African Journal of Environmental Science and Technology Vol. 7(2), pp. 61-67, February 2013
Available online at http://www.academicjournals.org/AJEST
DOI: 10.5897/AJEST11.309
ISSN 1996 0786 ©2013 Academic Journals

Full Length Research Paper

Effect of remediation on growth parameters, grain and dry matter yield of soybean (*Glycine max*) in crude oil polluted ultisols in Ogoni Land, South Eastern Nigeria

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Accepted 27 February, 2012

The effectiveness of cow dung, poultry manure, NPK (mineral fertilizers) and municipal waste compost which were the easily accessible materials in the remediation of crude oil polluted soils in Ogoni, Rivers state was assessed using soybean as a test crop. A simple factorial field experiment arranged into a randomized complete block design with six treatments was used. Poultry manure gave the highest emergence of 79 and 74.62% at both seasons followed by NPK, cow dung, municipal waste compost and control. The highest plant height of 11.48 and 19.18 cm at four and six weeks after planting (WAP); and 12.70 and 24.70 cm at 4/6 WAP for both seasons were obtained in plots treated with poultry manure. NPK (15:15:15) fertilizer gave the largest leaf area (12.70 and 12.95 cm^2) and (14.43 and 14.56 cm^2) at 4 and 6 WAP for both seasons, respectively followed by poultry manure (11.80 and 11.93 cm^2) and (13.72 and 12.8 cm^2. Poultry manure gave the highest grain yield per hectare of 2,800 and 3,875 kg ha^{-1}) for both seasons. NPK had the highest dry matter yield at both seasons (8,500 and 8,000 kg ha^{-1}), followed by poultry manure (7,000 and 7,500 kg ha^{-1}). Since there were no significant differences in leaf area between NPK, poultry manure and cow dung treatments, the results indicate that poultry manure is the best remediation material for crude oil polluted soils in which soybean is planted.

Key words: Crude oil, polluted soils, soy bean, remediation material, poultry manure, NPK fertilizers, grain yield, plant height, leaf area, Niger delta.

INTRODUCTION

Remediation practices are those treatments or technologies used to restore a polluted or contaminated soil and water (Odu, 2006). Remediation is very necessary in Ogoni land as a result of crude oil spillage; a regular occurrence in the area (Legbosi, 2005). Crude oil spillage is a regular occurrence in the Niger Delta region of Nigeria where over 80% of the crude oil is produced. Dublin-Green et al. (1998) reported that from 1979- 1997, the Nigeria petroleum industries spilled 5334 barrels of oil into the Niger Delta.

Ogoni land is located in the south-eastern part of the lower Niger Delta region and is endowed with abundant natural resources including oil and gas. Ogoni land thus, plays host to five flow stations and 96 oil wells (Vikoo, 2003). Despite the suspension of oil exploration and exploitation activities in Ogoni land since 1993, the area is yet to be spared from oil spillage due to the presence of oil pipeline cris-crossing the entire Ogoni landscape and some of which are trans-Niger tank lines that transport oil to shipment terminal in Bonny Island. No other post-spill remediation responses have been embarked on beyond extinguishing the fire and plastering of the leaking pipes (Hart, 1997). There is need for remediation of the coastal plain sands of Ogoni land using less expensive and easily affordable remediation material such as cow dung, poultry manure, municipal waste compost with soybean as a test crop (Ebie and Ayolagha, 2006).

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Soybean as a leguminous plant has a symbiotic relationship with microorganisms within the soil especially the symbiotic Nitrogen fixing bacteria which promote plant growth and development (Amakiri, 2000).

Soybean has been recognized as a leading tropical grain legume which provide cheap and balanced diet (Ogundipe et al., 1989) with proximate analysis of 40% protein, 32% carbohydrate, 20% edible oil, 5% mineral and 3% fibre.

Municipal waste compost (MWC) of oil polluted soils planted to soybean in Gokana Ogoni increased the levels of K, Na, and Ca; reduced total hydrocarbon content (THC) and seed germination counts; and gave no significant difference in other plant growth parameters (Ayolagha et al., 2000).

