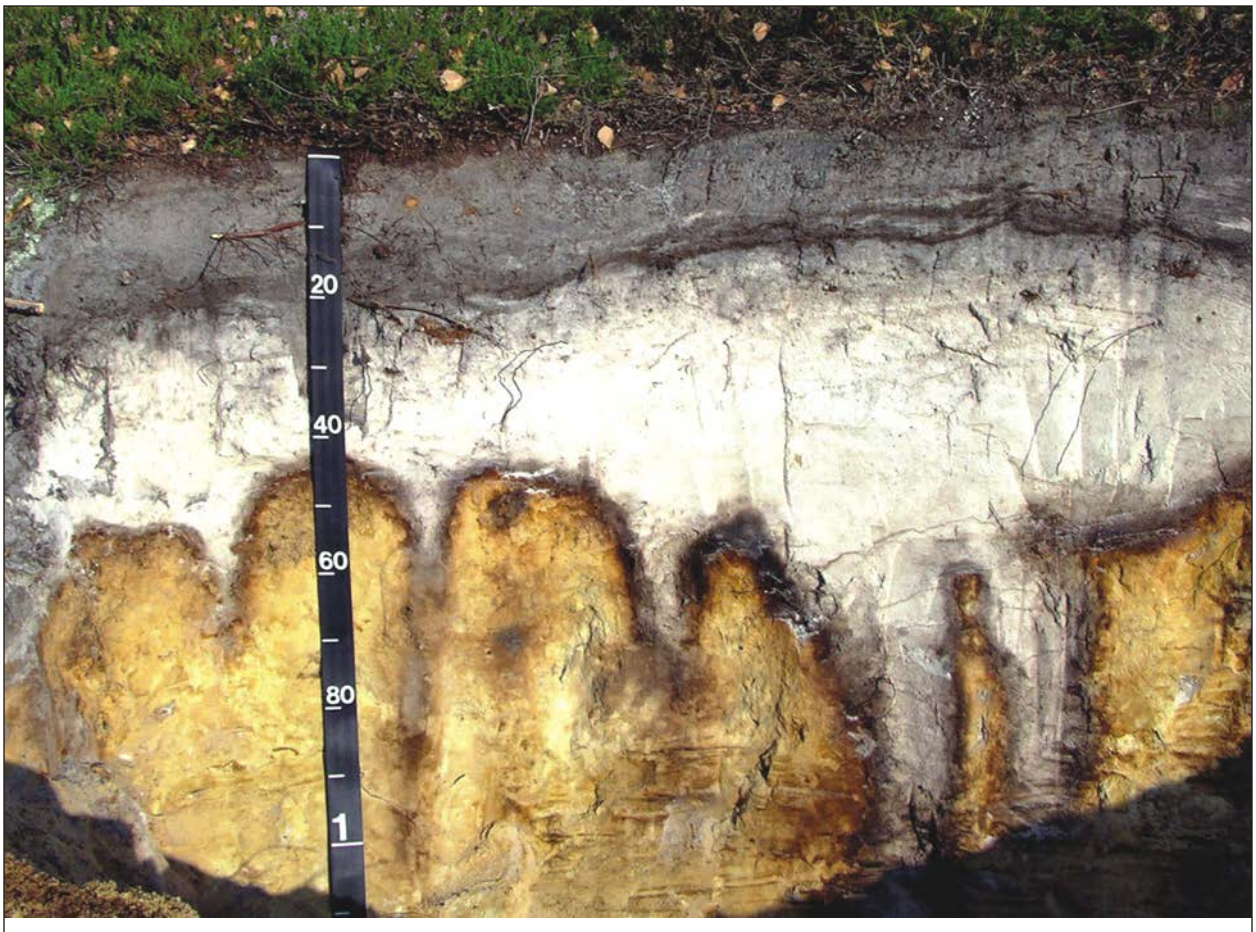

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Effect of Remediation of Crude Oil Polluted Inceptisols on Maize (*Zea mays*) Production Using Organic and Inorganic Fertilizers at Yenagoa, Bayelsa State

