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EFFECT OF CHARCOAL AND SPENT ENGINE OIL ON SOME GROWTH INDICES OF *Rhizophora racemosa* G. MAYER GROWN IN GARDEN SOIL

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ABSTRACT

This study investigated the effect of charcoal and spent engine oil on some growth indices of mangrove seedlings Rhizophora racemose G. Mayer grown in garden soil. The aim was to discover means of improving mangrove nursery growth and survival in the Niger Delta area of Nigeria. Rhizophora racemose was planted in garden soil amended with four different treatments: C (Garden soil only), PC (Garden soil + Charcoal), PCSEO (Garden soil + Charcoal + 6% Spent engine oil), and SSEO (Garden soil + 6% Spent engine oil), with three replicates each and randomized complete block design was adopted for the study. The effect of these treatments was monitored biweekly on some growth indices – plant height, leaf area, leaf length, number of leaves and stem girth, except for root length, number of roots, fresh weight, dry weight and chlorophyll content of R. racemosa which were obtained at 18th week after planting. The study revealed that PC treatment had the highest values for plant height, number of leaves, fresh weight, plant girth, root length when compared to other treatments (C, PCSEO and SSEO) while SSEO recorded the least values. Among the treatments, there were significant differences in the plant height, fresh weight and root length of R. racemosa at P = 0.05. The garden soil amended with charcoal improved the performance of R. racemosa than in spent engine oil alone (PC > PCSEO > SSEO). This could be attributed to the presence of heavy metals in spent engine oil. Again, the charcoal amended soil had higher values for growth indices when compared with the control (C) treatment. This suggest that charcoal has the potency of improving garden soil fertility, plant survival and productivity. Therefore, charcoal could be beneficial in environmental conservation, restoration of endangered forest especially the mangroves in the Niger Delta polluted with crude oil. The study recommends that, charcoal should be incorporated in reforestation and afforestation approaches of mangrove forests.

Keywords: Charcoal, effects, growth indices, *Rhizophora racemose*, spent engine oil

INTRODUCTION

Several authors have described mangroves to be salt tolerant plants. According to Spalding *et al.* (2010), mangroves are trees or large shrubs that have adapted to survive in harsh environmental conditions, thus developing unique survival features in the face of high salinity, anaerobic and waterlogged soils, and a challenging environment for seed dispersal and propagation. Mangroves, have the ability to survive extreme transitional zone, which serves as a link between marine and terrestrial habitats (Chand, 2018). Generally, mangroves are seen also, as other flora and fauna which utilize a coastal and saline depositional environment involving a variety of coastal landforms with typically anaerobic soil (Saifullah, 1985; Numbere and Obanye, 2023).

Due to the environmental stress conditions that is predominant within its habitat, mangroves developed some physiological and morphological adaptations to ensure its survival. These includes development of viviparous mode of reproduction, aerial roots (pneumatophores), salt exclusion and salt secretion to overcome the environmental stress and be able to survive in intertidal zones (Scholander, 1968; Shi *et al.*, 2005), as well as development of silt root which does not only provide physical support to the plant but serves as a means of gaseous exchange in the root system through the lenticels (McKee, 1993), Scientists in recent times, started unveiling the immense potentials and benefits the mangrove forest and wetlands at large possess. This interests toward mangrove forest today has revealed several ecosystem services offered by the mangrove forest and includes; **(**1) facilitate the expansion of coastal areas as well as enhancing the productivity of marine life, (2) home for Biodiversity (landing point for migratory birds), (3) enhancement of coastal fisheries (4) nursery grounds for commercially and recreationally valued species, (5) filtration of sediment, nutrients and pollutants, (6) prevent soil erosion, (7) protect coastlines; from natural disasters such as floods and protection of coastal communities against strong winds and devastating sea waves and (8) Carbon sequestration (FAO, 2007; Komiyama *et al.,* 2008; Hoang and Pham, 2010; Mukherjee *et al*., 2014; Huxham *et al.,* 2015; Barbier, 2016).

