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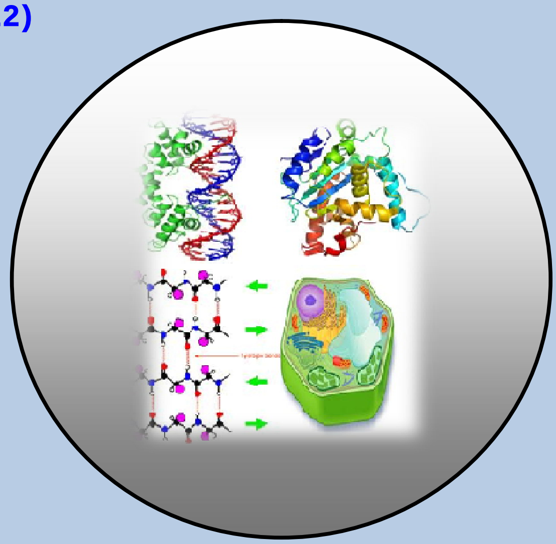

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RESEARCH PAPER

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Effects of Kerosene Contaminated Soil on the Growth of SoyaBean (*Glycine max* (L.) Merr.)

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ABSTRACT

The effects of kerosene contamination at various levels on the germination and growth of Soyabean were investigated in 2013 at the garden of the Department of Botany, Delta State University, Abraka. The levels of kerosene contamination used were 0.00, 0.68, 1.35, 2.03 and 2.70% (w/w). The experiment was laid out in a randomized complete block design with four replicates. The results indicated that kerosene contamination of soils significantly ($P \leq 0.05$) affected the growth parameters: germination percentage, days to 50% germination, rate of germination, plant height, number of leaves, leaf area, number of pods and biomass accumulation (fresh and dry weights) of the test plant- the effects being concentration dependent. A negative interaction existed between the level of the contaminant and the growth characteristics measured. This study has thus shown that soil contamination with kerosene has a highly significantly $P \leq 0.05$) effect of reducing the growth of Soyabean thereby posing a great threat to food security. The study also has a great implication in environmental management.
Keywords: Glycine max, Soil Contaminant, Kerosene, Germination Percentage and Growth Indices.

INTRODUCTION

Soyabean also called the miracle bean, golden bean, soy bean or soja bean is a native of China. It is an herbaceous annual crop belonging to the family of Fabaceae and a sub-family of Papilionaceae. Agbogidi, 2011 reported that Soyabean provides protein of high biological value and is very vital in soil improvement and management. Christo *et al.*, 2008 also noted that Soyabean is an excellent good livestock feed, perfect forage for ruminants and a commercial crops.

