EFFECTS OF INDUSTRIAL EFFLUENTS AND FERTILIZER APPLICATIONS ON THE GROWTH, YIELD AND NUTRITIONAL QUALITY OF SUNFLOWER

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ABSTRACT

A field experiment was conducted in south-western Nigeria to determine the effects of different fertilizer applications on the growth performance of sunflower when cultivated in an Alfisols contaminated with effluents from a paints industry. This was with a view to assessing the yield and nutrient quality of harvested sunflower grains. It was a randomised complete block design with three fertilizer applications [300 kg ha^{-1} of NPK 20-10-10 (IOF) ; 10,000 kg ha^{-1} of organomineral fertilizer (OMF) and control (CT)] ; and each was replicated thrice on the factory effluents impacted and un-impacted soils. At 10 weeks after planting, highest sunflower growth reduction rate (number of leaves 19.6 % ; plant height 3.9 % and stem girth 7.5 %) was obtained with OMF application when the impacted and un-impacted soils were compared. The highest mean yield of 1.17 t ha^{-1} obtained with OMF was not significantly ($p < 0.05$) higher than 0.80 t ha^{-1} obtained with IOF application, but significantly ($p < 0.05$) higher than 0.63 t ha^{-1} obtained in the controls with zero fertilizer application. The un-impacted plots gave comparable but higher mean yields of sunflower. Highest concentrations of the nutrient elements and heavy metals were obtained in the grains of sunflower when OMF was applied. The results indicated that the quantity and quality of sunflower grains harvested from factory effluents impacted soil with or without fertilizer application were adversely affected ; hence cultivation of similar impacted soils with edible crops should be discouraged.

Keywords : Factory effluent, fertilizer, Nigeria, nutrient quality, paint industry, sunflower.

RESUME

EFFETS DES EFFLUENTS D'INDUSTRIE ET DES APPORTS D'ENGRAIS SUR LE DEVELOPPEMENT, LE RENDEMENT ET LA QUALITE NUTRITIONNELLE DU TOURNESOL

Une expérience de terrain a été menée dans le sud ouest du Nigeria afin de déterminer les effets des différentes applications d'engrais sur les performances de croissance de tournesol lorsqu'elles sont cultivées dans un Alfisols contaminés par les effluents d'une industrie de la peinture. Ceci en vue d'évaluer la qualité et le rendement des éléments nutritifs des grains de tournesols récoltés. C'était un plan en blocs aléatoires complets avec trois applications d'engrais [300 kg ha^{-1} du NPK 20-10-10 (OIF), 10 000 kg ha^{-1} d'engrais organo-minéral (OMF) et de contrôle (CT)], et chacun a été reproduit trois fois sur les effluents des usines touchées et les sols non affectés. A 10 semaines après la plantation, le taux de réduction de la croissance de tournesol le plus élevé (nombre de feuilles de 19,6 % ; hauteur de la plante de 3,9 % et la circonférence de la tige de 7,5 %) a été obtenu avec une application OMF lorsque les sols contaminés et non touchés ont été comparés. Le rendement moyen le plus élevé de 1,17 t ha^{-1} obtenu avec OMF n'a pas été significativement ($p < 0,05$) plus élevé que 0,80 t ha^{-1} obtenu avec l'application IOF, mais de façon significative ($p < 0,05$) plus élevé que 0,63 t ha^{-1} obtenu dans les contrôles avec l'application d'engrais zéro. Les parcelles non touchées ont donné des rendements moyens comparables, mais plus élevé de tournesol. Les plus fortes concentrations d'éléments nutritifs et de métaux lourds ont été obtenues dans les grains de tournesol lorsque OMF a été appliquée. Les résultats indiquent que la quantité et la qualité des grains de tournesol récoltés à partir des sols contaminés par les effluents de l'usine avec ou sans application d'engrais ont été affectées, d'où la culture des sols contaminés similaires avec des cultures comestibles devrait ne plus être encouragée.

Mots-clés : *Usine d'effluents, engrais, Nigeria, qualité nutritive, industrie de la peinture, tourneso.*

INTRODUCTION

The cultivable sunflower (*Helianthus annuus* L.), is a member of the Compositae family originated from North America and spread around the world (Putnam *et al.,* 1990). It grows well on a sandy loam soil and thrives better in the dry than wet seasons (Ogunremi, 1988). In addition to the industrial importance of sunflower (Ogunremi, 1988), it has a phytoremediating ability of the inorganic (Dushenkov *et al.,* 1995) and organic (Ahmed-Danfulani, 2013) related polluted soils. There is increase in soil pollution, but little attention is paid to these polluted sites, especially in the humid tropics of Africa. Presently in Nigeria, there is increase in peri-urban agriculture (Oke *et al.,* 2011) for subsistence, mostly practiced by the small farmers regardless to the soil quality.