Mangrove forests occupy about 15.2 million hectares of tropical coast worldwide (Spalding *et al.,* 2010), Africa mangrove cover represents about 19%, housing over 16 species of mangroves which are equally distributed between the east and the west. *Rhizophora racemosa* belongs to the red mangrove family Rhizophoracea which is one of the most important and diverse families of mangroves (Mensah *et al.,* 2013; Oji *et al*., 2018). NDES (1996) reported that Rhizophoracea comprises other species such as *Rhizophora mangle* and *Rhizophora harrisonii,* which are widely distributed across the East Atlantic regions of the world, covering over 60% of the mangrove forest in the Niger Delta region of Nigeria. Oji *et al*., 2018 also reported that Nigeria mangrove forest is the fifth largest in the world and inhabits about 975,000 km^2 of the low-lying land fringing the coastal swamps of Southern Nigeria from Bakassi in the East to Badagry in the West of the Niger Delta, which is located in the Southern part of Nigeria (World Bank, 1995).

The Niger Delta region of Nigeria which is the area of this study is known for its large deposits of crude oil and gas. The Niger Delta accounts for over 80% of Nigeria's total annual earnings. However, the willful negligence of the oil and gas developments have been highly damaging to the Niger Delta's destroying habitats, threatening plant and animal species as well as destroying the livelihoods for many resource users, whose source of living is based on farming and fishing (UNEP, 2011). The effect of crude oil pollution on plants have shown to be directly proportional to the spill (Baker, 1981) which will determine the level of treatment to be used (Offor and Akonye, 2006). Amakiri and Onofeghara (1983) reported that oil tends to act as physical barrier preventing entry of vital factors and nutrients such as water and oxygen that are required for plant growth and development. When this happens, flora and fauna stand the risk of destruction. Therefore, this study, seek to investigate the effect of charcoal on some growth indices of mangrove seedlings *R. racemosa* raised in polluted garden soil for easy *ex situ* mangrove nursery and forest conservation.

MATERIALS AND METHODS

Sampling Site and collection of propagules: Study sites was at Gambia-Ama, University of Port Harcourt Choba rain forest (Lat.

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N4°54′15″, Long. E6°54′35″). Garden soil was also collected at the same location as the study site. Matured seedlings of *R. racemosa*, were harvested from Borokiri waterside in Port Harcourt Local Government Area of Rivers State. Matured and viable seedlings were physically accessed, seedlings were sorted according to their sizes, colour and maturity. Those showing reddish colour with lengths between 29 – 36 cm and with no physical damage were considered mature and viable for use.

Planting of *R. racemosa*: Seedlings of *R. racemosa* were planted in garden soils with various amendments:

i. Garden soil only [Control (C)]
ii. Garden soil + Charcoal (PC)
iii. Garden soil + Spent engine oil (SSEO)
iv. Garden soil + Charcoal + Spent engine oil (PCSEO)

The control was garden soil with no mixture of either charcoal or spent engine oil, PC consisted of the mixture of charcoal and garden soil in a ratio of 1:1, SSEO had the garden soil polluted with 6% spent engine oil while PCSEO had garden soil mixed with charcoal in a 1:1 ratio with the addition of 6% spent engine oil. All treatments were replicated 3 times. *Rhizophora racemosa* propagules were planted on the different soil treatments on the same day. Replicates of treatment were kept under a conducive condition where all treatments had access to light rays from the sun and rainfall in other to allow for seedling development. Before planting, soil pollution was done one week before mixing with or without charcoal in the different treatment types.

Growth Indices measured: Growth parameters investigated were plant height, leaf area, number of leaves, length of leaf, and plant girth. These parameters were observed bi-weekly. The number of roots, chlorophyll content, plant fresh weight and plant dry weight were obtained 18 weeks after planting.

Statistical Analysis: Data collected were subjected to statistical analysis at the probability of 95% confident limit using analysis of variance (ANOVA).

RESULTS

Theeffect of treatments on some growth indices of mangrove seedlings are shown in Table 1. The effect of charcoal and spent engine oil on area of leaves of mangrove seedlings showed that, seedlings grown in PCSEO gave the highest area of leaves, with a mean area of 11.07 ± 1.34 at the end of the 18th week, followed by C (8.85 ± 0.77) while SSEO 8.47 ± 0.58. The value for SSEO was higher than the value recorded for PC (7.5 ± 0.93). The results indicated that PCSEO gave the highest area of leave value. Thus, the result obtained showed that there was no significant difference between all the treatments at P = 0.05.

