^b	48.5 ± 1.2 ^b	56.0 ± 0.3 ^a	44.3 ± 1.5 ^c	53.1 ± 1.1 ^c
Length of radicle	8.1 ± 1.0 ^a	7.0 ± 3.1 ^b	7.5 ± 0.2 ^c	8.0 ± 1.2 ^a	7.9 ± 1.5 ^b	7.9 ± 0.2 ^a
Leaf area	73.1 ± 1.2 ^a	52.1 ± 0.1 ^b	55 ± 0.9 ^c	74.0 ± 1.0 ^a	62.3 ± 0.3 ^b	68.3 ± 0.2 ^a

Each value is the mean of 10 replicates. Values in rows followed by the different letters are significantly different at $P \leq 0.05$ according to Duncan's multiple range tests.

4. Discussion

The leaf number did not differ significantly in WC and WSF from the control 7 days post germination. However, in 14 and 21 days post germination, LN of maize in WC and WSF was significantly reduced compared to the control with WC having the lowest value. This same trend was observed in plant height, length of radicle, length of root and leaf area (Tables 4 and 5). Another visible symptom was the yellowness of leaves in WC and WSF treatment.

At 2% contamination, there was a negative effect on the growth parameters of maize.

The yellowness of leaves and reduction of growth parameters of the maize could be due to nutrient immobilization, as oil pollution has been reported to cause unavailability of essential nutrients to the young seedling[14]. The WSF also could have been absorbed alongside soil water, thereby accumulating in tissues such as chloroplast, xylem and phloem affecting the photosynthetic process and movement of essential materials in the plant[4]. This would have caused a general reduction in the growth parameters being considered by this study.

The effect of PBA in enhancing bioremediation of crude oil and its fraction on phytotoxicity shows that there is no significant difference in the number of leaves 7 days post germination in all treatment and control. In WCA and WSFA, there was a significant difference in plant height, length of root, length of radicle and leaf area compared to their corresponding treatment without PBA. In 14 and 21 days post germination, there was a consistent improvement in plant height, number of leaves, length of root, length of radicle and leaf area of toxic soil treated with PBA compared with crude oil treated soil only. The improvement in growth parameters of the maize was a result of improvement in soil condition following the application of PBA. The growth parameter of the CA treatment did not show any significant difference compared with the control. PBA has been reported to contain potassium carbonate and potassium hydroxide which have no toxic effect to the soil or maize[9]. Onyelucheya et al.[10] reported the specific growth rate of microbes increased with the addition of PBA at low level of contamination, hence the rate of breakdown of the crude oil and its fractions increased. Udoetok[15] reported that the presence of essential compounds such as phosphate, chloride, nitrate and sulphate in PBA could enhance the hydrocarbon degrading potential of hydrocarbon degraders in the soil.

The improvement in the growth parameters of maize as reported in this study is consistent with the previous report of improved germination and plant growth after remediation[16,17]. With the use of PBA enhanced preferential remediation[10], crude oil toxicity effect can be mitigated and crop cultivation is possible in exposed land. People living in underprivileged conditions, especially in Africa where there is a continuous incidence of crude oil contamination of the soil leading to low yield of maize, can improve their productivity by applying PBA to their contaminated farmland, which can be harnessed locally from their surroundings.

Conflict of interest statement

We declare that we have no conflict of interest.

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