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Effect of Remediation on Growth Parameters, Grain and Dry Matter Yield of Soybean (*Glycine max*) in Crude Oil Polluted Soils in Ogoni Land, South Eastern Nigeria

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ABSTRACT

The effectiveness of organic and inorganic fertilizers (cow dung, poultry manure, NPK and municipal waste compost) in the remediation of crude oil polluted soil 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 four replicates and twenty-four experimental plot with six treatments was used. Plot treated with poultry manure recorded the highest value of emergence (79 and 74.62%) at both seasons followed by NPK (73 and 68.32%), Cow dung (69.37 and 67.92%), municipal waste compost (66.25 and 65.3%), respectively. The least emergence (56.50 and 60%) was observed in the control for both seasons. Soybean plants height were highest in plot treated with poultry manure 4 and 6 WAP (11.48 and 12.70 cm) and (24.70 and 19.18 cm) for both seasons. There was decreased in the following order NPK (10.98 and 11.58 cm) and (23.28 and 17.05 cm), cow dung (10.18 and 11.96 cm) and (20.88 and 17.10 cm), municipal waste compost (10.03 and 11.08 cm) and (18.58 and 16.88 cm), No pollution plot (9.80 and 10.65 cm) and (16.43 and 16.70 cm) and then the control (polluted with no amendment) (8.65 and 9.33 cm) and (14.85 and 14.50 cm). NPK had the largest leaf area (12.95 and 12.70 cm^2) and (14.43 and 14.56 cm^2) 4 and 6WAP for both seasons, followed by poultry manure (11.80 and 11.93 cm^2) and (13.72 and 12.8 cm^2), municipal waste compost (12.29 and 11.53 cm^2) and (12.93 and 12.49 cm^2), cow dung (11.45 and 11.13 cm^2) and (13.06 and 12.51 cm^2), respectively. Poultry manure gave the highest grain yield per hectare (2,800 and 3,875 kg ha^{-1}) for both seasons followed by NPK (2,220 and 2,687 kg ha^{-1}), municipal waste compost (2,000 and 2,190 kg ha^{-1}) and no pollution (1,575 and 1,780 kg ha^{-1}) for both season. NPK had the highest dry matter yield at both season (8,500 and 8,000 kg ha^{-1}), respectively. This was followed by poultry manure (7,000 and 7,500 kg ha^{-1}), cow dung (6,000 and 7,000 kg ha^{-1}), municipal waste compost (5,500 and 4,500 kg ha^{-1}) and no pollution (3,000 and 2,500 kg ha^{-1}), respectively. The least dry matter yield was observed in the control (2,500 and 2,000 kg ha^{-1}) for both seasons. There was improvement in the dry matter yield value of poultry manure (7,500 kg ha^{-1}) and cow dung (7,000 kg ha^{-1}) at late planting when compared to that of early planting. Since, there were no significant differences in leaf area between NPK, poultry manure and cow dung treatments, the results indicate poultry manure as a remediation material in crude oil polluted soils planted to soybean.

Key words: Crude oil, organic and inorganic fertilizers, soybean, dry matter, waste compost

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 Ogoniland 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.

Ogoniland is located in the south-eastern part of the lower Niger Delta region and is endowed with abundant natural resources including oil and gas. Ogoniland thus, plays host to five flow stations and 96 oil wells (Vikoo, 2003). Despite the suspension of oil exploration and exploitation activities in Ogoniland since the year 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 Ogoniland using less expensive and easily affordable remediation material such as cow dung, poultry manure, municipal waste compost with soybean as a test crop. Some research workers have investigated the effect of crude oil pollution on soils and crop growth (Rowell, 1977; Kinako, 1981; Amakiri and Onofeghara, 1983; Amadi *et al.*, 1992; Ebie, 2006). Those researches were carried out in the temperate region, Sambriemo-warri Deltaic plain geomorphic zone and the Meander belt or Rivers and Bayelsa State (Snowden and Ikweozor, 1987). Ayolagha *et al.* (1994) also carried out research on remediation of crude oil polluted soils using municipal waste compost for soybean production in Niger Delta, but this experiment was carried out in a green house which was a limiting factor because, the grains and dry matter yield of soybean after harvest under natural conditions which is important to farmers was not assessed.