The Soyabean products we are familiar with in Delta State are the Soyabean flour and Soyabean milk which can be readily processed with domestic utensils. Soyabean oil and cake production require industrial machines and substantial capacity outlay (Agbogidi, 2011). Soyabean oil has many potential uses. The vegetable oil is used for cooking and baking cake. It is used in industrial products – soap, cosmetics, resins, plastics, inks, crayons, solvent and clothing. Soyabean oil is the primary source of biodiesel in the United States, accounting for 80% of domestic biodiesel production (National Biodiesel Board, 2008). Generally, the crop offers hope, nutrition, medicinal and economically devastating poor third countries. It grows in both tropical and sub-tropical temperate, and varies in growth and habit. The height of the plant varies from less than 0.2m to 2.0m. The pods, stems and leaves are covered with fine brown or grey hairs. The leaves are trifoliate, having three to four leaflets per leaf and leaflets are 6-15cm long and 2-7cm broad. The leaves fall before the seeds are matured. The inconspicuous, self fertile flowers are borne in the axils of leaf and are white, pink or purple. The fruit is a hairy pod that grows in clusters of 3 to 5, each pod is 3-8cm long, and usually contains 2 to 4 (rarely more) seeds 5-11mm in diameter. The hull of the matured bean is hard, water resistant and protects the cotyledon and hypocotyls from damage. The scar, visible in the seed coat is called hilium, and at one end of the hilium is the micropyle, or small opening in the seed coat which can allow the absorption of water for sprouting. Soyabean requires an optimum temperature of 26^0 to 30^{0C}. Low temperature tends to delay flowering. The time of planting is very important for most southern Guinea savanna, planting should be done from early June to early July, for northern Guinea and Sudan savanna, planting is from mid June to early July. In Nigeria, Soyabean performs well in the southern and Northern Guinea savanna were rainfall is above 700mm per annum. Harvesting of Soyabean should coincide with dry weather especially in the case of farmers who plant in August. Soyabean matures within 3and4 months after planting. Mechanical dryers or manual methods are used to harvest Soyabeans. The Soyabeans have been extensively used as important source protein and oil throughout the world. Dry Soyabean contain approximately 36-40% protein, 19% oil, 35% carbohydrate (17% of which are dietary fiber), 5% minerals and several other components including vitamins (Liu, 1997). Ngeze, 2000 reported that Soyabean is a good replacement for meat, egg, and milk due to its protein fat, mineral and starch content. Agbogidi *et al*., 2006 noted that Soyabean is a good source of protein in the prevention of malnutrition in children and perfect forage for ruminant animals. Agbogidi, 2011 also stated that Soyabean is an excellent good livestock feed and that some indigenous foods such as moi moi, akara, kunun, fura and other cereal foods can be enriched with Soyabean products including soy flour and soy paste etc while the soy paste can be used as egusi in preparing 'egusi soup'. Soyabean oil (19%) is characterized by relatively large amounts of polyunsaturated fatty acids (PUFA), that is, about 55% linoleic acid and about 8% α-linoleic acid of essential fatty acids (Messina, 1997). Linoleic acid renders Soyabean oil prone to rancidification due to the presence of lipoxygenases in Soyabean.

Ajay, 2011 reported that Soyabean oil contains triglycerides as the major component, and minor components are phospholipids collectively called lecithin, as well as phytosterol and tocopherols. Kerosene is a common and environmental pollutant not naturally found in the environment but large amounts are disposed into the environment when kerosene in domestic cooking stoves, lamp, and kerosene for burning rubbish are discharged into the environment; water drain, open vacant plots and farmland, thereby making the soil unsuitable for plant growth (Agbogidi *et al*., 2007, Agbogidi, 2010, Akpoveta *et al*., 2011, Ekpo *et al*., 2012). As a product of crude oil, kerosene pollution exerts significant effects on the biological, chemical and microbiological properties on soil thereby affecting plant growth development and yield of agricultural crop plants. The objective of the research was to evaluate the performance of Soyabean grown in kerosene contaminated soil with a view to determining the critical level where significant damage could be done.

MATERIAL AND METHODS

Study area

The experiment was conducted from 1st July to 24th September, 2013 at the local garden behind the Department of Botany Office, Site 2, Delta State University, Abraka, Delta State. Abraka is in Ethiope East Local Government Area of Delta State, Nigeria and is located at latitude 5^0 47'N and longitude 6^0 47' E of the equator, with an elevation of 21m. Abraka falls within the equatorial climate belt of the world, tropical rain forest zone and mangrove forest. The area is characterized by a mean annual rainfall of above 2323mm, annual temperature of 30^{0C}, relative humidity of 68% per annum, mean monthly rainfall from 25.8 mm in December to 628.9mm in September, soil temperature of 28^0c at 100m depth, soil pH ranging from 4.5 to 8, and mean monthly sunshine of 4.8 h. Dry season is from November to February, while the rainy season lasts for 8 months. Rainfall peaks in July and October (Abraka Meteorological Station, 2012). The Soyabean (Samsoy 1) seeds were obtained from the Agricultural Development Program (ADP) Office, Agbor, Delta State. The soil sample (top soil) was collected at surface depth (0-15cm) from a loamy soil land at site 2, Delta State University, Abraka, having no pollution history. Domestic petroleum kerosene (DPK) sample was obtained from Oando petroleum marketing station, Abraka, Delta State, Nigeria. The soil was air dried and then sieved to remove stones, roots and other materials that may be detrimental to emergence of plumule upon germination. The contamination of soil sample was done by thoroughly mixing 4kg of top soil with appropriate kerosene volumes to establish five treatments. Levels of kerosene contamination used were 0.00, 0.68, 1.35, 2.03 and 2.70% wet weight. Each level of treatment was filled in polypots measuring 25cm wide and 22.5cm deep, and the soil was up to a depth of 16cm. The polypots were perforated at the bottom to facilitate drainage. Two seeds were planted in each polypot. Prior to that, the seeds were first subjected to viability test for five minutes just before planting using the floatation method- involves the steeping of seeds in water in a container and the seeds that sank to the bottom were used.