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ABSTRACT

The efficacy of organic and inorganic fertilizers (poultry manure, Cow dung N.P.K. and Urea) as remediation materials in crude oil polluted inceptisols of the Meander belt zone of Yenegoa, Bayelsa State was evaluated using maize (*Zea mays*) as a test crop. A simple factorial experiment fitted into a randomized complete block design with four replicates and twenty four experimental plots and six treatments was used. Fifty six litres of Bony light crude oil at one percent pollutions level was also used. The remediation materials were poultry manure, cow dung, Urea and NPK. The result revealed that plots treated with poultry manure had the best performance in terms of maize seedling emergence (95 and 77.5%), seedling survivability (17.50 and 16.00%), maize plant height (132 and 126 cm), maize plant girth (4.65 and 4.90 cm), (7.00 and 5.50 cm) and (9.00 and 7.50 cm) at 2, 3 and 4 weeks after planting, leaf area (380 and 360 cm), (400 and 381 cm) and (430 and 405 cm) at 4, 5 and 6 weeks after planting, grain yield (2500 and 185 kg ha^{-1}) and straw yield (13187 and 12969 kg ha^{-1}) across seasons. This was followed by Cow dung, NPK and Urea in that order. The least was observed in the control. The results also revealed that poultry manure showed superiority over cow dung in amending crude oil degraded soils (Inceptisols). It was recommended that poultry manure be employed in the amendment of crude oil polluted soils.

Key words: Effect, crude oil, organic and inorganic fertilizers, maize, inceptisols

INTRODUCTION

Soil remediation is the collective term for various strategies that is used to purify and revitalize contaminated soil (Odu, 2006). There are a number of different methods currently employed in the process of dealing with soil pollution. The selection of the most effective strategy will depend on the nature of the contamination, how the method will impact surrounding Wildlife or humans living in the general vicinity and the degree of success that can be anticipated from the soil remediation practice (Peter and Ayolagha, 2012).

Among the process used in soil remediation, excavation and dredging are among the most common. This process involves extracting soil that is contaminated. Others used soil remediation methods known as pump and treat; a process that involves the removal of contaminated ground water, then using various methods to purify the extracted liquid. While the water is purified, the soil is also extracted and filtered to remove various contaminants then return to its original position

(Diaze, 2008). This method is time consuming and very expensive and cannot be used in a water logged environment. As technology advance, new methods of restoring contaminated soils are employed such as bioremediation; which is the use of microorganism metabolism to remove pollutants from the soil environment. This method enables the purification of land and the use of the area for growing of crops, wildlife preservation and even structural development for residential and commercial purposes on the restored land (Odu, 2006). Bioremediation is a new method for cleaning up degraded environment whereby the natural biodegradation capabilities of the soil are enhanced by nutrient addition and/or cultured micro-organisms with advantages as cost effectiveness and without causing any environmental damage (Adoki and Orugbani, 2007).

In Niger Delta, crude oil pollution has created the biggest concern and reactions from the various communities (Odu, 1981). The land area and shoreline are vital agricultural lands and often put in cultivation. The Meander Belt Zone of Bayelsa State is made up of alluvial soils which are recent deposits of alluvium (Wenibo, 2012). The soils (inceptisols) are developed on alluvial parent materials with high crop production potentials.

The Meander Belt of Bayelsa State is bordered on the east by the Sombreiro-Warri Deltaic plain, in the south by the mangrove swamps, in the west by the Forcados River and in the north by the River Niger. It is always prone to crude oil pollution due to persistent oil exploration, exploitation and oil pipeline maintenance activities. The recent past, oil pipeline maintenance excise led to the 18th September 2003 oil spill in Eteqwe and Biogbolo Communities in Yenegoa resulting to environmental pollution, destruction of aquatic and terrestrial biodiversity and poor land and air quality (Ebie, 2006). There is need for remediation of the soil in the Meander Belt Zone of Bayelsa State using less expensive and easily affordable remediation materials such as cow dung and poultry manure with maize as a test crop.

Some research workers have investigated the effect of crude oil pollution on soil physicochemical and microbiological properties and crop growth (Rowell, 1977; Amakiri and Onofeghara, 1983; Ebie, 2006; Peter and Ayolagha, 2012). These researches were carried out in the temperate region and coastal plain sand of the humid tropics.

Little or no base line information is available on the effect of crude oil polluted soil on maize yield per hectare in Yenegoa area of the Meander belt zone. Maize (*Zea mays*) is one of the oldest and widely cultivated world cereals in this part of the country that provide food for man and feed for livestock (Anyanwu *et al*., 1979).

