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EFFECTS OF INDUSTRIAL EFFLUENT CONTAMINATION ON SOIL PROPERTIES, GROWTH AND YIELD OF *CAPSICUM CHINENSE* TOURN.

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ABSTRACT

An experiment was conducted to evaluate the growth and yield characteristics of *Capsicum chinense* **(**Tourn) grown on soil affected by effluent discharge from Iron and steel company. Seeds of *Capsicum chinense* Tourn. collected from Osun State Control Development Project Office, Modakeke were broadcasted in a plastic bowl of 60 cm diameter and 20 cm height that contained top soil. The seedlings were grown for a period of four weeks in the nursery bed after which they were transplanted into 50 plastic pots containing regrowth forest soil and effluent discharged soil. *Capsicum chinense* seedlings were established at varying density (one, two, three, four and five) with each density having ten replicates for both soil samples. Data were collected on the following growth parameters; the number of leaves, leaf area, shoot height, petiole length, stem dry weight, root dry weight, leaves dry weight and fruit dry weight. The data obtained from this study were subjected to appropriate statistical analysis. The chemical analysis of the two soil samples showed that effluent discharged soil had higher organic carbon contents (2.9 mg/kg), higher amount of nitrogen (0.92 mg/kg), phosphorus (17.81 mg/kg), potassium (19.5 cmol/kg), lead (22.82 mg/kg), cadmium (2.49 mg/kg), and copper (10.3mg/kg) when compared to control soil. Among the growth parameters studied, soil condition had significant effect on the total number of leaves (82.32) at $P<0.05$. It can be concluded that at low concentration, industrial effluent in soil produced desirable and better growth characteristics and crop yield. It also improve the soil properties by improving the soil nutrient status especially the soil organic matter.

Keywords: Environment, Global, Re-growth, Degradation, Waste.

INTRODUCTION

Rapid industrial development and world global growth have led to degradation of environmental quality which call for increasing understanding of relationship between pollution, public health and environment. Although industrialization is inevitable, various devastating ecological and human disasters had occurred over the years, industrialization is therefore a major cause of environmental degradation and pollution problems of various magnitude (Abdel-shafy and Abdel-Basir, 1991).The application of sewage sludge and effluents on soils is increasingly receiving attention (Jiries, 2001). This has become an important routine of urban and industrial wastes disposal programmes with substantial ecological and recreational effects (FAO, 1992; Strauss, 2000). Effluents not only increase the nutrient level, but when excess affect tolerance limits and cause toxicity (Mishra *et al.,* 1999). Soils as the major sink for heavy metals released into the environment by anthropogenic activities may become contaminated and unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals do not undergo microbial or chemical degradation. In spite of the importance of soil to support different kinds of life, it has become a dumping place for several industrial and municipal wastes, most of which contain heavy metals (Yusuf *et al*., 2003), which are not subjected to bacterial attack or other breakdown or degradation process. Hence, they found their way up the food pyramid and can profoundly disrupt biological processes (Okunola *et al*., 2007).

In recent years, heavy metals are one of the more serious pollutants in our natural environment due to their toxicity, persistence and bio-accumulation problems (Zouboulis *et al.*, 2004). Excess accumulation of these micronutrients and other heavy metals like Cadmium, Lead and Nickel in plants operate as stress factors causing physiological constraints leading to decreased vigour and plant growth. They generally interfere with the activities of a number of enzymes essential for normal metabolic and developmental processes (Zouboulis *et al*., 2004). Although some heavy metals are essential trace elements, most can be, at high concentrations, toxic to all forms of life, including microbes, humans and animals. Like all living organisms, plants are also sensitive both to the deficiency and to the excess availability of some heavy metal ions as essential micronutrient, while the same at higher concentration are strongly poisonous to the metabolic activities.

