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# Effect of Soil Pollution on the Nodulation Competence of Some Cowpea Cultivars in the Tropical Rainforest Region of Nigeria

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**Abstract:** The aim of this study is to evaluate the effect of soil pollution on the nodulation competence of some selected cowpea cultivars. Three cowpea varieties (Tvu1647, IT84552-249 and IT95K-1491) were selected for this study. The polluted soil types were soil samples taken from a factory effluent site, piggery waste soil, gasoline polluted soil while normal unpolluted sandy loam served as the control. The plant height, terminal leaf length, sterm girth, nodule number and plant shoot dry mass were determined. Nodulation in the polluted soils reduced significantly ($p<0.001$) compared to the control while the stem girth, terminal leaf length and shoot dry mass increased significantly ($p<0.001$) compared to the control. The plant height of each variety significantly differed ($p<0.005$) from one another. This study has shown that soil pollution causes significant reduction in nodule numbers hence having immense negative impact on nodulation in cowpea varieties used in this study. Meanwhile soil pollution is shown in this study to increase the stem girth, plant height, leaf length and shoot dry mass of the cowpea plants compared to the control.

**Keywords:** Leaf length, nodulation, plant height, shoot dry mass, stem girth

## INTRODUCTION

The ever increasing pollution of the environment has been the greatest concerns of science and the general public in the last 50 years. The rapid industrialization of agriculture expansion of the chemical industry and the need to generate cheap forms of energy has caused the continuous release of man-made organic chemicals into the natural ecosystem. A number of environmental, chemical and management factors affect the biodegradation of soil pollutant including moisture content, pH, temperature, the microbial community that is present and the availability of nutrients. With the development of industries, mining activities application of waste and sewage sludge on land, heavy metal pollution of soil is increasingly becoming a serious environmental problem. Petrochemical plants generate solid waste and sludge, some of which may be considered hazardous because of the presence of toxic organic and heavy metals (Eliwa, 2000).

During the last two decades, increasing accumulation of heavy metals had been observed in cultivated soils, lakes and even air. These accumulation from sewage, industrial wastes and accumulation of such pollutant in soil, water and air may cause a great annoying eutrophication problem for all living organisms including man not only in the polluted locations but also in the non-polluted areas (Eliwa, 2000). Legumes and other associated rhizobial bacteria are important component of the biogeochemical cycles in agricultural and natural ecosystem. Legumes and *Rhizobia* are often desirable species during and after the remediation of contaminated lands. Complex interaction between roots, microorganisms and fauna in the rhizosphere has a fundamental effect on metal uptake and plant growth.

Sewage sludge application to agricultural soils is an economic way of disposal (Ferreira and Castro, 1995; Markensson and Witter, 1990 and Obbard *et al*., 1994). It improves the physical characteristics of soil (Wei and Liu, 2005) and increases organic matter content and essential plant nutrients in particular N and P (Ferreira and Castro, 1995). Sewage sludge contain numerous component required for microbial growth and may increase the activity of soil microorganism (Speaker and Scopper, 1988), including rhizobial growth (Kinkle *et al*., 1987). Martensson and Witter (1990) reported that contaminants associated with certain fertilizers such as sewage sludge may also negatively affect the survival of various microorganisms. Heavy metals are known to persist in the soil over long period and have toxicological effect

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on plants and soil microorganism (Ernst, 1990). Obbard *et al*. (1994) reported that there is increasing evidence of adverse effect on microbial processes related to nutrient cycling in the soil. Several environmental conditions are limiting factor to the growth and activity of the $N_2$-fixing plants. A principle of limiting factor states that "the level of the crop production can be no higher than that allowed by the maximum limiting factor" (Brockwell and Twies, 1995). Typical environmental stresses faced by the legume nodules and their symbiotic partner (Rhizobium) may include photosynthetate deprivation, water stress, salinity, soil nitrate, temperature, heavy metals and biocides (Walsh, 1995).

This study therefore, is aimed at determining the effect of soil pollution on the nodulation competence of some elected cowpea cultivars.

## MATERIALS AND METHODS

**Colllection of samples:** Cowpea varieties used for this study were TVu16467, IT8452-249 and IT95K-1491 all of which are improved varieties obtained from the International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria.