The seeds were sown at 2cm depth. After sowing the soils were watered immediately to field capacity and afterwards, every other day in the absence of rainfall. The set up was monitored for 12 weeks after planting (WAP), while parameters were measured following the procedures of Ekpo *et al*. 2012, Olayinka and Arinde 2012 and Agbogidi and Ilondu 2013. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicates. There were three samples for each treatment, a total of 15 polypots in each replicate, and total of 45 polypots in the experimental field. Germination records were taken in each polypot containing the different treatments levels up to 12 days after sowing (DAS). First germination was observed (in the control) 3 days after sowing. Germination percentage was calculated thus;

$$\text{\% Germination} = \frac{\text{number of seeds germinated}}{\text{number of seeds sown}} \times \frac{100}{1}$$

This procedure followed that of Vwioko and Fashemi, 2005, Olayinka and Arinde, 2012, Ekpo *et al*., 2012 and Agbogidi and Ilondu, 2013. Seeds which failed to sprout within the 12 days period were regarded as haven not germinated. At the end of the germination test, seedlings were thinned to one per polypot at 2 weeks after sowing (WAS). Readings were taken on growth and morphology based on the following parameters: percentage germination, days to 50% seedling emergence, rate of germination, plant height, number of leaves, leaf area number of pods and biomass accumulation (fresh and dry weight). Days of seedling emergence were calculated by counting from the day of sowing to the day of plumule emergence while the rate of germination was calculated based on when 50% of the seeds planted germinated. The height (cm) of the plant was measured from the soil surface to the terminal bud using a meter rule. The number of leaves in a seedling per polypot per treatment was determined by visual counting. The leaf area (cm^2) was determined by measuring, using a meter rule, the length and breadth of the leaf, and was used to multiply the correction factor (0.75) and the total number of leaves. The fresh weights (g) of the roots, stems, leaves were measured using a triple beam balance. The dry weight (g) was measured also by the electronic weighing balance after they had been air dried for two days, thereafter, oven dried at 60^{0C} for 25 hours until a constant weight was achieved following the procedure of Agbogidi, 2011. The weights of the pods were also taken. Data collected were subjected to analysis of variance (ANOVA) and the significant means were separated with the Duncan's multiple range tests using the statistical analytical system (SAS, 2005).

RESULTS AND DISCUSSION

Results of germination characteristics of Soyabean as affected by kerosene are presented in Table 1. Seeds sown in the uncontaminated soil (0.00w/w) had 100% germination and this value differed significantly ($P \leq 0.05$) from seeds sown (in soil contaminated with kerosene. 83.33% (0.68 w/w), 50:00% (1.35% w/w), 43.33% (2.03% w/w) and 0.00% (2.70% w/w).

This result indicates that % germination of the test seeds was kerosene concentration-dependent. This finding is in harmony with earlier reports of Agbogidi, 2011 and Ekpo *et al.,* 2012 using spent lubricating oil and crude oil respectively. Data on days to 50% germination and rate of germination of Soyabean seeds in kerosene contaminated soils are presented in Table 1. It took the seeds planted in the control plots 3-4 days to germinate and 6-7 days for seeds grown in kerosene treated soils to emerge. This observation showed that kerosene in soil delayed and depressed seed germination as evident by the significant decrease (Table 1). In the same vein, the rate of germination was also significantly affected. All the Soyabean seeds grown in the control plots emerged while only one seed sprouted in plots treated with 1.35 and 2.03% w/w of the contaminant. No seeds sown in 2.70% w/w germinated (Table 1.).