Pepper, an important vegetable in the world and generally grown in Nigeria and other parts of the humid and semi-arid tropics (Aliyu, 2000) is commonly used as condiments (Alabi, 2006). It is sensitive to water logging and excessive rain (Udoh *et al*., 2005) and thrives best in relatively warm climate with a temperature range of 18-27 ^{o}C. As a medicinal plant, pepper is used in the prevention and treatment of cold and fever (Udoh *et al*., 2005). However, the relationship between crop yield and soil condition is of considerable agronomic interest. It is clear that soil conditions on the yield are due to the mineral nutrient composition in them. Many workers have monitored the effects of sewage effluents on the chemical properties of soils, the germination of seeds and growth and development of plants (Emongor *et al*., 2005; Aganga *et al.*, 2005) and reported significant effects of various sewage effluents on the chemical composition of different soils and the germination of seeds and growth of different crop plants (Aganga *et al*., 2005). Soil contamination by industrial effluents has affected adversely both soil health and crop productivity. Industrial effluents are the rich sources of both beneficial as well as harmful elements but untreated and contaminated industrial effluents may have hazardous effect on the growth of plant. Against this background, the objectives of this study were to evaluate the effect of the industrial effluents on the soil properties, growth and yield of *Capsicum chinense* Tourn.

MATERIALS AND METHODS

Pot experiment was conducted at the premises of Department of Botany, Obafemi Awolowo University, Ile-Ife. Soil samples were collected randomly from a re-growth forest, specifically between the Department of Botany and Faculty of Agriculture while effluent soil samples were collected from the premises of Ife Iron and steel Nigeria limited, Fashina, along Ibadan express road, Osun State, Nigeria. Each soil sample was thoroughly mixed, air dried, loosened and put in 21 cm diameter and 24 cm height plastic containers that were perforated at the base for effective drainage. The soil samples were analyzed for pH using pH-meter, particle size distribution (bouyoucos hydrometer), and the organic matter content. The organic matter was determined by wet combustion with $K_2Cr_2O_7$ (Nelson and Sommers, 1982). Total Nitrogen was determined by micro-Kjeldal method (Jackson, 1973) while potassium was extracted through 1M CH_3COONH_4 and determined by flame photometry (Black, 1965). Available phosphorous content was determined by sodium bicarbonate extraction (Olsen *et al*., 1954) while the concentrations of Cd^{2+}, Cu^{2+} and Pb^{2+} were determined by ICPOES (Inductively Coupled Plasma Optical Emission Spectrometer). Viable seeds of *Capsicum chinense* were collected from Control development project, Modakeke-Ife, Osun State. Seedlings were raised by broadcasting the seed of *Capsicum chinense* in a rectangular container filled with soil for the establishment of nursery bed. The bowls were perforated for effective drainage. After four weeks, the emerged seedlings of *Capsicum chinense* were transferred into perforated pots that have been filled with the soil samples at densities of 1,2,3,4, and 5. Each density had 5 replicates, for each soil samples. During the growing period, some growth parameters such as number of leaves, leaf length, leaf breadth, leaf area, shoot length were measured weekly. At harvest, plants were carefully harvested and dry matter yield (leaves, stems, fruits and roots) were measured after oven dried in a Gallenkamp oven at 80 ^{o}C for 72 hours. All results were subjected to analysis of variance (ANOVA). Significant means were separated by Duncan's multiple range test at 5 % probability level.

RESULTS

Soil properties

The results of the chemical analysis of the two soil samples showed that the effluent discharged soil had higher organic carbon contents when compared with the uncontaminated soil, the particle size distribution of the samples showed that effluent discharged soil had greater percentage of clay and silt contents compared to the control soil, while the control soil had a greater percentage of sand particles. The amount nitrogen and available phosphorus were higher in effluent discharged soil when compared with the control soil. The result also shows that the concentration of copper, cadmium and lead were higher in effluent discharged soil. (Table 1).

Growth characteristics

Seedlings of *C. chinense* grown on uncontaminated soil had larger leaf area and taller plants when compared to seedlings of *C. chinense* grown on effluent discharged soil. It was observed that the seedlings of *C. chinense* in effluent discharged soil began to flower some weeks earlier than the control soil. Throughout the growth period, the number of leaves, leaf area and plant height of *C. chinense* in each soil sample increased gradually in respect to the number of weeks (Fig 1a – 3b). The analysis of variance showed that the number of weeks and soil condition had significant effect on the growth parameter that were measured.