In Nigeria, when tonnes of finished products and monetary gains are declared by process industries, no information is given on the industrial effluents they generate. These untreated effluents and other solid wastes are most often dumped into the vacant land at the back of the factory (Adewole *et al.,* 2010). Many of these polluted sites are being cultivated to food crops by the subsistence farmers living around these factories. Crops such as vegetables, cereals and legumes that are cultivated in these contaminated sites are consumed either raw or cooked. There is the possibility of the plant roots to intercept and absorb the mobile pollutants that can be translocated to other parts of the plants, especially in sunflower. Etagene (1999) obtained 5.675 mg Pb kg^{-1} (dry weight) using 20 t ha^{-1} of organic manure while Awotoye *et al.* (2009) obtained 0.11 mg Cd kg^{-1} and 0.29 mg Pb kg^{-1} (dry weight) using *Glomus intraradices*, an arbuscular mycorrhizal as soil conditioners in the shoot of sunflower. Therefore, sunflower consumption could induce adverse effects on the human health.

Despite several phytoremediation studies on sunflower, very little information is avalable on the plant health and the quality of harvested seeds of sunflower. There is a dearth of information on the morphological characteristics of sunflower when cultivated on wastewater contaminated sites in Nigeria. The study was therefore conducted to determine the growth response, yield and quality of sunflower seeds from a contaminated *Alfisols* with wastewater from paints industry when organomineral (grade A) and inorganic fertilizers were applied.

MATERIALS AND METHODS

LOCATION OF THE STUDY AND EXPERIMENTAL DESIGN

The experiment was conducted on a sandy loam *Alfisols* during the wet season of 2000 on a manually cleared piece of land at Eleyele, Ibadan, (07º25.254'N ; 003º34.625´E, 214 m above sea level) in Nigeria, on the cantonment of a paints industry. Viable seeds of sunflower were obtained from the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria. The plot of land was believed to have been polluted with effluents from this factory for over forty years. The fertilizers were purchased at a local market in Ibadan, Nigeria.

The two sets of experimental sites, labelled A and B were manually cleared twice, and each covering an area of 91.0 m^2. The impacted experimental site A consisted of three blocks of 13 m x 2 m dimensions ; each block was in turn divided into three plots of 4 m x 2 m with an alley of 0.5 m between blocks and 0.5 m within plots. The impacted site had a total of nine plots laid out in a completely randomised block design of three treatments in three replications. A similar design was applied for the un-impacted experimental site B within the factory cantonment at 10 metres away in the opposite direction of the industrial effluent flow. The treatments consisted of the following : (a) 300 kg ha^{-1} of NPK 20-10-10, (b) 10 000 kg ha^{-1} of organomineral fertilizer (OMF) and (c) control, without fertilizer application. The OMF contains 44.2 g N kg^{-1}, 5.0 g P kg^{-1} and 1.5 g K kg^{-1}.

Seeds of sunflower were planted at four per hole, spaced by 60 cm × 30 cm. The seedlings were thinned to two seeds per hole at 2 weeks after planting (WAP) to give a plant density of 112 stands per plot. The plots were manually weeded two times (2 and 5 WAP) with hand-held hoe. Fertilizer treatments were applied 2 WAP, using a band fertilizer application method at 5 cm away from the plant. Plant growth parameters such as number of leaves, plant height and stem girth were measured at 2, 4, 6, 8 and 10 WAP. The sunflower heads were manually harvested at 16 WAP, air-dried for two weeks, hand-threshed to recover the sunflower seeds and weighed. A repeat experiment was conducted on the same plots (impacted A and un-impacted B) of land during the dry season of 2000.

SOIL SAMPLING AND SAMPLE ANALYSES

Using random sampling technique, three composite surface (0 - 15 cm depth) soil samples per experimental set-up were collected with hand auger from the cleared farmland. The pre-planting soil samples were air-dried for 7 days, sieved through a 2-mm mesh and analysed for native soil physical and chemical properties using the standard methods of soil laboratory analysis : The soil pH was electrometrically determined (McLean, 1982) ; the particle size analysis of the soil was determined using hydrometer method in 5 % sodium hexametaphosphate as outlined by Bouyoucos (1951) ; soil nitrogen and available phosphorus were determined by Kjeldahl method (Bremner and Mulvaney, 1982) and Olsen and Sommers (1982) respectively. The organic carbon concentration in soil was determined using Walkley-Black wet oxidation method (Nelson and Sommers, 1982).