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.

Application of N to soybean in the tropic has given variable result depending on such factors as rhizobial strains (Harder-Son *et al.*, 1987). But no information has been said on the effect of crude oil polluted soil on soybean in Ogoniland (coastal plain sand) under natural field conditions. The objective of this research was to investigate the effect of remediation materials on growth parameters of soybean planted to crude oil polluted soils of the coastal plain sands of Ogoniland, Rivers State.

MATERIALS AND METHODS

The experiment was conducted on a farmer's field in Baa-Lueku in Nyokhana District of Khana local Government Area of Rivers State. It could be located at the following georgraphical co-ordenate, (4405[1]N and 7°22 53. 7E and 4°43 19.5N and 70 27°9.8E).

The soil of the study area is the well-drained costal plain sand deposit (Ultisol). The experimental site has been under 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 2000-3000 mm per annum in a bimodal form with average temperature of about 28-35°C 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 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 10,000 kg ha^{-1}, NPK 250 kg ha^{-1} and municipal waste compost 10,000 kg ha^{-1} in that order.

Two weeks after crude oil pollution of each plot, remediation materials were carefully applied except the control and no pollution plots. 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 using the ring method except the control and no pollution plots.

Percentage emergence 7 days after planting (7DAP): Percentage emergence of soybean plant was taken 7 days after planting (7DAP). Emergence counts was determined by the formula:

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

Plant height 4 and 6 weeks after planting (4 and 6 WAP): 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 of soybean plant (*Glycine max*) 4 and 6 weeks after planting: The leaf area of soybean plant 4 and 6 weeks after planting was determined using the punch techniques described by Osodeke and Ojenije (2003). 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 formula:

$$\text{Fresh weight of the total leaves per plant} = \frac{\text{Total leaf area}}{\text{Total fresh weight of the leaves}} \times \frac{\text{Area of leaf disc}}{\text{Weight of punched leaves}}$$

Grain and dry matter yield 12 weeks after planting: Twelve week after planting the grain yield was assessed by weighing the dry grains in 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.

All data from the field were analyzed using statistical procedure for the analysis of variance (ANOVA) (Steel and Torrie, 1960). The new Duncan (1955) multiple range test (NDMRT) and SAS (1999) 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 (7) days after planting (7DAP): The number of soybean plant that emerged at 7 DAP is presented in Table 1. Soybean emergence was highest in 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%). The control pollution with no amendment was (56 and 60%). Low seedling emergence in the control was because crude oil soaked some of the seed 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. The soaked cotyledons or embryo by crude oil leads to poor germination.

This also support the finding of Horne (1978) which stated that heavy crude oil pollution lead to poor germination due to poor soil aeration. He pointed out that this increase soil temperature leading to poor seedling emergence.

The highest seedling emergence in plot treated with poultry manure and NPK was as a result of the fact that they are easily dissolvable and absorbable (Awodun, 2007). They added that this promote microbial degradation of hydrocarbon because poultry 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. Early planting had highest seedling emergence than late planting to support the finding of Ebie (2006) that high rainfall at late planting season affect the rate of seed germination. However, the mean value for both seasons were not significantly different from one another 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 Fig 1. Result showed that poultry manure has significant veridical growth measurement across the different seasons in conformity with the report of Alasiri and Ogunkeyede (1999) and Awodun (2007) which stated that poultry manure is easily dissolvable and absorbable as such soybean quickly absorbed the nutrient leading to fast growth rate. Poultry manure 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 least vertical growth measurement was recorded

Table 1: Effect of remediation materials on emergence of soybean plant

	Emergence	7 DAP (%)
Treatment	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