At harvest, the numbers of fruits in effluent discharged soil were more than the fruits in the control soil (Fig 4). The total number of leaves in control soil were higher than that of the effluent discharged soil, also as density increases, total number of leaves increased (Table 2). *C. chinense* plant grown on effluent discharge soil had the highest mean leaf, stem, root fruit dry weight (Table 2).

Table 1: The chemical analysis of effluent discharged soil and Control soil

Soil type	pH (H_2O)	O.C Mg/kg	P (Mg/kg)	K Cmol/kg	Sand	Clay	Silt	N Mg/kg	Cu^{2+} (Mg/kg)	Pb^{2+} (Mg/kg)	Cd^{2+} (Mg/kg)
EDS	7.6a	2.9a	17.81a	19.5a	7.5a	11.5a	13.5a	0.92a	10.3a	22.82a	2.49a
Control	7.6a	0.6b	7.12b	5.15b	8.1a	17.5a	12.0a	0.67a	10.17a	21.19ab	2.47b

*Means within the same column and with the same letter are not significantly different at 5 % ($p \leq 0.05$)

EDS: Effluent Discharge Soil.

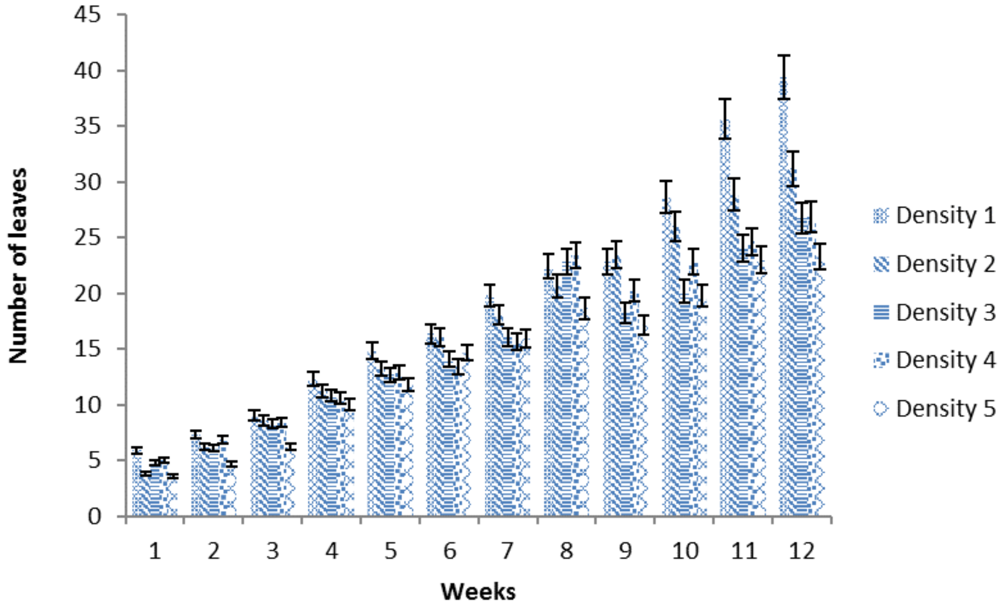

Fig1a: Number of leaves of *C. chinense* during the growing period (Control).