Calcium ions and Mg^{2+} were determined using 1 M NH_4OAc (ammonium acetate) buffered at pH 7.0 as the extractant (Thomas, 1982) and their concentrations in the soil extracts were measured using a Perkin-Elmer Model 403 (Shelton, Connecticut, USA) Atomic Absorption Spectrophotometer (AAS). The micronutrient (Mn, Fe and Cu) were extracted with 0.1 M HCl while Pb and Cd were extracted with 5 ml of the mixture (conc. HNO_3 and conc. $HClO_4$ in the ratio 2:1) with 5 ml of conc. H_2SO_4 (Juo, 1979) and their concentrations in the soil extracts were read using an AAS. The mean values of selected soil properties before planting in the wet and dry seasons of 2000 are presented in Table 1.

GRAIN SAMPLING AND SAMPLE ANALYSES

Three representative composite samples of air-dried sunflower grains of about 5.0 g from the harvested lots were taken from each of the fertilizer treatment in sites A and B for analysis. Total nitrogen in the grain samples was determined using micro Kjeldahl method (Bremner and Mulvaney, 1982). Concentrated $HClO_4$ and HNO_3 mixed (5 ml) in the ratio 1:2 was used to digest 0.2 g of each grain sample for 2 h at 150° C using a Tecator block digestor (Odu *et al.,* 1986). Concentrations of Ca, Mn, Fe and Cu in each grain digest were read using AAS. Also, Pb and Cd extracts from the sunflower grains were obtained using 5 ml of the mixture (conc. HNO_3 and conc. $HClO_4$ in the ratio 2:1) with 5 ml of conc. H_2SO_4 (Juo, 1979) and their concentrations were read using AAS.

Table 1 : Mean values of selected soil properties of the experimental sites before planting (wet and dry seasons).

Valeurs moyennes des propriétés de sol des sites d'expérimentation avant le semis (saisons puvieuse et sèche)..

Property	Value	
	Site A	Site B
pH (1:1 soil-water)	6.55	6.97
Organic carbon (g kg^{-1})	4.42	4.45
Total nitrogen (g kg^{-1})	0.92	0.80
Available phosphorus (mg kg^{-1})	29.73	23.25
Ca^{++} (cmol kg^{-1})	1.65	1.12
Mg^{++} (cmol kg^{-1})	1.00	0.76
Fe (mg kg^{-1})	103.41	86.25
Mn (mg kg^{-1})	74.57	55.69
Cu (mg kg^{-1})	4.79	0.35
Pb (mg kg^{-1})	144.27	1.49
Cd (mg kg^{-1})	21.74	0.05
Textural class	Sandy loam	Sandy loam

Legend : Site A = Impacted site / Site B =Un-impacted site.

SELECTED WEATHER PARAMETERS

The selected monthly mean weather (surface soil temperature, rainfall, relative humidity and solar radiation) data collected from the Federal Department of Meteorological Services, Air Force Base, Samonda, Ibadan, Nigeria during the cropping periods in 2000 are presented in Table 2.

STATISTICAL ANALYSIS

Growth parameters and yield of the test crop were subjected to SAS system statistical analysis for analysis of variance and Duncan's Multiple Range Test at 5 % probability to test the degree of significance among the treatments. Data on nutrient and heavy metal contents of the harvested grains of sunflower were subjected to descriptive analysis.

Table 2 : Selected monthly mean weather parameters during the wet and dry seasons cultivation of sunflower in 2000.

Moyennes annuelles des paramètres climatiques durant les saisons pluvieuse et sèche de la culture de tournesol en 2000.

Month	Soil surface temperature (°C)	Rainfall (mm)	Relative humidity (%)	Solar radiation (Wm^{-2})
January	30.2	0.0	73.0	144.2
February	31.5	9.5	57.0	147.5
March	32.6	30.7	73.0	213.8
April	31.1	78.3	75.0	165.8
May	29.9	232.6	78.0	152.5
June	28.2	245.1	83.0	146.2
July	26.5	200.5	87.0	167.9
August	24.3	70.7	89.0	243.5
September	25.2	373.0	86.0	167.8
October	27.1	127.2	83.0	215.5
November	30.0	0.0	77.0	233.7
December	30.5	0.0	76.0	187.4

Source : Department of Meteorological Services, Air Force Base, Samonda, Ibadan.