Application of N to soybean in the tropic has given variable result depending on such factors as rhizobial strains (Handerson et al., 1987; Somado and Sahrawat, 2007; Chianu et al., 2011). But no information has been obtained on the comparative effects of poultry manure, cow dung, MWC and NPK fertilizers on the remediation of crude oil polluted soils planted to soybean in Ogoni land (coastal plain sands) under natural field conditions. It is the objective of this research to investigate the effect of remediation materials on growth and yield of soybean planted to crude oil polluted soils of the coastal plain sands of Ogoni land, Rivers State.

MATERIALS AND METHODS

The experiment was conducted on a farm in Baa-Lueku in Nyokhana district of Khana local Government Area of Rivers State (Plate 1). It could be located at the following geographical co-ordinate: Latitude 4°40' 5''N and 4° 43' 19.5''N and Longitude 7° 22' 53.7''E and 7° 27' 9.8''E. The soil of the study area is the well-drained costal plain sands deposit (Ultisol). The experimental site has been fallow after some years of intensive cultivation of maize, Okra, yam, cocoyam cassava pumpkin and garden egg without history of soybean cultivation.

The rainfall distribution of the study area ranges from 2000 to 3000 mm (Oyegun and Ologunorisa, 2002) per annum in a bimodal from with average temperature of about 28 to 35°C (Oyegun and Ologunorisa, 2002) depending on the season of the year.

The experiment involves six treatments with four replicates.

These gave a total of twenty four plots in randomized complete block design. Each plot of 2 × 2 m sizes was polluted with 2.4 L of fresh Bonny light crude oil with specific gravity of 0.835 which is equivalent to one percent pollution (Elf, 2000). The no pollution and control plots were not polluted. The crude oil was measured into watering can and spread on each plot and allow to fallow for two weeks before application of remediation materials. The remediation materials used were cow dung, poultry manure, NPK and municipal waste compost. The rate of application were cow dung 10,000 kg ha^{-1}, poultry manure 10,000kg ha^{-1}, NPK 250 kg ha^{-1} and municipal waste compost 10,000kg ha^{-1} in that order (Ethirveerasingam et al., 1985). The chemical composition of the organic manures are presented in Table 1. The following chemical composition: pH, % Org. C, %N, P, Ca and Na show that poultry manure had higher levels than cow dung and MWC in that order.

However, the reverse holds through for Mg and K. The C:N ratio increased from poultry manure, cow dung to MWC. Two weeks after crude oil pollution of each plot, remediation materials were carefully applied except the control and no pollution plots. The control plot was polluted while the non pollution plot was not, however, both were not remediated. The remediation materials were tilled into the soil after being spread and left fallow for another two weeks before planting. After four weeks of planting, the second round of remediation materials were applied in the plots except the control and no pollution plots (Ayolagha et al., 2000). The rate of application of remediation materials was similar to those of the first as stated above.

Emergence of soybean plant seven days after planting

The number of soybean plants that emerged 7 days after planting were observed and estimated in each plot and the percentage emergence calculated. All plots were polluted and amended with remediation materials except the control and no- pollution plots. The control plot was polluted but not amended while the non-pollution plot was neither polluted nor amended. Emergence was determined by the formula:

$$\frac{\text{Number of seeds emerged}}{\text{Number of seeds planted}} \times \frac{100}{1}$$

Plant height 4 and 6 weeks after planting

Plant height per plot was taken at 4 and 6 weeks after planting. The height of soybean plants per plot was measured using measuring tape from the base of the plant to the collar of the last leaf in the plant.

Leaf area 4 and 6 weeks after planting

The leaf area of soybean plant 4 and 6 weeks after planting was determined using the punch techniques. Five leaves were taken from the total leaves per plot and punched. The punched leaves were weighted. The fresh weight of the total leaves per plot was also taken for analysis to relate weight with length using the following formula:

$$\frac{\text{Area of leaf disc}}{\text{Weight of punched leaves}} \times \frac{\text{Total leaf area}}{\text{Total fresh weight of the leaves}}$$

Grain and dry matter yield 12 weeks after planting

The grain yield was assessed after 12 weeks of planting by weighing the dry grains in kilogram per hectare (kg ha^{-1}). The dry matter yield was assessed by oven drying the whole plant at 80°C for 48 h to a moisture content of 14% and determining the dry weight using top weighing balance (Ebie and Ayolagha, 2006).