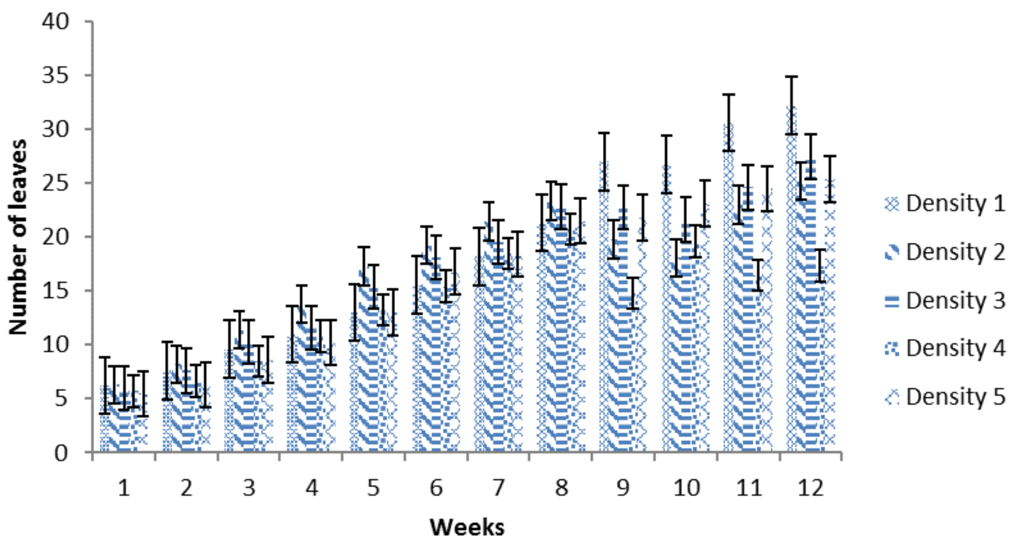

Fig1b: Number of leaves of *C. chinense* during the growing period (Effluent Discharged Soil).

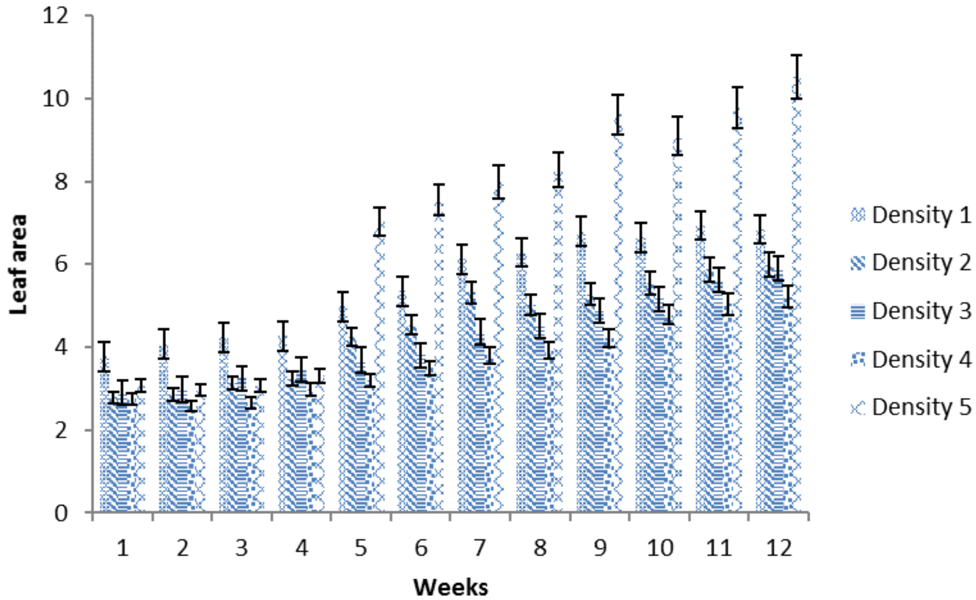

Fig 2a: Leaves area of *C. chinense* during the growing period (Control).