RESULTS

EFFECTS OF FACTORY EFFLUENTS ON THE SOIL PHYSICAL AND CHEMICAL CHARACTERISTICS

The soil texture of the two sites was sandy loam. The mean soil pH (1:1 soil 1 M KCl) of the impacted site A was 6.55, indicating a slightly acidic soil condition. Some of the other mean values were : total nitrogen, 0.92 g kg^{-1} ; organic carbon, 4.42 g kg^{-1} and available phosphorus, 29.73 mg kg^{-1}. The values obtained for Cu, Pb and Cd were 4.79, 144.27 and 21.74 mg kg^{-1}. However, for the un-impacted site B, the mean soil pH (1:1 soil : 1 M KCl) was 6.97, indicating a relatively neutral soil condition. Except for organic carbon (4.45 g kg^{-1}) that was comparable with impacted site A, other nutrient elements and the heavy metals were much lower (Table 1).

EFFECTS OF FERTILIZER TREATMENTS ON THE GROWTH OF SUNFLOWER IN THE IMPACTED SITE A

There were no significant ($p > 0.05$) differences in the number of leaves, heights and stem girths of sunflower at 2 and 4 WAP despite the application of fertilizers. However, at 6 WAP in the impacted site A, the growth performance (number of leaves: 19.3 ; plant height : 52.1 cm and stem girth : 1.8 cm) obtained from zero fertilizer application was significantly ($p < 0.05$) lower than those obtained with the OMF (number of leaves : 21.7 ; plant height : 61.6 cm and stem girth : 2.3 cm) and IOF (number of leaves : 21.0 ; plant height : 62.6 cm and stem girth : 2.3 cm) applications (Table 3). Comparatively, similar trends were observed at 8 and 10 WAP.

Table 3 : Percent reduction in the selected growth parameters (number of leaves, plant height and stem girth) of sunflower as affected by fertilizer treatments and soil contamination.

Pourcentage de réduction des paramètres de croissance (nombre de feuilles, hauteur du plant, circonférence de la tige) du tournesol en fonction des traitements d'engrais et de la contamination du sol.

Treatment	2		4		6		8		10	
	WAP									
	A	B	A	B	A	B	A	B	A	B
Number of leaves										
OMF	5.7ns	5.8ns	10.7ns	10.7ns	21.7a	27.6a	24.7a	32.3a	28.3a	35.2a
					(21.4 %)		(23.5 %)		(19.6 %)	
IOF	5.7ns	6.8ns	12.3ns	12.4ns	21.0a	21.2b	23.0a	26.1b	27.0a	27.9b
					(1.1 %)		(11.9 %)		(3.2 %)	
CT	6.3ns	5.8ns	11.3ns	10.7ns	19.3b	20.0b	19.7b	22.3c	22.7b	23.1c
					(3.5 %)		(1.7 %)		(1.7 %)	
Plant height (cm)										
OMF	5.5ns	5.6ns	28.6ns	30.2ns	61.6a	68.4a	134.1a	145.0a	167.3a	173.0a
					(9.9 %)		(7.5 %)		(3.9 %)	
IOF	5.3ns	5.6ns	24.5ns	30.3ns	62.6a	63.0a	131.1a	137.3b	165.4a	170.3a
					(0.6 %)		(4.5 %)		(2.9 %)	
CT	5.0ns	5.5ns	29.7ns	30.2ns	52.1b	53.3b	95.1b	95.1c	121.1b	123.6b
					(2.3 %)		(0 %)		(2.0 %)	
Stem girth (cm)										
OMF	0.9ns	0.9ns	1.3ns	1.5ns	2.3a	3.1ns	6.3a	7.3a	7.4a	8.0a
					(25.8 %)		(13.7 %)		(7.5 %)	
IOF	0.9ns	0.9ns	1.2ns	1.5ns	2.3a	3.0ns	6.8a	6.9a	7.3a	7.5a
					(23.3 %)		(1.4 %)		(2.7 %)	
CT	0.9ns	0.9ns	1.1ns	1.2ns	1.8b	2.5ns	3.9b	3.9b	4.3b	4.3b
					(28.0 %)		(0 %)		(0 %)	

Means with the same letter(s) down the column are not significantly different at $p < 0.05$.
Les moyennes suivies de la même lettre dans la même colonne ne sont pas significativement différentes à p < 0.05.
Legend :
OMF = 10,000 kg ha^{-1} of organomineral fertilizer ; IOF = 300 kg ha^{-1} of NPK 20-10-10 ; CT = Control treatment ; A = Impacted site ; B = Un-impacted site.
Values in parenthesis are reductions (in %) of growth parameters.