All data from the field were analyzed using statistical procedure for the analysis of variance (ANOVA) (Steel and Torries, 1960). The new Duncan multiple range test (DMRT, 1955) was used to compare the mean and to analyze the least significant differences (LSD).

RESULTS AND DISCUSSION

Effect of remediation materials on emergence of soybean plant seven days after planting (DAP)

The number of soybean plant that emerged at 7 DAP is

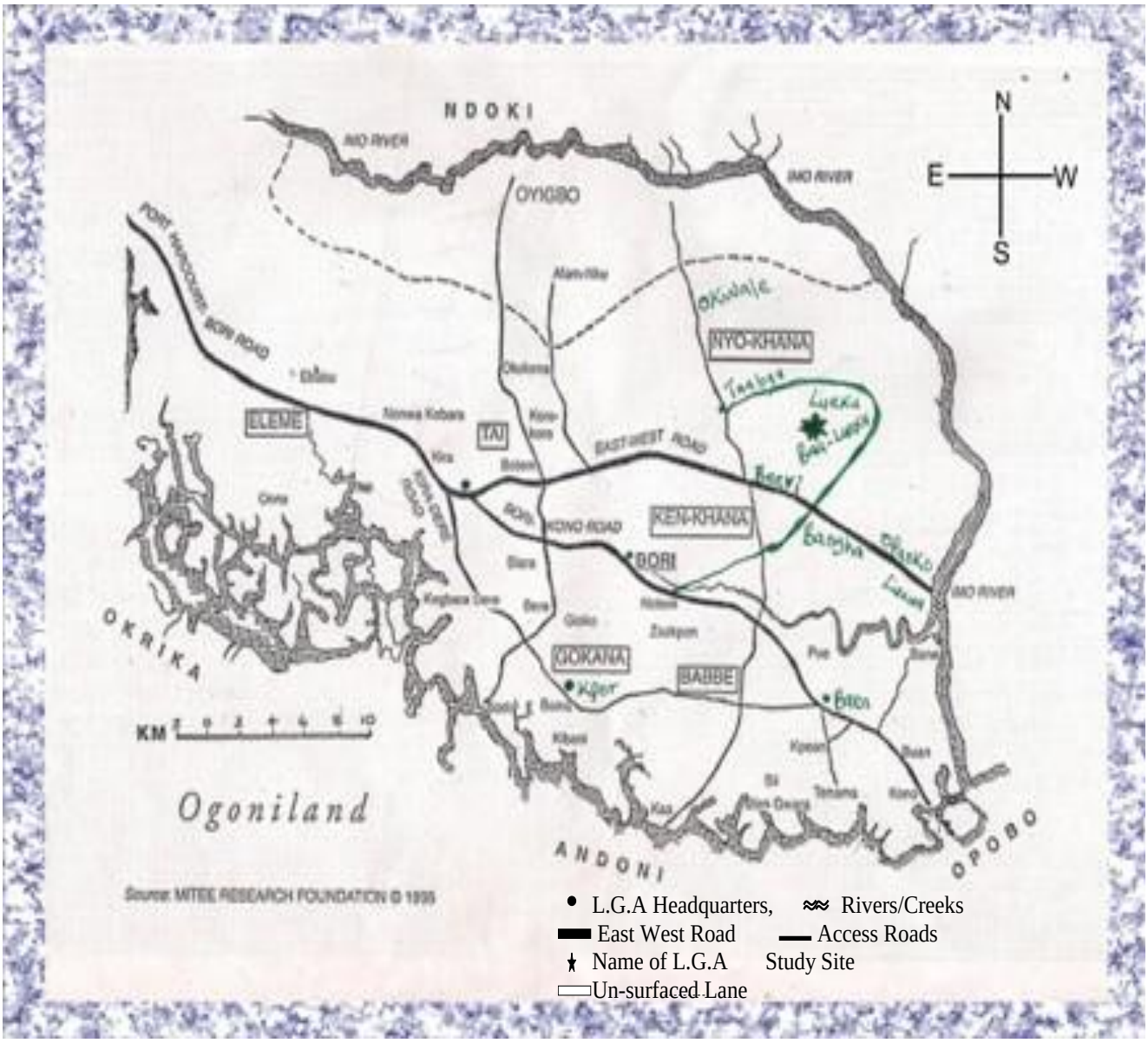

Plate 1. Map of Ogoni.