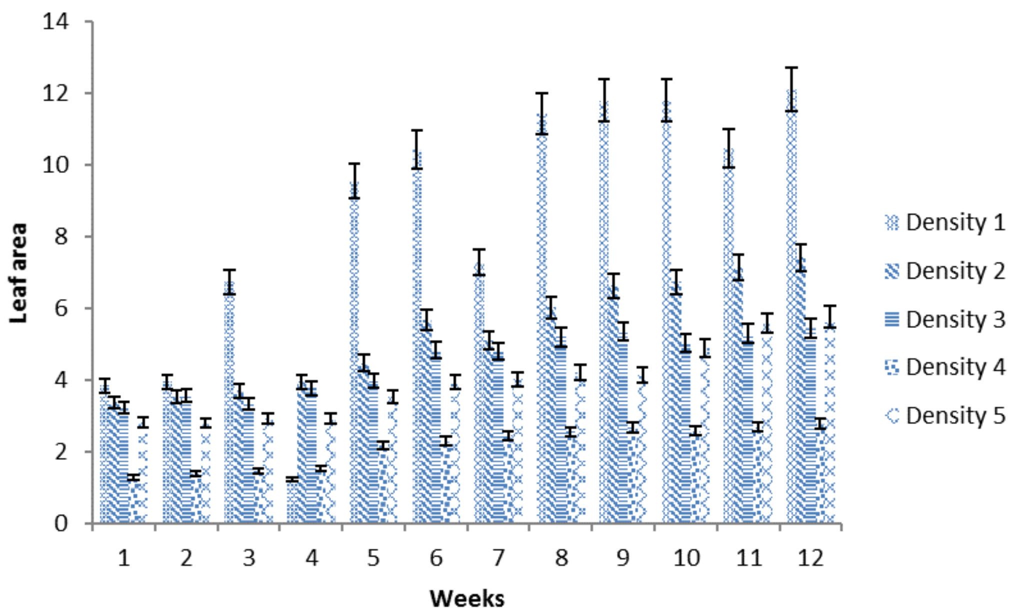

Fig 2b: Leaves area of *C. chinense* during the growing period (Effluent Discharged Soil).

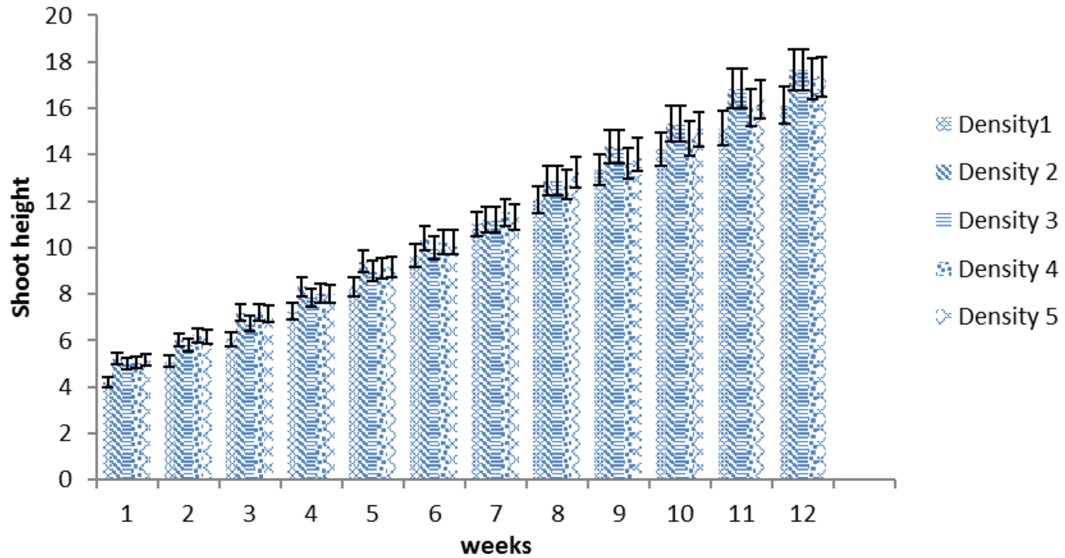

Fig 3a: Shoot height of *C. chinense* during the growing period (Control).