The objective of this research was to investigate the effect of remediation material on growth of maize (*Zea mays*) planted to crude oil polluted inceptisols of Yenegoa in the Meander Belt zone of Bayelsa state.

MATERIALS AND METHODS

Location: The experimental site for this experiment was at Ministry of Agriculture Demonstration Farm, Yenagoa, Bayelsa State. Yenagoa is located between latitude 4°.50 00 N and 6°.20 0 0N and longitude 6°.15 0 0E and 5°00' 0 0E. The elevation of Yenagoa Land surface is between 12-15.5 Metres above mean sea level.

Soil: The soils of the study area is classified by USDA as inceptisol, while the soil geomorphic unit of Rivers/Bayelsa State determined the soil to be alluvial plain meander belt zone (Okonny *et al*., 1999).

Vegetation: The experiment was carried out, on secondary vegetation. The experimental site had been previously used by the Forestry Department of the Bayelsa State Ministry of Agriculture as pineapple orch ard. It became a fallow with prominent West African weed species such as *Panacum maximum*, *Commelina* species, *Emilia sonchifolis*, *Tridax procumbens*, *Ageratum conyzoids* and *Euphorbia heterophyalla* without any history of maize cultivation.

Climate: The rainfall distribution of the study area ranges between 2000-3000 mm with two peaks in June and September and a period of low precipitation popularly known as August break. The mean monthly maximum temperature varies between 28 and 33°C, while the mean monthly minimum temperature ranges between 21-23°C depending on the season of the year. The relative humidity of the study area varies between 81-87% depending on the particular period of the year.

Experimental design: The experiment involved six treatments with four replicates that gave a total of twenty-four plots in a completely randomized block design. Each plot of 2.4 m size was polluted with 2.8 L of fresh Bonny light crude-oil with specify gravity of 0.835 equivalent one percent pollution (Elf, 2000). The control plots were unpolluted. The crude oil was carefully measured into a watering can with a fine hose and evenly sprayed on each plot. The oil was then worked into the soil with a garden fork and allowed to rest for two weeks before remediation and planting of maize (the test crop). A total of 56 L of crude oil was used for the experiment.

Remediation material: The remediation materials used for the experiment were Urea 64:0:0 and NPK 15:15:15 (inorganic fertilizers), Poultry manure and Cow dung (organic manures).

The rate of application of the remediation materials were Urea 1250 kg ha^{-1}, NPK 1000 kg ha^{-1}, Poultry manure 5000 kg $ha^{1-}$and Cow dung 5000 kg ha^{-1} in that order. Two weeks after crude oil pollution of each plot, remediation materials were applied except the No pollution and control plots. The remediation materials was carefully spread and left fallowed for two weeks before planting. Four weeks after planting, second round of remediation material were applied using the ring method of fertilizer application except the No pollution control plots.

Percentage emergence 7 days after planting (7 DAP): Percentage emergence of maize plant was counted 7 days after planting (7 DAP). The count was ascertained using the formula:

$$\text{Emergence count (\%)} = \frac{\text{No. of seeds that emerged}}{\text{No. of seed planted}} \times 100$$

While after 8 days of planting, careful counting of dead seedling on each plot was done to obtain the number dead seedlings 8 days after planting.

Survivability of maize seedlings 14 days after planting (14 DAP): Number of maize plants that survived 8 days after planting was ascertained by physical counting of the number of survived maize seedlings in each of the plot.

Plant height 4, 5 and 6 weeks after planting (4, 5 and 6 WAP): Plant height per plot was taken 4, 5 and 6 weeks after planting with the aid of flexible measuring tape from the base of the plant to the collar of the last leaf on the plant to determine the plant height in centimeter.

Plant girth 2, 3 and 4 weeks after planting (2, 3 and 4 WAP): Two, three and four weeks after planting (2, 3 and 4 WAP), six plants from each plot were taken to determined the girth of maize plant per plot. Measurement of the plant girth was done using flexible measuring tape in centimeter.

Leaf area of maize plant 4, 5 and 6 weeks after planting (4, 5, 6 WAP): The assessment of leaf area of maize plant was carried out using flexible measuring tape, taking the total length and width at both the broadest point and the longest leaf in the same plant. The result was then multiplied by a correction factor 0.75 (Curnard, 1971).