Table 1. Chemical properties of organic manure used as remediation materials.

Chemical composition of remediation materials	Remediation material		
	Poultry manure	Cow dung	MWC
pH (H_2O)	6.14	5.25	5.20
Org. C. (%)	3.26	3.25	3.24
Total N (%)	0.37	0.30	0.17
Avail. P. (mg kg^{-1})	0.65	0.44	0.64
Ca (mg kg^{-1})	5.80	3.87	3.86
Mg (mg kg^{-1})	1.26	2.43	2.43
K (mg kg^{-1})	1.98	3.61	3.21
Na (mg kg^{-1})	8.00	7.78	7.82
C :N ratio	8.81	10.83	19.06

MCW, Municipal waste compost.

Table 2. Effect of remediation materials on emergence of soybean seedlings.

Treatment	Emergence	7 DAP (%)
	Early planting	Late planting
No pollution	65.38	64.60
Control (pollution without amendment)	56.50	60.00
Cow dung	69.37	67.92
Poultry manure	79.00	74.62
NPK	73.43	68.32
Municipal waste compost	66.25	65.32
Overall means	68.32	65.70

DAP, Days after planting; MWC, municipal waste compost; NPK, nitrogen, phosphorous and potassium fertilizer.

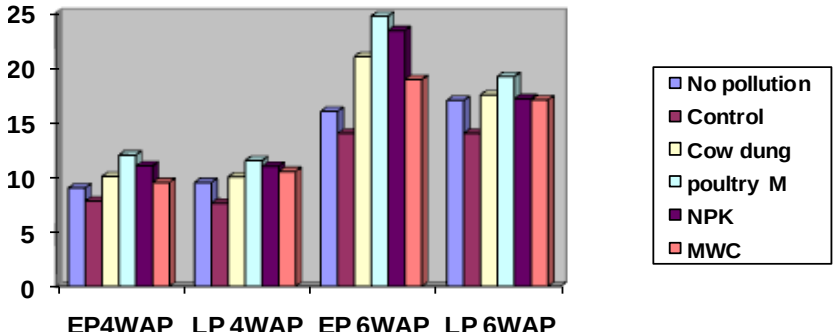

Figure 1. Effects of remediation on soybeans plant height (cm). EP, Early planting, LP, late planting; WAP, weeks after planting; NPK, nitrogen, phosphorus and potassium fertilizer; MWC, municipal waste compost.

crude oil polluted soil treated with poultry manure (79 and 74%) and decreased in the following order NPK (73 and 68%), Cow dung (69 and 67%), municipal waste compost (66 and 65%) and no pollution (65 and 64%) (Table 2). The control (pollution with no amendment) had the least emergence of 56 and 60%. However, the mean value for both seasons was not significantly different from one another.

The low seedling emergence in the control was because crude oil soaked some seeds and damaged them. This is in support of the findings of Kalio (2003) that for a seed to germinate effectively, it must be viable or alive. He reported that the crude oil soaked cotyledons or embryo lead to poor germination. The result also supported the findings of Horne (1978) that heavy crude oil pollution lead to poor germination due to poor soil aeration. He pointed out that the increased C:N ratio and soil temperature lead to poor seedling emergence.

The highest seedling emergence in plot treated with poultry manure and NPK was because these manure and fertilizers were easily dissolvable and absorbable (Awodum, 2007). He added that this promote microbial degradation of hydrocarbon because poultry manure had a lot of micro organisms and at the same time help to bind the soil particles to improve the soil structure thereby improving the soil water and temperature regimes. Cow dung and especially MWC were not as highly dissolvable as poultry manure hence gave lower seedlings emergence. The lower C:N ratio in poultry than the other manures enhanced the higher emergence. Early planting had higher seedling emergence than late planting to support the findings of Ebie (2006) who reported that high rainfall at late planting season affected the rate of seed germination at $p < 0.05$.