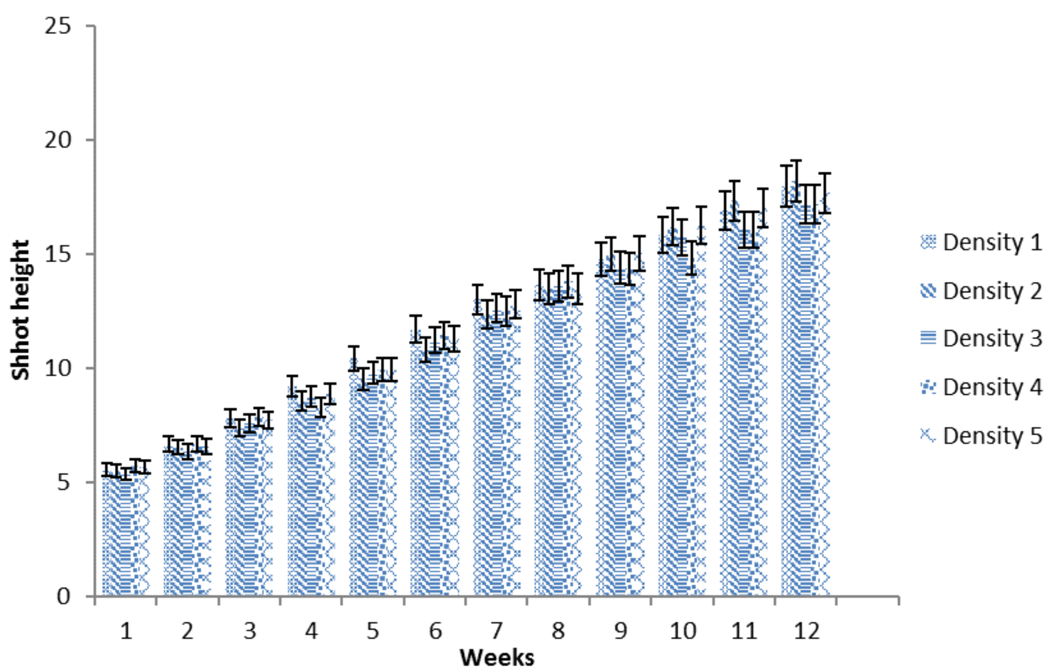

Fig 3b: Shoot height of *C. chinense* during the growing period (Effluent Discharged Soil).

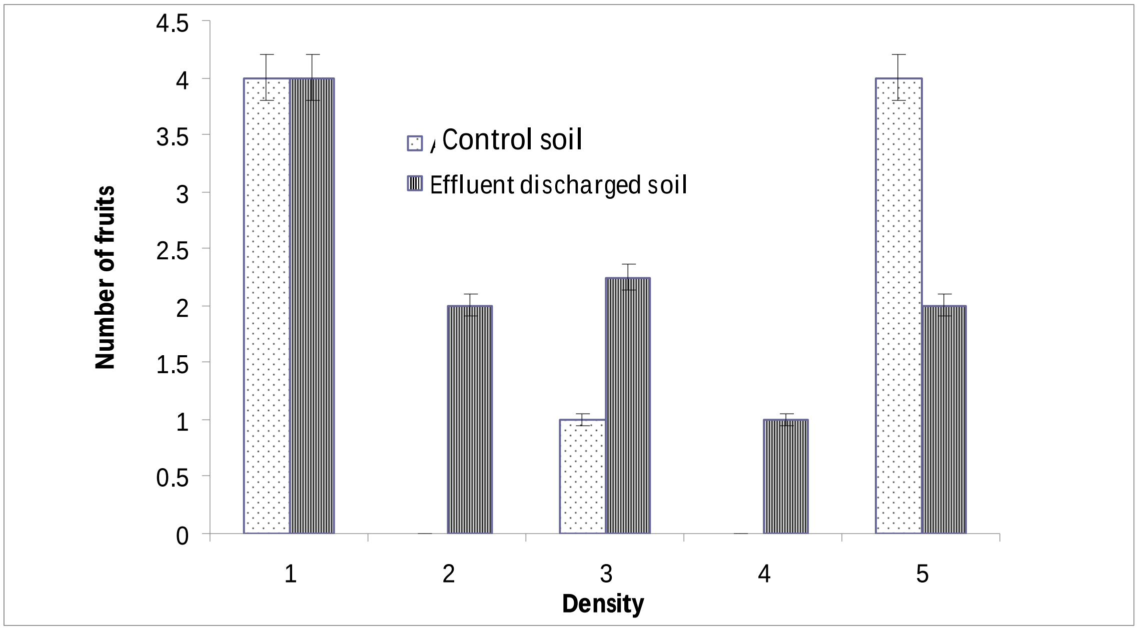

Fig.4: Number of fruits at harvest

Table 2: Some growth characteristic and yield of *Capsicum chinense* grown under different soil condition at harvest

Soil type	Stem dry wt	Root dry wt	No of fruits	Leaf number	Leaf dry wt
EDS	0.94a	1.02a	2.20a	82.32a	1.04a
Control	0.85a	0.89a	1.80a	76.80b	0.99a

*Means within the same column and with the same letter are not significantly different at 5% ($p \leq 0.05$)
EDS: Effluent Discharge Soil.