Grains and dry stover yield 14 weeks after planting: Fourteen weeks after planting grain yield was assessed by weighing the dry grain in kg ha^{-1} while the biomass or dry matter was ascertained by carefully uprooting the plant and washing up the roots to removed soil particles. These were then chopped. The chopped shoots, leaves and roots were weighed to get the fresh weight. They are oven dried at 80°C for 2 days to a moisture content of 14% and to obtained dry weight (Odjegba and Sadiq, 2002).

Statistical analysis: All data collected were subjected to the statistical procedure for Analysis of Variance (ANOVA) (Steel and Torrie, 1960). The New Duncan Multiple Range Test (NDMRT) and SAS (1999) were used to compare the means and to analyze the Least Significant Differences (LSD).

RESULTS AND DISCUSSION

Effects of remediation materials (organic and inorganic fertilizers) on emergence and death of maize plant 7 and 8 days after planting The number of maize plants that emerged 7 days after planting and died at 8 days after planting is presented in Table 1. Maize plant emergence was highest in crude oil polluted soil treated with poultry manure (95 and 77.5%) and decreased in the following order NPK (93.75 and 76.25%), cow dung (93.75 and 76.25%), urea (92.50 and 75.00%) and No pollution (87.50 and 73.35%). The control (polluted and un amended plot) was the least (77.50 and 63.75%).

The number of maize plants that died was highest in control plot (2.50 and 7.25%) and decreased in the following order No pollution (1.75 and 5.00%) Urea (1.50 and 4.00%), NPK (1.25 and 4.00), cow dung (1.25 and 4.00) and poultry manure 1.00 and 3.00%, respectively. The Low percentage emergence in the control plots was as result of the damage caused on the maize seeds

Table 1: Effect of remediation materials on emergence and death of maize plants 7 and 8 days after planting (7 and 8 DAP)

	Emergence 7 DAP (%)		Death plant 8 DAP (%)	
Treatment	Early planting	Late planting	Early planting	Late planting
Control	77.50	63.75	2.50	7.25
Urea	92.50	75.00	1.50	4.00
NPK	93.75	76.25	1.25	4.00
DPM	95.00	77.50	1.00	3.00
CD dung	93.75	76.25	1.25	4.00
No pollution	87.50	73.35	1.75	5.00
Overall means	91.46	73.75	1.71	4.71

Table 2: Effect of remediation materials on survivability of maize plants 2 WAP

	Plant that survived 2 WAP (%)	
Treatment	Early planting	Late planting
Control	13.00	14.00
Urea	15.75	14.00
NPK	16.75	15.50
PM	17.50	16.00
Cowdung	15.50	13.25
No polluted	13.75	13.25
Over all mean	15.42	14.08

by crude oil. This also resulted to high death rate in the polluted and un-amended plots. This confirmed the findings of Kalio (2003) that it is only viable seed that can germinate effectively. The maize seed was soaked by crude oil leading to poor seedling emergence.

The highest seedling emergence was in the plot treated with poultry manure. This is in line with Awodun (2007) finding that poultry manure are in easily dissolvable and absorbable form. He pointed out that this promote microbial population resulting in crude oil degradation. He also added that poultry manure is rich in a lot of micro-organism and at the same time help to bind soil particles thereby improving the soil structure, aeration, porosity and temperature regime.

It was also observed that early planting season had better seedling emergence than late planting. This is also in line with the findings of Ebie (2006) and Peter and Ayolagha (2012) that high rainfall at late planting season hindered the rate of seed germination. The Control (polluted and un-amended) plots had the highest number of dead maize plants at both late and early planting seasons. This is in support of the findings of Udo and Fayemi (1975) and McGill (1975) that seed emergence decreases with increase in crude oil pollution levels. This is also in line with the report of Amakiri and Onofeghara (1983) on maize, Okra and Pepper.

Effects of remediation materials on survivability of maize seedlings 14 days after planting (14 DAP): The result of the effect of remediation on the survivability of maize seedlings 14 days after planting is presented in Table 2. Result showed that plots amended with poultry manure had the highest percentage maize seedlings (17.50 and 16.00%) that survived 14 days (Two weeks) after planting across the different planting seasons. This was followed by NPK (16.75 and 15.50%), urea (15.75 and 14.00%), cow dung (15.50 and 13.25%), No pollution (13.75 and 13.00%) and control (13.00 and 11.00%) in that order across seasons. The result also showed that there were no significant differences at $p>0.05$ among treatments for survivability at both season 14 days after planting. The highest survivability of maize seedlings in plot treated with poultry manure also support the findings of McGill (1980) Zuofa *et al.* (1985) that there is always significant crop growth rate in crude oil polluted soil when poultry manure is used as remediation materials in such soils.