Results on the growth indices (plant height, number of leaves, leaf area, number of pods, fresh and dry weights of Soyabean grown in kerosene contaminated soil are presented in Tables 2, 3, 4 and 5 respectively. Similarly, the fresh and dry weight biomasses of Soyabean as regards tissues as affected by different levels of kerosene contaminated soil are presented in Tables 6 and 7 respectively. The response of the plant to the contaminant is kerosene-dose-dependent. A negative relationship was observed ie, the lower the concentration of the kerosene in soil, the better the performance of the plant. Significant ($P \leq 0.05$) reductions were noticed with increasing level of soil contaminant. For example, while 46.9cm was recorded as the means plant height for Soyabean seedlings grown in the control, as low as 20.3cm was obtained for seedlings sown in 2.03% w/w of the kerosene treated soil (Table 2). Similarly, 38.6cm^2 was obtained for leaf area grown from the kerosene untreated plants while 14.3cm^2 was recorded for seeds germinated from 2.03% w/w of the kerosene (Table 4).The number of pods, fresh weight and dry weight biomass also followed the same trend as in plant height, number of leaves and leaf area. The results indicated that soil contaminated with kerosene has an acute effect on germination and growth parameters of Soyabean. The observed reduced or absence of germination, and depressed germination could be attributed to one or a combination of the following: presence of volatile oil components that have been shown to have adverse inhibitory effects on germination. There could have been a disruption of the soil-water relationships following kerosene application to soil, endangerment of seed embryo thereby affecting vital metabolic processes, a disruption in the gaseous exchange between the atmosphere and soil following blockage, thereby delaying seedling emergence. This finding is in conformity with prior reports of Anoliefo and Vwioko, 2001, Agbogidi *et al.,* 2006, Adeduku and Ataga, 2007, Ekpo *et al*., 2012, Agbogidi and Ilondu, 2013. The observed significant reduction in the growth characteristics including plant height, number of leaves, leaf area, number of pods and fresh and dry weight biomass could be attributed to the kerosene adulterated soil which could be resulted in nutrient immobilization, presence of heavy metals, toxic effects of the oil components thereby resulting in metabolic dysfunctions in plants which could have reduced photosynthesis. The accumulation of heavy metals has been shown to affect biological, physical, chemical and microbiological components of soil in various ways.

Besides, the phytotoxic and herbicidal properties of petroleum and its refined products on biota have been widely reported by Anoliefo and Edegbai, 2000, Agbogidi and Eshegbeyi, 2006, Agbogidi *et al.,* 2007, Bamidele *et al.,* 2007, Akpoveta *et al.,* 2011, Olayinka and Arinde, 2012 and Agbogidi and Ilondu, 2013.

Table 1. Germination indices of Soyabean as affected by kerosene in soil.

Kerosene level %w/w	Percentage germination (%)
100.00[a]	
83.33[b]	
50.00[c]	
43.33[d]	
0.00[e]	
	Days to germination (days)
4.0[d]	
5.7[c]	
6.3[b]	
7.0[a]	
0.0[e]	
	Rate of germination
3.0[a]	
3.0[a]	
2.5[b]	
2.0[b]	
2.70	0.0[c]

Means with different letters are significantly different at P≤ 0.05 using the Duncan's multiple range tests.

Table 2. Plant height (cm) of Soyabean as affected by different levels of kerosene contaminated soil.