Table 3. Threshold limit of cadmium and lead

Heavy metals	Stipulated concentration Denmark (ppm)	Stipulated Concentration WHO (ppm)	Stipulated Concentration FEPA (ppm)
Cadmium	5	10	3-6
Lead	40	70	250-500

Culled from FEPA and Cited by Ezigbo 2011.

DISCUSSION

This study evaluate the response of the growth characteristics of *Capsicum chinense* to soil condition. The observed higher plant height in *C. chinense* when grown in effluent discharged soil is in line with the report of Ajmal and Khan (1984), who observed increased plant height in kidney beans (*Phaseolus vulgaris*) and pear millet (*Pennisetum glaucum*) in dairy effluent discharged soil. The higher shoot biomass recorded in effluent discharged soil when compared with control soil may be due to an increase in soil nutrients. in the soil which was caused by the release of industrial effluent into the environment. Dhanam, (2009) reported that effluent contains plant nutrients and trace elements, which are essential for plant growth. Yoon *et al.*, (2006) report similar trend in their study on rice and concluded that rice grown on effluent soil supplied the nutrient needs of the plants. Kulvinder *et al.*, (1990) reported an increase in seedling height of three varieties of rice when grown on sugar industry effluent soil.

The data obtained for the shoot dry weight showed that seedlings grown on effluent discharged soil has higher mass than the seedlings grown on control soil. This agree with the submission of Alizadeh *et al*. (2001) who reported that irrigation with sewage significantly increased plant height and stem dry weight in corn. It was also in consonance with the findings of Ammar *et al.* (1999) who concluded that industrial effluent had positive effect on plant stem girth.

The higher number of fruits and fruit dry weight of *C. chinense* grown on effluent discharged soil when compared with *C. chinense* grown on control soil might be due to the increase in soil nutrients. This is in line with the works of Zou *et al.* (2006), who reported yield increases in crops grown on fermented waste water soil. The root dry weight showed that *Capsicum chinense* grown on effluent discharged soil had higher weight than the *Capsicum chinense* grown on control soil. This observation is in accordance with the work of Augusthy and Sherin (2001) who indicated that length of root system and number of lateral roots of *Vigna radiata* increased by low concentration of industrial effluent. Nawaz *et al*., (2006) also discovered that textile mill effluents supported the root growth which ultimately leads to an increase in root dry weight of *Cicer arientum.* The higher leaf dry weight observed in *Capsicum chinense* grown on effluent soil is in accordance with the work of Hussain *et al*., (2010) who reported that leaf fresh and dry weight increased with increasing concentration of tannery effluent on two cultivars of Sun flower. The higher petiole length recorded in *C. chinense* grown on effluent discharged soil when compared with *C. chinense* grown on Control soil may be attributed to availability of essential nutrients in effluent discharged soil than in the Control soil.

The result of soil chemical analysis indicated that the concentration of lead, cadmium and copper were higher in effluent discharged soil when compared with control soil. However, comparing the concentration of these heavy metals with the threshold concentration value released by FEPA and quoted by Ezigbo (2011), it can be concluded that the concentration of lead, copper and cadmium that were found in both the effluent discharge and Control soils are below the threshold limits of FEPA and WHO. Moreso, the observed concentrations of lead, cadmium, copper, potassium, nitrogen and phosphorus in effluent discharged soil is similar to those reported by Ohue (2007) and Augusthy and Mani (2001) who obtained high amounts of these elements in effluent discharged soil.

CONCLUSION

This study showed that *C. chinense* grown on soil affected by industrial effluent produced better growth characteristics and crop yield when compared with control soil. It also improve the soil properties by increasing the organic matter content of the soil and other nutrient required for plant growth.

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