Effects of remediation on maize plant height 4, 5 and 6 weeks after planting: The result of remediation on maize plant height is presented in Fig. 1. Result showed that poultry manure had the highest vertical growth measurement across the different season in line with the report of Peter and Ayolagha (2012) Alasiri and Ogunkeyede (1999) and Awodun (2007) who reported that poultry manure has a lot of micro-organism and it is easily dissolvable and absorbable. Maize plant

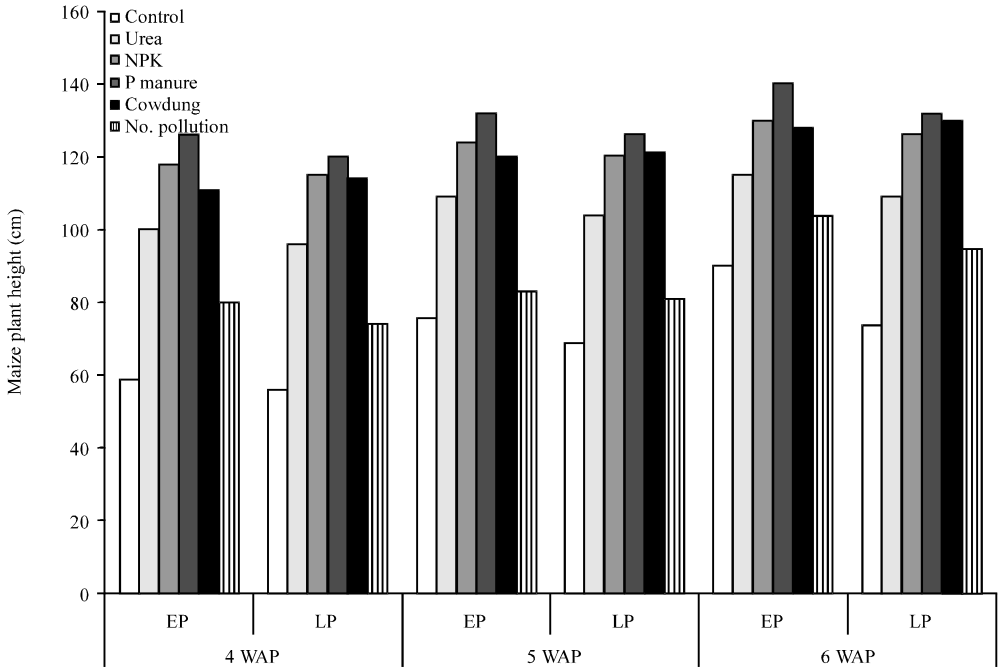

Fig. 1: Effect of remediation materials on maize plant height. EP: Early planting, LP: Late planting, WAP: Weeks after planting, NPK: Nitrogen, phosphorus and potassium fertilizer

quickly absorbed the nutrients resulting to their fast growth rate. Urea and NPK were also in simple forms that released nutrients easily but because of the water logged nature of inceptisols in the Meander Belt of Bayelsa State, they were easily leached beyond the reach of maize plant roots. This confirmed the findings of Ebie (2006) that application of inorganic fertilizer to soils with high moisture content lead to leaching of available nutrient present in them down the soil profile.

It was also observed that at late planting, cow dung had the second highest maize plant height at 4 , 5 and 6 weeks after planting to support the finding of Peter and Ayolagha (2012), that farm yard manure do not released their nutrient immediately after application but over time. At late planting the nutrient materials in cow dung might have been released due to proper decomposition over time resulting in fast growth rate of maize plant at late planting (4, 5 and 6 WAP). Poultry manure gave the highest plant height (126 and 120 cm), (132 and 126 cm) and (140 and 132 cm) 4, 5 and 6 week after planning at early and late planting respectively. This was followed by NPK (118 and 115 cm), (124 and 120 cm) and (130 and 126 cm); cow dung (114 and 124 cm), (120 and 121 cm), (128 and 130 cm) and Urea and No pollution in that order. The least vertical growth measurement was recorded in the control plot. There was higher plant height at 6 weeks than 4 and 5 weeks after planting across seasons probably due to age and time of planting. The result of the effect of remediation materials on crude oil polluted inceptisols of effect of remediation materials on plant girth 2, 3, 4, weeks after planting.