**Soil samples:** Four soil samples (Normal sandy loam soil (unpolluted), Gasoline polluted soil sample, Soil polluted with factory effluent, Piggery soil sample) were used in this study. Normal unpolluted soil samples (which serve as the control) were collected from the research farm of the department of biological sciences, Tai Solarin University of Education, Ijebu-Ode, Nigeria. Soils polluted with factory effluent were obtained from Consolidated Brewery, Imagbon, Ogun State, Nigeria. Gasoline polluted soil samples were collected from Ikoto Mechanic village, Ijebu-Ode, Nigeria while piggery wastes were obtained from Sambram Farm, Erunwon, Ogun State, Nigeria

**Planting:** The experiment was conducted at the Research Farm of the department of Biological Sciences, Tai Solarin University of Education, Ijagun, Ogun State, Nigeria in March, 2010. Thirty six experimental pots were used in this experiment. The first nine buckets were filled with normal unpolluted soil samples. Another nine buckets were filled with soil polluted with factory effluent. The next nine buckets were filled with gasoline polluted soil samples while the remaining nine buckets were filled with piggery waste. Each pot had two cowpea seeds planted in it and later thinned to one plant per pot 1 week after planting. The experimental design used in this study was complete randomized block design with four treatment (soil types), three replicates and three varieties. The pots were carefully observed for six weeks after which the plants were harvested.

**Measurement of plant characters:** The roots of the harvested plants were gently washed in a bucket filled with water to remove the soil particles and data on the following traits; nodule number, plant height, terminal leaf length, stem girth, plant shoot dry mass were then determined. The harvested plants were placed in brown envelopes and then oven dried at 60$^{o}$C for 24 h and later weighed with an electric weighing balance to determine the shoot dry mass. The plant height was determined using a tape rule and the terminal leaf length and width was measured with a ruler and the plant girth was measured using vernier caliper.

## RESULTS

Nodulation in the polluted soils reduced significantly ($p<0.001$) compared to the control. There was no significant difference in the nodule numbers among each variety ($p = 0.29$) and the replicates ($p = 0.20$). Variety IT845-249 had the highest mean nodule number in brewery effluent (12.83) and in control soils (18.17) (Fig. 1), nodulating poorly (0.67) in piggery soils (Fig. 1). Meanwhile variety Tvu164-67 recorded the highest mean nodule number of 4.76 in gasoline polluted soils.

The stem girth of the cowpea varieties cultivated on the polluted soils was significantly ($p<0.001$) wider than those cultivated on control soils. There was no significant difference in the stem girth among the varieties ($p = 0.328$) and replicates ($p = 0.909$). IT95K-1491 variety had the widest stem girth of 7.76 cm in the piggery soils (Fig. 2). Meanwhile the stem girth of variety IT845-249 was poorly developed in gasoline polluted soils (2.37 cm) (Fig. 2).

There was no significant difference ($p = 0.420$) in the plant heights on polluted soils compared to control soils. The plant height of each variety significantly differed ($p<0.005$) from one another, meanwhile there was no significant difference in the plant heights among the replicates ($p = 0.188$). IT95K-1491 variety had the highest plant height of 31.47 cm (Fig. 3) on gasoline polluted soils. While variety Tvu164-67 recorded the lowest plant height of 22.5 cm on brewery effluent polluted soils of all the polluted soils investigated in this study (Fig. 3).

The terminal leaf length was significantly higher ($p<0.001$) in cowpea varieties cultivated on polluted soils compared to those cultivated on control soils. Meanwhile there was no significant difference in the