Kerosene in soil % (w/w)	Weeks after planting/plant height						
	2	**4**	**6**	**8**	**10**	**12**	**Means**
0.00	14.5	24.1	40.8	55.7	72.3	74.3	46.9[a]
0.68	10.7	17.8	26.3	38.6	50.6	57.0	33.5[b]
1.35	10.9	13.3	22.1	35.3	37.0	42.3	26.8[c]
2.03	9.2	10.6	16.6	26.2	29.0	30.8	20.3[d]
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0 [e]

Means with different alphabets within the same column are significantly different at P≤0.05 using the Duncan's multiple range tests.

Table 3. Number of leaves of Soyabean as affected by different levels of kerosene contaminated soil.

Kerosene in soil % (w/w)	Weeks after planting/number of leaves						Means
	2	**4**	**6**	**8**	**10**	**12**	
0.00	4.3	9.3	19.7	29.8	32.3	31.6	22.4^{a}
0.68	2.7	7.7	12.0	18.1	20.6	20.7	13.6^{b}
1.35	2.0	6.3	11.0	14.3	14.6	16.7	10.8^{c}
2.03	1.3	2.7	9.5	9.8	16.3	17.0	9.4^{d}
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0^{e}

Means with different alphabets within the same column are significantly different at the P≤0.05 Duncan's multiple range tests

Table 4. Leaf area (cm^2) of Soyabean as affected by different levels of kerosene contaminated soil.

Kerosene in soil % (w/w)	Weeks after planting/number of leaves						Means
	2	**4**	**6**	**8**	**10**	**12**	
0.00	12.9	26.6	39.9	48.2	50.9	53.1	38.6^{a}
0.68	8.9	11.2	23.3	29.8	33.5	32.9	23.3^{b}
1.35	9.3	10.1	18.1	21.6	25.5	25.4	10.8^{c}
2.03	7.0	7.8	13.1	17.3	21.2	19.3	14.3^{d}
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0^{e}

Means with different alphabets within the same column are significantly different at P≤0.05 using the Duncan's multiple range tests.

Table 5. Number of pods and fresh and dry weights of Soyabean as affected by different levels of kerosene contaminated soil.

Kerosene in soil % (w/w)	Number of pods	Fresh weight	: Dry weight
0.00	10.2a	11.2^{a}	5.1^{a}
0.68	4.9^{b}	5.6^{b}	2.1^{b}
1.35	4.3^{c}	4.7 ^{c}	1.7^{c}
2.03	2.6^{d}	2.2 ^{d}	0.5^{d}
2.70	0.0^{e}	0.0^{e}	0.0^{e}

Means with different alphabets within the same column are significantly different at P≤0.05 using the Duncan's multiple range tests.

Table 6. Fresh weight (g) of Soyabean as affected by different levels of kerosene contaminated soil.

Kerosene in soil % (w/w)	Fresh weight/plant parts			
	Roots	**Stems**	**Leaves**	**Means**
0.00	3.1	10.3	16.7	10.0[a]
0.68	1.9	6.3	11.0	6.4[b]
1.35	3.3	7.1	13.0	7.8[c]
2.03	1.9	6.6	6.3	4.9[d]
2.70	0.0	0.0	0.0	0.0[e]

Means with different alphabets within the same column are significantly different at $P \leq 0.05$ using the Duncan's multiple range tests.

Table 7. Dry weight (g) of Soyabean as affected by different levels of kerosene contaminated soil.

Kerosene in soil % (w/w)	Dry weight/plant parts			
	Roots	**Stems**	**Leaves**	**Means**
0.00	0.9	3.1	4.6	3.5[a]
0.68	0.4	1.8	1.8	1.5[b]
1.35	0.5	1.7	3.2	1.8[c]
2.03	0.4	0.9	1.3	0.8[d]
2.70	0.0	0.0	0.0	0.0[e]

Means with different alphabets within the same column are significantly different at $P \leq 0.05$ using the Duncan multiple range test.

CONCLUSION

The present study has demonstrated that soil contamination with kerosene has a highly significant effect of reducing the growth of Soyabean – the effect being concentration dependent. The study also has a great implication in environmental management and food security.

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