The effect of remediation materials on maize plant girth 2, 3 and 4 weeks after planting in Meander Belt zone of Bayelsa State is presented in Fig. 2. The highest plant girth (4.65 and 4.90 cm), (7.00 and 5.50 cm) and (9.00 and 7.50 cm) 2, 3 and 4 weeks after planting was observed in plots treated with poultry manure at both early and late planting seasons. This was followed by

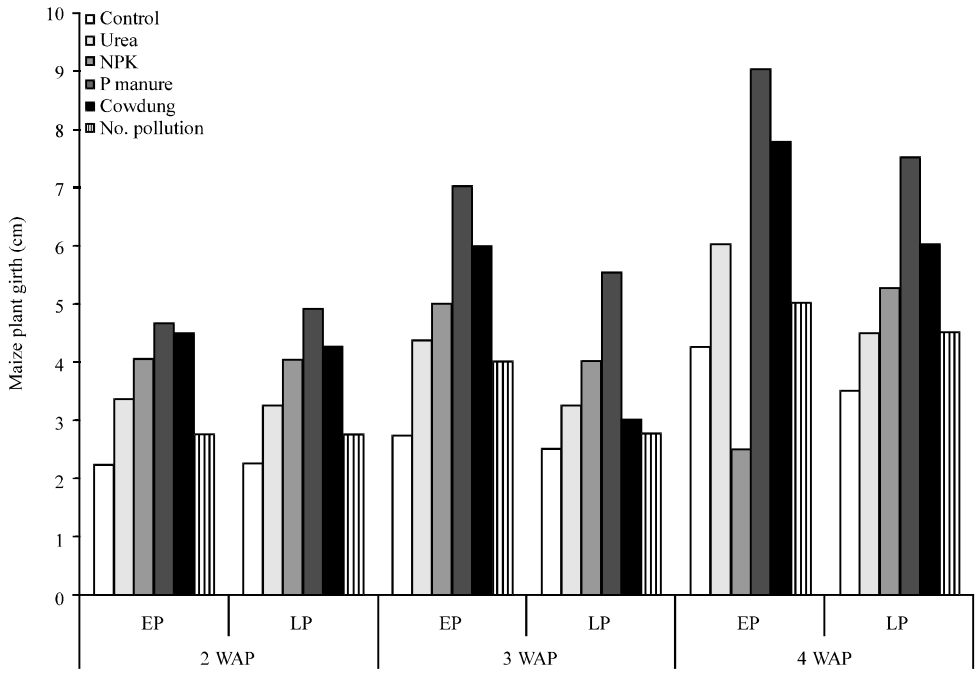

Fig. 2: Effect of remediation materials on maize plant girth 2, 3, 4 weeks after planting. EP: Early planting, LP: Late planting, WAP: Weeks after planting, NPK: Nitrogen, phosphorus and potassium fertilizer

cow dung, NPK, urea and No pollution plot in that order at both seasons. The least plant girth was observed in the control (polluted and un-amended plots). However, the mean value for both seasons was not significantly different from one another at $p<0.05$.

At 4 weeks after planting, poultry manure and cow dung had the highest plant girth. Their values was not significantly higher than that of NPK, but was better than the control and No pollution plots.

Effect of remediation materials on leaf area of maize plant: The result of effect of remediation on leaf area of maize plants planted to crude oil polluted inceptisols is presented in Fig. 3. The result indicated that poultry manure had the highest leaf area (380 and 560 cm), (400 and 381 cm) and (430 and 405 cm) 4, 5 and 6 weeks after planting. Leaf area of maize was positively affected by treatment application in both seasons. The amended plots obtained significantly higher leaf area ranging from poultry manure, NPK, cow dung, Urea, No pollution and Control plots in that order in each cropping season.