EFFECTS OF FERTILIZER TREATMENTS ON THE GROWTH OF SUNFLOWER IN THE UN-IMPACTED SITE B

In the un-impacted site B, significantly ($p < 0.05$) lower value was obtained only in the plant height at 6 WAP. However, at 8 WAP, the growth performance (number of leaves : 22.3 ; plant height : 95.1 cm and stem girth : 3.9 cm) from zero fertilizer application was significantly ($p < 0.05$) lower than those obtained with the OMF (number of leaves : 32.3 ; plant height : 145.0 cm and stem girth : 7.3 cm) and IOF (number of leaves : 26.1 ; plant height : 137.3 cm and stem girth : 6.9 cm) applications (Table 3). Comparatively, similar trends were observed at 10 WAP.

EFFECTS OF FERTILIZER APPLICATIONS AND SEASONAL VARIATION ON YIELD OF SUNFLOWER

In the wet season, the highest mean yield (1.17 t ha^{-1}) of sunflower grains obtained with 10 t ha^{-1} OMF was not significantly higher than 0.80 t ha^{-1} obtained with 0.30 t ha^{-1} IOF applications, but significantly ($p < 0.05$) higher than the mean yield, 0.63 t ha^{-1} obtained with zero fertilizer application (Table 4) from the impacted site A. The un-impacted site B by the factory effluents produced the higher yields of sunflower grains. During the same period, the highest mean yield (1.65 t ha^{-1}) of sunflower grains obtained with 10 t ha^{-1} OMF was not significantly higher than 1.45 t ha^{-1} obtained with

0.30 t ha^{-1} IOF applications, but significantly ($p < 0.05$) higher than the yield, 0.84 t ha^{-1} obtained with zero fertilizer application (Table 4) from the un-impacted site B. Higher yields of sunflower grains were obtained during the dry season.

Table 4 : Mean yield (t ha^{-1}) of sunflower grain from experimental sites A and B.

Rendement moyen des graines (t ha^{-1}) de tournesol obtenu sur les sites expérimentaux A et B.

Treatment	Site A		Site B	
	Wet	Dry	Wet	Dry
OMF	1.17a	1.20a	1.65a	1.92a
IOF	0.80a	1.02a	1.45a	1.60a
CT	0.63b	0.80b	0.84b	0.93b

Means with the same letter down the column are not significantly different at $p < 0.05$
Legend :
OMF = 10,000 kg ha^{-1} of organomineral fertilizer ; IOF = 300 kg ha^{-1} of NPK 20-10-10 ; CT = Control treatment.
Site A = Impacted site ; Site B = Un-impacted site

NUTRIENT ELEMENT AND HEAVY METAL CONTENTS OF SUNFLOWER GRAINS

The nutrient element and heavy metal contents in the harvested grains of oily-type sunflower from an industrial wastewater contaminated Alfisols under different fertilizer applications are presented in Table 5. During the two cropping seasons, the harvested sunflower grains from the impacted soils contained : 1.82 mg Cu kg^{-1}, 67.13 mg Pb kg^{-1} and 3.83 mg Cd kg^{-1} when OMF was applied ; as against 1.13 mg Cu kg^{-1}, 54.75 mg Pb kg^{-1} and 2.43 mg Cd kg^{-1} with the application of IOF and 1.02 mg Cu kg^{-1}, 44.80 mg Pb kg^{-1} and 2.40 mg Cd kg^{-1} from the control plots. However, from the un-impacted plots, marginal 0.06 mg Pb kg^{-1} with OMF application was obtained ; while Cu and Cd values were below detection levels in the IOF and the control treatments. Values obtained for the nutrient elements were also higher in the impacted than the un-impacted sites in the order : OMF > IOF > CT.

Table 5 : Nutrients element and heavy metal contents of sunflower grains under different fertilizer treatments during the two cropping seasons in sites A and B.

Teneur en éléments nutritifs et en métaux lourds dans les graines de tournesol, sous différents fertilisants durant les saisons de culture sur les sites A et B.