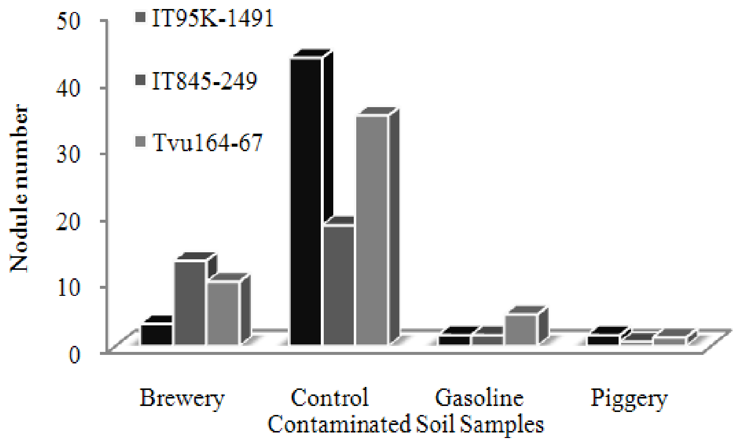


Fig. 1: Mean nodule number for the three cultivars

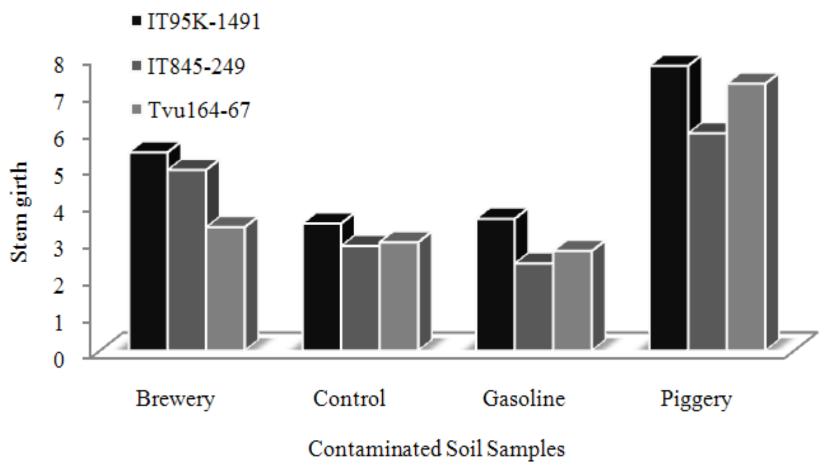


Fig. 2: Mean stem girth

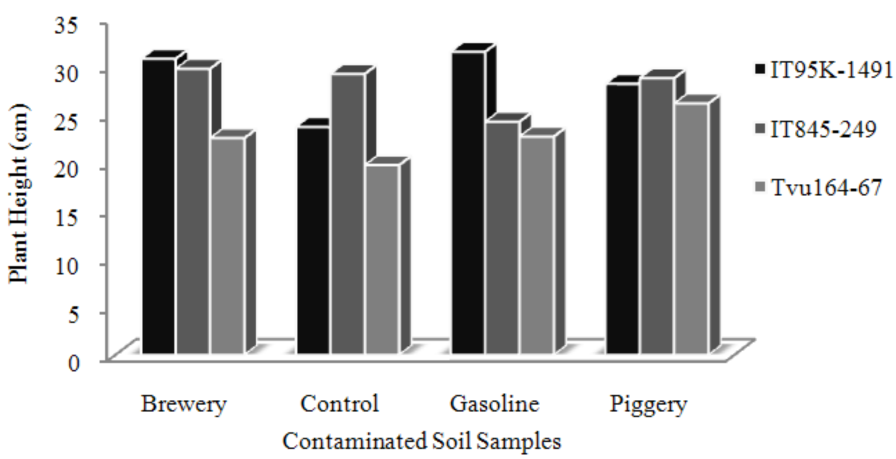


Fig. 3: Mean plant height for the three cultivars

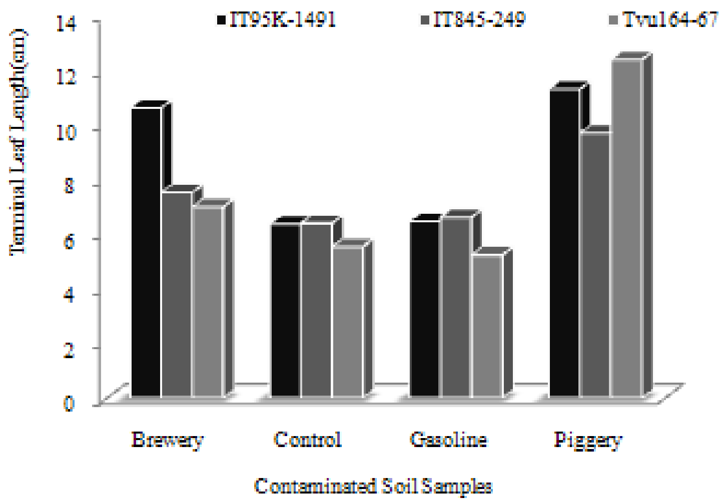


Fig. 4: Mean terminal leaf length for the three cultivars

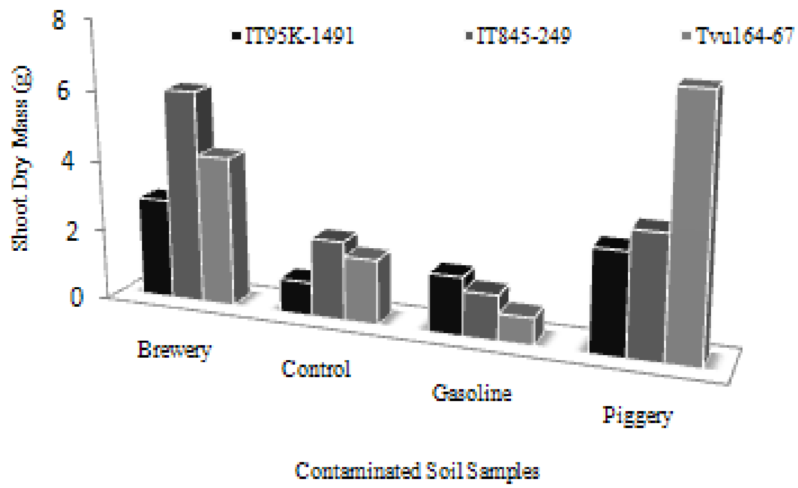


Fig. 5: Mean shoot dry mass for the three cultivars

terminal leaf lengths among the varieties ($p = 0.459$) and replicates ($p = 0.329$) Tvu164-67 variety had the highest mean terminal leaf length of 12.457 cm on piggery soils (Fig. 4) while also recording the lowest mean terminal leaf length of 5.267 cm on gasoline polluted soils (Fig. 4). The mean shoot dry mass of cowpea cultivars recovered from polluted soils was found to be significantly ($p<0.001$) higher than that obtained from control soil samples except for varieties IT845-249 and Tvu164-67 on gasoline polluted soils. There was no significant difference in shoot dry mass among varieties ($p = 0.209$) and replicates ($p = 0.929$). Tvu164-67 recorded the highest mean dry mass of 7.153 g on piggery soils (Fig. 5) while IT845-249 variety recorded the lowest mean dry mass of 1.267 g on gasoline polluted soils of all the polluted soils used in this study (Fig. 5).

## DISCUSSION

The stem girth of the cowpea cultivars on the piggery soil samples was found to be the widest when compared to other soil samples used in this study. The nodule numbers decreased significantly in the polluted soils compared to the control. To a large extent soil pollution affects the nodulation of