Effect of remediation on soybean plant height 4 and 6 weeks after planting

The result of remediation on soybean plant height is presented in Figure 1. Poultry manure had significant vertical growth measurement across the different seasons. Poultry manure also gave plant height of (11.48 and 12.70 cm) 4 weeks after planting at early and late planting and (24.70 and 19.18 cm) 6 weeks after planting at early and late planting respectively. This was followed by NPK (10.98 and 11.58 cm) 4 WAP at both early and late planting and (23.28 and 17.05 cm) 6 WAP for both early and late planting; followed by cow dung, municipal waste compost and no pollution in that order. The control gave the least vertical growth.

Poultry manure gave the highest plant height in

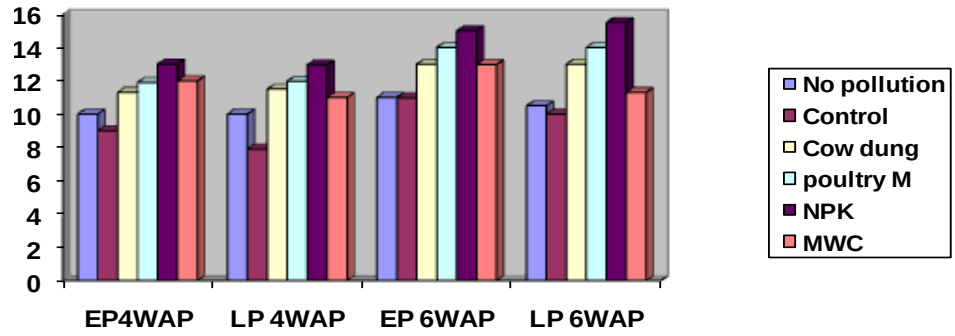

Figure 2. Effects of remediation on soybeans leaf area (cm^2). EP, Early planting; LP, late planting; WAP, weeks after planting; NPK , nitrogen; phosphorus and potassium fertilizer; MWC, municipal waste compost.

conformity with the report of some researchers (Alasiri and Ogunkeyede, 1999; Awodinn, 2007). They stated that poultry manure was easily dissolvable and absorbable and had lower C:N ratio than cow dung and MWC, as such soybean quickly absorbed the nutrient leading to fast growth rate. Soybean is a leguminous crop, hence fixed N into the soil with a resultant decrease in the C:N ratio. Nitrosomonas convert the N to Nitrite while Nitrobacter mineralized the Nitrite to Nitrate (NO_3^{-1}). This easily absorbable Nitrate enhanced growth rate of soybean. The lower C:N ratio of poultry manure enhanced better mineralization of soil minerals, improvement of soil structure, aeration and hence greater productivity and growth of soybean. The higher C:N ratio in cow dung and MWC might have lead to immobilization of minerals and lower productivity. Plant height were higher at 6 weeks than at 4 weeks after planting due to climatic advantages. The higher plant heights observed in plots treated with poultry manures and NPK were because of their quicker dissolvability and absorbability that promotes easy plant uptake for their growth (Awodinn, 2007).

At late planting, the growth rate of soybean in no pollution plot improved to (10.65 cm) because non application of remediation material increased the rate of nodulation to enhance Nitrogen fixation. This is in conformity with the findings of some researchers (Amakiri, 2000; Singh and Saxena, 1977; Mansimba and Mondibaye, 1996). The increase in root nodules could also be caused by their ability to adapt to the environmental stress created by the non-application of remediation materials. This is in line with the observations of (Giller and Wilson, 1993; Chinke et al., 2000) that the Rhizobia species have the ability to adapt to the environmental stress.

Effect of remediation on leaf area of soybean plant

The results of the effect of remediation on crude oil polluted soils as indicated by leaf area of soybean are presented in Figure 2. The results showed that leaf area generally was highest in NPK plot followed by that of poultry manure. The general trend in a decreasing order is as follows: NPK, poultry manure, municipal waste compost, cow dung, No pollution and control plot both in early and late plantings at 4 and 6 weeks after planting. The leaf area at 4 WAP ranged from 9.24 to 12.96 cm^2 for NPK during early planting, and 12.70 cm^2 for NPK at late planting. The leaf area at 6 WAP ranged from 10.48 cm^2 for control to 14.43 cm^2 for NPK at early planting and 10.69 cm^2 for no pollution plot to 14.56 cm^2 for NPK at late planting respectively.