Treatment	TN (g kg^{-1})	Ca	Fe	Mn (mg kg^{-1})	Cu	Pb	Cd
OMF	3.27	0.25	42.59	34.27	1.82	67.13	3.83
	3.32	0.22	16.27	25.13	Bdl	0.06	Bdl
IOF	3.02	0.19	24.33	9.24	1.13	54.75	2.43
	3.00	0.19	11.69	9.04	Bdl	Bdl	Bdl
CT	3.00	0.21	20.65	7.48	1.02	44.80	2.40
	3.12	0.18	10.15	6.25	Bdl	Bdl	Bdl

Legend :
TN = Total Nitrogen ; OMF = 10.000 kg ha^{-1} of organomineral fertilizer ; IOF = 300 kg ha^{-1} of NPK 20-10-10 ; CT = Zero fertilizer application.
p = Nutrient and heavy metal contents in the seed of sunflower from site A
q : Nutrient and heavy metal contents in the seed of sunflower from site B
Bdl = Below detection level

DISCUSSION

All the selected morphological characteristics (number of leaves, heights and stem girths) of sunflower were negatively affected by the contaminated soil with wastewater from the paint industry irrespective of fertilizer applications. Contaminated soils are usually deficient in macro and micro nutrients or could cause some of these nutrients to be in fixed state thereby preventing the establishment of healthy and vigorous plants (Alloway and Ayres, 1997). However, the fertilizer treatments applied enhanced the growth of the test crop as presented in Table 3.

The marked organic carbon constituent of OMF which was absent in IOF could have accounted for improved leafy production and better agronomic performance of the test crop from six weeks after sowing. Makinde *et al.* (2010) obtained similar results when Kola pod husk, organomineral and NPK fertilizers were compared in the morphological studies of Amaranthus cruentus on two soil types. Ryan and Angus (2003) also obtained improved biomass production and plant growth when organic-based fertilizers were applied. There was no significant difference in the sunflower biomass produced when the fertilizers applied were different; but biomass produced at zero fertilizer application was significantly ($p < 0.05$) lower (Table 3). This perhaps justifies the reasons why fertilizers (Adewole *et al.,* 2010) and chelating agents (Yanshan *et al.,* 2004) were used to enhance biomass production by sunflower.

The excess heavy metals in site A could have lowered protein formation, resulting from inhibition of photosynthetic processes and hence lowered leafy production and general growth performance of sunflower (Chaves *et al.,* 2011). Gopal and Khurana (2011) observed drastic growth reduction in sunflower from 40 mg Cu kg^{-1} and 10 mg Cd kg^{-1} soil contamination when the test crop was planted on heavy metal polluted soils.

Siddiqui *et al.* (2009) and Montemurro *et al.* (2007) earlier obtained higher grain yields of sunflower when NPK fertilizer amended with Zn and B micronutrients and N-fertilizer, respectively than the controls. Cerný and Veverková (2012) also observed the significant influence of N-fertilizer on the grain yield and fat content of sunflower over the control plots. Our findings suggested that organomineral and NPK fertilization with adequate agronomic practises positively enhanced the grain yield of sunflower. Comparative sunflower yield, though relatively higher values were obtained during the dry season in concordance with the assertion that the high humidity generally recorded during the rains causes sunflower head rot thus leading to low yield of sunflower (Ogunremi, 1988). The higher yield of sunflower grains obtained during the dry season could also be as a result of higher solar radiation recorded during the period (Tables 2 and 4). The radiation use efficiency which is a function of solar radiation is directly related to crop productivity (Kumar *et al.,* 2008).

The enhanced bioavailability and mobility of Cu, Pb and Cd in the soil brought about by organomineral fertilizer application (Adewole *et al.,* 2010) could have accounted for higher values of these metals in sunflower grains when compared with NPK 20-10-10 fertilizer application to soil. Lower mean values of these heavy metals were obtained from the un-impacted soils. These lower values could be as a result of the reduced availability of these heavy metals in the un-impacted area.

CONCLUSION

The study concluded that the growth performance, yield and nutrient element concentrations of sunflower grains were greatly enhanced with fertilizer applications when cultivated in an impacted or un-impacted soil by wastewater from the paint industry. Also, from the present study, more of the nutrient elements and heavy metals concentrations were obtained in the grains of sunflower when cultivated on factory effluent contaminated soil with or without fertilizer application. The reduction in the quantity and quality of the grains of this crop harvested from factory effluents impacted soil with or without fertilizer application is a strong evidence to discourage the cultivation of similar impacted soils with edible or industrial crops such as sunflower.

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