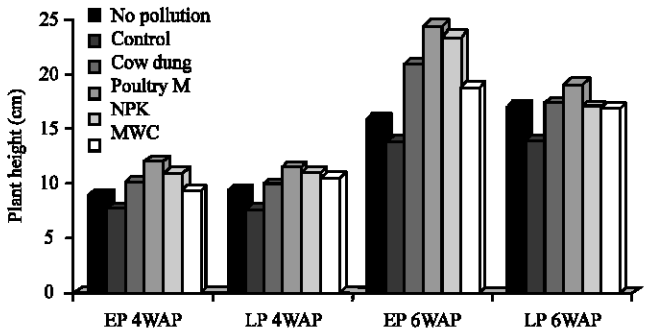

Fig. 1: Effects of remediation on soybeans plant height. EP: Early planting, LP: Late planting, WAP: Weeks after planting, NPK: Nitrogen, phosphorus and potassium fertilizer, MWC: Municipal waste compost

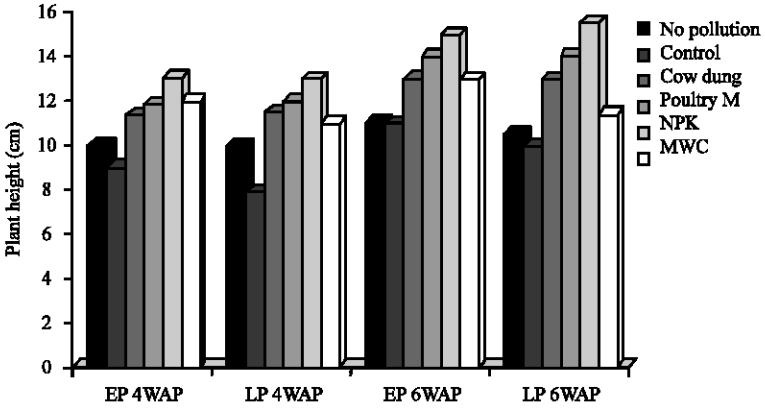

Fig. 2: Effects of remediation on soybeans leaf area, EP: Early planting, LP: Late planting, WAP: Weeks after planting, NPK: Nitrogen, phosphorus and potassium fertilizer, MWC: Municipal waste compost

in the control plot. Plants were higher were 6 weeks than at 4 weeks after planting due to climatic advantages. The higher plants observed in plots treated with poultry manures and NPK was because they were in simple dissolvable and absorbable form, that promotes easy plant uptake for their growth (Awodun, 2007). He reported that poultry manure contain a lot of microorganism which help to degrade the crude oil and enhance plant growth.

At late planting 4 weeks after 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 in conformity with the findings of other researchers (Amakiri, 2000; Singh and Saxena, 1977; Mansimba and Mondibaye, 1996). The increase in root nodules could also be caused by their ability to adopt to the environmental stress created by the non-application of remediation materials. This is in line with the observation of Giller and Wilson (1993) and Chinke *et al.* (2000) which stated 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 represented in Fig. 2. The result

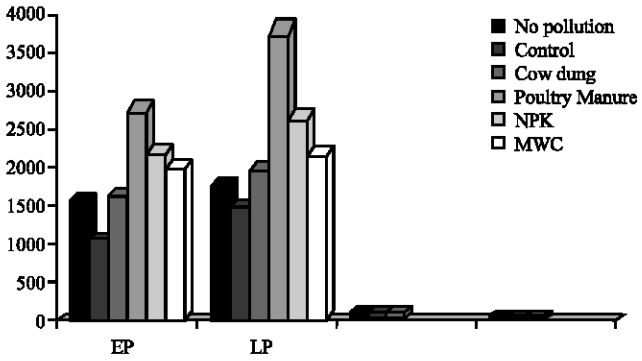

Fig. 3: Effect of Remediation on soybean grain yield per hectare. EP = Early Planting, LP = Late Planting, NPK = Nitrogen, phosphorus and potassium fertilize, Mwc = Municipal waste compost

showed that leaf area generally was highest in NPK Plot followed by that of poultry manure because their nutrients were probably released faster and absorbed by plant (Awodun, 2007). The general trend in a decreasing order is as followed, 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 o 12.96 cm^2 for NPK during early planting 8.92 cm^2 for control to 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.