NPK (15:15:15) plot gave higher leaf area followed by poultry manure probably because of their capacity to release nutrients to plants faster due to higher N content and lower C:N ratio (Awodinn, 2007). Micro organisms had to use up the low N in the cow dung and MWC as nutrient before breaking down their carbon. This process reduced the capacity of these materials for remediation of the oil polluted soils.

Effect of remediation on soybean grain yield (kg ha^{-1})

The result on soybean grain yield per hectare is presented in Figure 3. The results showed that at early planting poultry manure had the highest grain yield per hectare (2,800 kg ha^{-1}). This was followed by NPK fertilizer (2,220 kg ha^{-1}), municipal waste compost (2,000 $kgha^{-1}$), cow dung (1,631 $kgha^{-1}$) and no pollution (1,575 $kgha^{-1}$) respectively. The lowest grain yield per hectare (1,044 kg ha^{-1}) was observed in the control. The easy dissolvability and absorbability of poultry manure and NPK which promoted other growth parameters also enhanced increase in yield at early planting, during late planting, poultry manure also had the highest grain yield of (3,875 kg ha^{-1}) followed by NPK (2,687$kgha^{-1}$) and municipal waste compost (2,190kg ha^{-1}). Cow dung and no pollution plots had similar grain yield of 2,000 and 1,780 kg ha^{-1} respectively. Results of yield after various treatments were significantly different from one another at

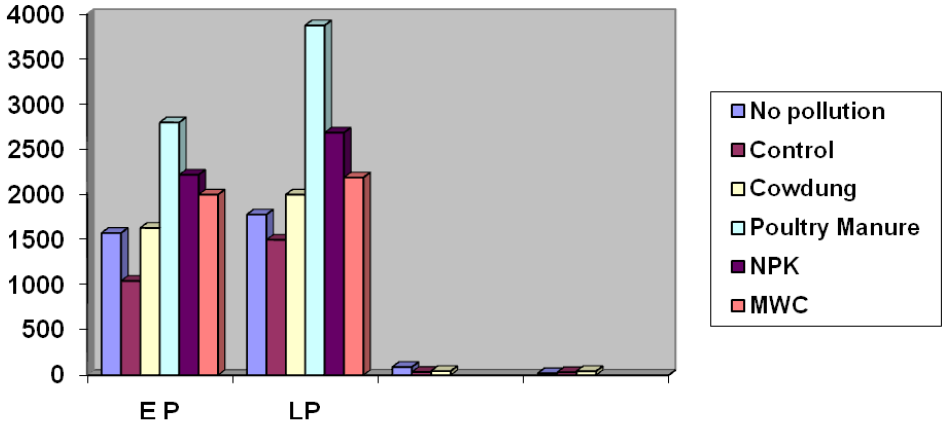

Figure 3. Effect of Remediation on soybean grain yield per hectare. EP, early planting; MWC, municipal waste compost; LP, late planting; NPK, nitrogen; phosphorus and potassium fertilizer.