The observed reduction in the leaf area of maize plants in the control plot may be attributed to the fact that crude oil application to soil created conditions that limited water supply to the plants (Agbogidi *et al.*, 2007). This also confirmed the report of Cutler *et al.* (1977) that water stress limits leaf development primarily through a reduction in cell size rather than cell number in *Nicotiana tabacum* and *Gossy pium arboreum*. They added that the reduction and depression in leaf area of maize plant grown in soil of higher level of crude oil probably led to reduction in photosynthesis as the surface area of the leaves were reduced. Leaf area depression following

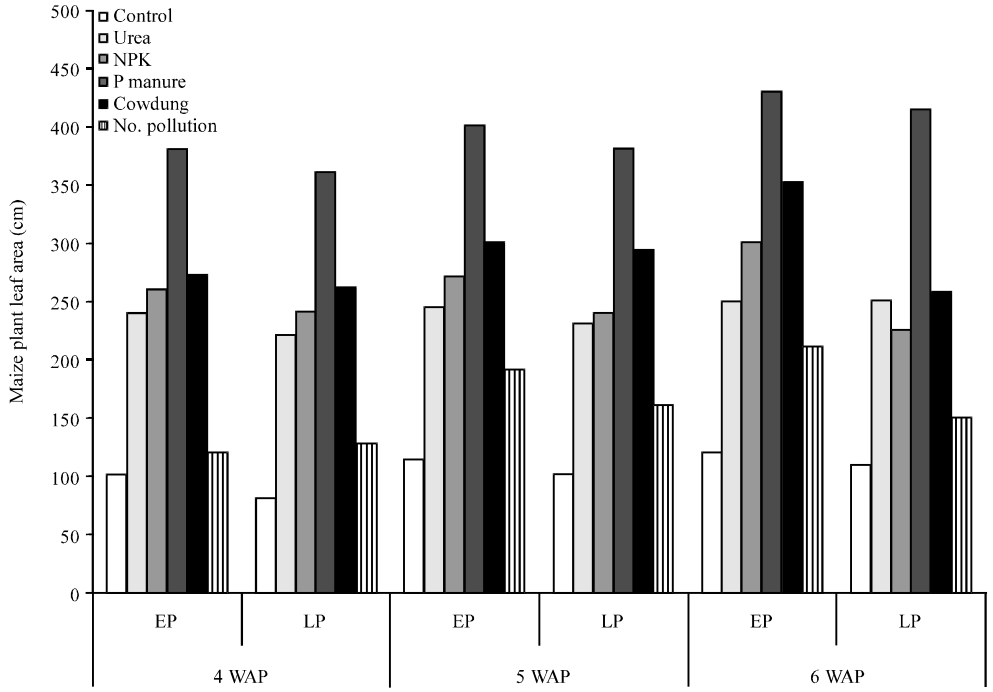

Fig. 3: Effect of remediation materials on leaf area of maize plant, EP: Early planting, LP: Late planting, WAP: Weeks after planting, NPK: Nitrogen, phosphorus and potassium fertilizer

stressed conditions (presence of crude oil) has been reported for melon, hot pepper and tomatoes (Anoliefo and Nwoko, 1954); aquatic macrophytes (Bamidele and Agbogidi, 2000) and *Amaranthus hybridus* (Odjegba and Sadiq, 2002). The significant increase in the leaf area of maize plants in amended plot showed that application of bioremediants (poultry manure, cow dung NPK and urea) to crude oil polluted soils stimulate greater leaf area in maize plants (Agbogidi *et al.*, 2007). This is also in line with the report of Adedokun and Ataga (2007) that improvement in plant growth could be attributed to the addition of soil amendment and bioaugmentation.

Effects of remediation materials on grain and straw yield of maize plant (kg ha^{-1}): The effects of remediation materials on grain and straw yield of maize plant (kg ha^{-1}) is presented in Fig. 4. There are significant differences among the different treatments for grain and straw yield per hectare. Maximum grain yield per hectare (2500 and 1850 kg ha^{-1}) was recorded in plots treated with poultry manure across seasons, while minimum grains yield per hectare (850 and 800 kg ha^{-1}) was observed in the control across seasons. This trend might be due to the role of the different bioremediations applied to the soil which could enhance crop maturation, flowering, fruiting and seed formation. These results are in accordance with those of Thakur *et al.* (1981). The maize yield revealed that crop responded significantly to the different bio-remediation materials as compared to the No pollution and control plots. It was also found that application of poultry manure, cow dung, NPK and Urea improve various crop growth parameters like percent emergency, height, girth and leaf area in line with the report of Krylov and Pavlov (1989) and Wilhelm (1998), thus resulting in higher grain yields across seasons.