Effect of remediation on soybean grain yield in kilogram per hectare (kg ha^{-1}): The result on soybean grain yield for hectare is presented in Fig. 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 kg ha^{-1}), cow dung (1,631 kg ha^{-1}) and No pollution (1,575 kg ha^{-1}), respectively.

The lowest grain yield per hectare (1,044 kg ha^{-1}) was observed in the control. The easily dissolvable and absorbable form of poultry manure and NPK which promotes 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 kg ha^{-1}) and municipal waste compost (2,190 kg ha^{-1}). Cow dung and no pollution plots had similar grain yield of (2,000 and 1,780 kg ha^{-1}), respectively.

However, there were significantly different from one another at $p<0.05$. 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 carbon content. Increase soil organic carbon is detrimental to plant growth and development. It was also observed that the highest grain yield per hectare for poultry manure at late planting was as result of it ability to bind soil particles to form a good soil structure to retain moisture at late planting.

When compare with the findings of Ebie (2006) on maize grain yield, it was discover 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}).

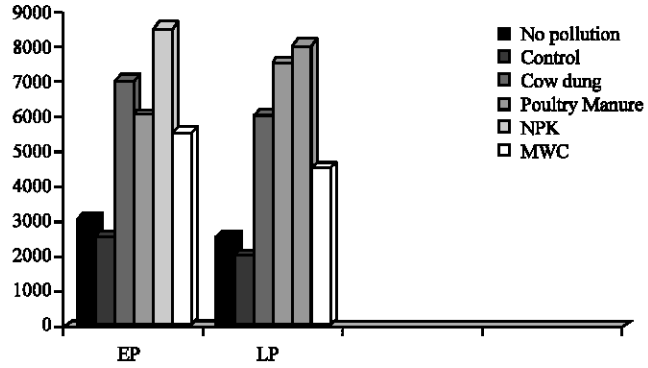

Fig. 4: Effects of Remediation on soybean Dry matter yield in kilogram per hectare (kg ha^{-1}). EP = Early Planting, LP = Late Planting, NPK = Nitrogen, phosphorus and potassium fertilizer, Mwc = municipal waste compost

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 (2006) worked on maize in the Meander Belt geomorphic regions of Bayelsa State, while Peter (2009) worked on soybean planted to crude oil polluted soil in coastal plain sand of Ogoni all in Niger Delta.

Effect of remediation on soybean dry matter in kilogram per hectare (kg ha^{-1}): The effect of the various remediation materials on soybean dry matter is shown in Fig. 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 and NPK is in a form that is easily dissolvable and absorbable, thereby enhance quick up take for proper growth and development in plant. Poultry manure had (7,000 and 7,500 kg 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. These findings were compare with Ebie (2006) re on maize dry matter and it was 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 may be as a result of the structural or morphological differences in both plants (maize and soybean). It was also observed that poultry manure gave the highest dry matter yield in maize (Ebie, 2006). While NPK gave the highest dry matter yield in soybean across seasons. The dry matter of soybean treated with poultry manure improved to 7,500 kg ha^{-1} at late planting due to climatic advantage and it ability to bind soil particles to form a good soil structure. The higher moisture retentive capacity of poultry manure might have also contributed to the improved dry matter yield at late planting irrespective of the treatments dry matter yield for both seasons (early and 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 week after planting at both early and late planting. Generally, the highest performance in term 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. These show that the remediation materials have positive effect on crude oil polluted soil planted to soybean in Ogoniland, Rivers State.

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