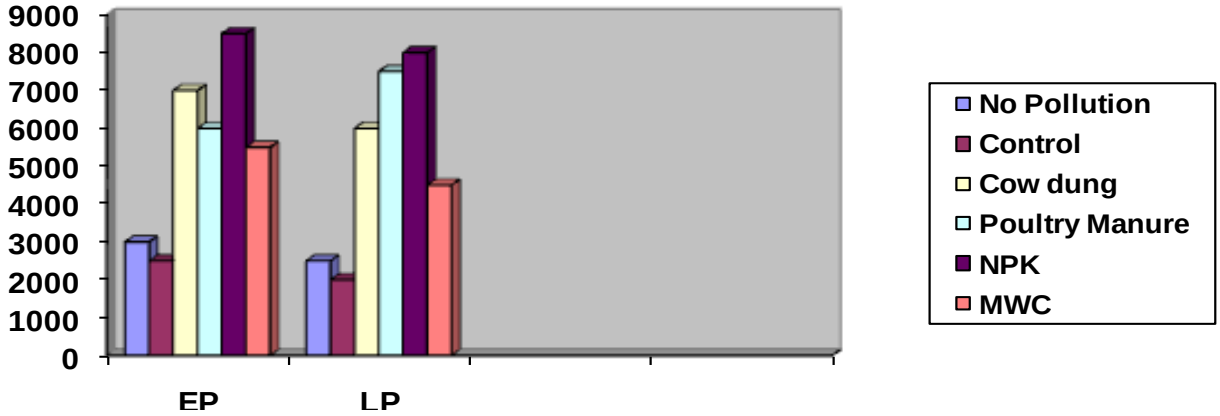

Figure 4. Effects of Remediation on soybean Dry matter yield (kg ha^{-1}). EP, early planting; LP, late planting; MWC, municipal waste compost; NPK, nitrogen; phosphorus and potassium fertilizer.

P<0.05. The control had the lowest grain yield of 1,500 kg ha^{-1}.

The lowest grain yield observed in the control plot was as a result of the non application of remediation materials. This agrees with Raymond et al. (1976) that crude oil has negative effect on the soil because of the high carbon content. Highly increased soil organic carbon is detrimental to plant growth and development due to higher C:N ratio, while N fixation by rhizobium in the soybean nodules and lower C:N ratio increase grain yield.

When compared with the findings of Ebie and Ayolagha (2006) on maize grain yield, it was discovered that poultry manure had (2,039 and 2,109 kg ha^{-1}) at early and late planting seasons respectively followed by cow dung (510 and 1,615 kg ha^{-1}) and NPK (1,500 kg ha^{-1}). This showed that soybean had better grain yield in crude oil polluted soils amended with similar remediation materials than maize. It was also observed that Ebie and Ayolagha (2006) worked on maize planted on the Inceptisols in the Meander Belt geomorphic regions of Bayelsa State while the present research is on soybean planted to crude oil polluted Ultisols in coastal plain sands of Ogoni Rivers State all in Niger Delta.

Effect of remediation on soybean dry matter yield (kg ha^{-1})

The effect of the various remediation materials on soybean dry matter is presented in Figure 4. It showed that soybean plant treated with NPK had the highest dry matter yield of (8,500 and 8,000 kg ha^{-1}) at both early and late planting seasons. Poultry manure had the second position (7,000 and 7,500kg ha^{-1}) followed by cow dung (6,000 and 7,000 kg ha^{-1}) and municipal waste compost

(5,500 and 4,500 kg ha^{-1}) at early and late planting respectively.

Soybean having the highest dry matter yield in NPK plot might be because of NPK's easy dissolvability and absolvability, which enhanced quick up take for proper growth and development of the soybean plant. However, Ebie and Ayolagha (2006) observed that poultry manure gave the highest dry matter of (13,187 and 12,969 kg ha^{-1}), followed by cow-dung (11,145 and 10,052 kg ha^{-1}) and NPK (8,229 and 7,239. 5 kg ha^{-1}) for early and late seasons, respectively. The higher dry matter in maize plants than soybean might be as a result of the structural or morphological differences in both plants. The dry matter yield of soybean treated with poultry manure improved to 7,500 $kgha^{-1}$ at late planting due to climatic advantage and its ability to bind soil particles to form a good soil structure, total pore spaces and hence aeration. The higher moisture retentive capacity of poultry manure might also have contributed to the improved dry matter yield at late planting.

Conclusion

The various remediation materials used for this study improved the different growth parameters of soybean such as seeding emergence 7 DAP, plant height and leaf area 4 and 6 weeks after planting at both early and late planting. Generally, the highest performance in terms of percentage emergence and plant height was recorded in plot treated with poultry manure, followed by NPK, cow dung and municipal waste compost. NPK had the highest leaf area in both seasons the least growth parameters were recorded in the no pollution and controls. Poultry manure also gave the best grain yield in both early and late planting seasons. Poultry manure gave the second best dry matter yield at both plantings. All the above showed that poultry manure is the best remediation material on crude oil polluted soils planted to soybean in the Ultisols of Ogoni land, Rivers State in the Niger Delta.

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