cowpea. Gasoline, brewery and piggery waste soil samples tend to generate a lot of heat during microbial activity and thereby lead to heat stress on the plant which leads to reduced nodules number in legumes. The plant height of variety IT95K-1491 on gasoline polluted soil sample was significantly higher compared with other soil samples used in this study. Similar findings were recorded by Gresshoff *et al*. (2008) who highlighted the numerous factors affecting nodules which include microbial specificity, heat stress, drought, salinity, nutrition and other environmental factors. Recent research findings have shown inter and intra specific differences in the amount of $N_2$ fixed by grain legumes and several factors have been responsible for these variations, they include cultivar differences in nodule number and mass, speed of nodulation, lateral root nodulation, post flowering, N accumulation, acetylene reduction, allantoic production and nodule enzyme production and function (Yusuf *et al*., 2008). Different materials such as industry bye-products, organic wastes, mineral soils, plant bye-products, coal, perlite, agro-industrial wastes have been tested as culture media for growth of rhizobia (Brockwell and Twies, 1995; Stephens and Rask, 2000).

This study has shown that soil pollution causes significant reduction in nodule numbers hence having immense negative impact on nodulation in cowpea varieties used in this study. Meanwhile soil pollution is shown in this study to increase the stem girth, plant height, leaf length and shoot dry mass of the cowpea plants compared to the control.

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