Straw yield was also significantly affected by the application of different bioremediations. The highest straw yield (13, 187 and 12969 kg ha^{-1}) was observed in plot treated with poultry manure

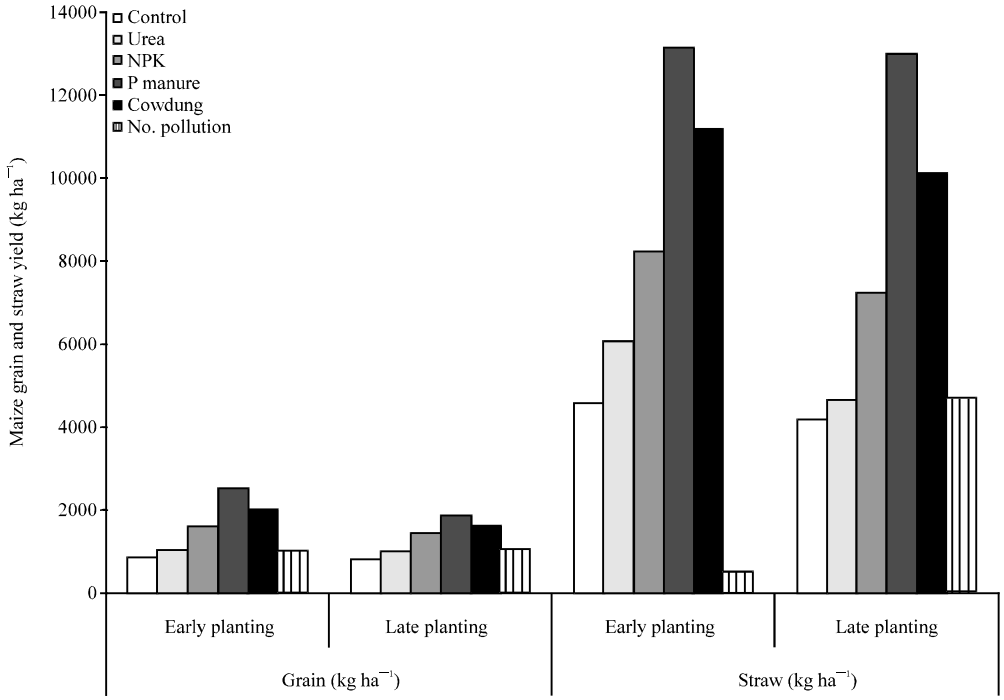

Fig. 4: Effect of remediation materials on grain and straw yield (kg ha^{-1}) of maize plant, EP: Early planting, LP: Late planting, WAP: Weeks after planting, NPK: Nitrogen, phosphorus and potassium fertilizer

followed by cow dung (11, 145 and 10,052 kg ha^{-1}) NPK (8,229 and 7239.5 kg ha^{-1}) and urea (6050 and 6020 kg ha^{-1}) in that order. Least straw yield was observed in the control. The increase in straw yield was due to the nutrients supply by the various bioremediations and well developed root system resulting in better absorption of water and nutrient release by the various remediation materials. This results is in line with the findings of Datt *et al.* (2003). The increase in grain and straw yield owing to the application of remediation materials may be attributed to the fact that the nutrients supplied by these bioremediations are important constituents of nucleotides protein, chlorophyll and enzymes involved in various metabolic processes which have direct impact on the vegetative and reproductive growth of maize plant. These findings confirmed those of Mengel and Kirkby (1996). The Low yield observed in NPK may be attributed to the structure and texture of the Meander belt soils and low water table resulting in leaching of the readily available nutrients (N, P and K) from the mineral fertilizer despite its attribute of containing adequate and balanced nutrients (IFA-UNEP, 2002).

CONCLUSION

Crude Oil pollution adversely affects the soil, but the condition could be improved and ameliorated by the addition of soil nutrient supplement (bioremedants). Data obtained from this experiment showed that, the various remediation materials (Poultry manure, cow dung, Urea and NPK) promoted plant growth parameters such emergence, height, girth, leaf area, grain and dry matter yield. Poultry manure had the best performance across seasons . Evidence that the remediation materials have positive effect on crude oil polluted Inceptisols planted to maize (*Zea mays* L.) in Yenegoa, Bayelsa State, Nigeria.

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