The chlorophyll content of mangrove seedlings showed that, seedlings grown in PC and C had the same chlorophyll contentat the 18th week after planting, followed by SSEO and PCSEO. However, this difference in chlorophyll content is not statistically different at P = 0.05.

The leaf dry weight shows the mean values of the different mangrove propagules treatments. It indicated that treatments PCSEO gave the highest values for dry weight with a mean value of 34.05 ± 0.49at the end of the eighteenth week of growth. This was followed by the PC (32.56 ± 4.74).The mean dry weight of C and SSEO indicated low values of 31.3 ± 0.4and 24.45 ± 1.23respectively. The results for dry weight generally indicate that treatment PCSEO recorded the highest values. Statistical analysis showed no significant difference among the mean values of all treatments at P=0.05. While the study showed that PC had the highest value for fresh weight when compared to C. It was observed that the fresh weight of C was appreciably higher than PCSEO and SSEO treatments. At the end of 18 weeks after growth, SSEO recorded the least mean value. The result showed significant difference between treatments at P=0.05.

The stem girth of *R. racemosa* varied across treatments. PC had the highest girth of plant, with a mean height of 4.77 ± 0.36 at the end of the 18th week, followed by the PCSEO treatment (4.43 ± 0.31) and SSEO treatment SSEO (4.24 ± 0.26). However, the result obtained showed that there was no significant difference among the treatments at P = 0.05.

The effect of charcoal and spent engine oil on the growth of mangrove seedlings showed that on plant height, treatments PC gave the highest height, with a mean height of 35.07 ± 2.96 at the end of the 18th week, followed by the C treatments (10.41 ± 2.13cm) while the treatments PCSEO recorded 27.32 ± 1.43. The value for PCSEO was higher than the value recorded for SSEO (25 ± 1.2). The results indicated that treatments PC gave the highest plant height value. Thus, the result obtained showed that there was significant difference among the treatments at P = 0.05.

The leaf length of *R. racemose* indicated that treatment PCSEO gave the highest values for leaf length with an average leaf length of 5.84 ± 0.63at the end of the eighteenth week of growth. This was followed by the SSEO treatment (5.28 ± 0.35). The mean length of leaves of PC and C treatments indicated low values of 5.25 ± 0.44 and 4.94 ± 0.29respectively. The results for leaf area generally indicate that PCSEO treatment recorded the highest mean value. Statistical analysis showed no significant difference between PCSEO and SSEO but showed significant difference between PC and C at P=0.05. While for number of leaves, PC gave the highest values for number of leaves with a mean value of 5.2 ± 0.74 at the end of the eighteen weeks of growth. This was followed by the PCSEO (5 ± 0.62).The mean number of leaves of C and SSEO indicated least mean values of 4.73 ± 0.57 and 4 ± 0.54 respectively. The results for number of leaves generally indicate that treatment PC recorded the highest mean value. Statistical analysis showed that all treatments were not significantly difference from each other at P=0.05.

For the root length, the study showed that treatments PC gave the highest values for root length with a mean value of 19.33 ± 1.2 at the end of the eighteenth week of growth. This was followed by the SSEO (18.67 ± 1.45).The mean root length of C and PCSEO indicated least mean values of 17 ± 2.08 and 12.33 ± 1.45 respectively. The results for root length generally indicate that treatment PC recorded the highest mean value. Statistical analysis showed that PC and SSEO were statistically the same with C but showed significant difference with PCSEO. However, treatment C was not statistically different from PCSEO at P= 0.05. While for number of roots showed the result of propagules treatments indicated decrease in number of roots from C (27.33 ± 3.71) to PC (26.67 ± 6.01). However, the number of roots sharply decreased further with addition of spent engine oil on treatments recording 25.67 ± 3.84 for PCSEO and 20 ± 2.89for SSEO treatments respectively. This result was comparable to C, PC and PCSEO treatments but appreciably higher than the SSEO treatment. Again, C treatment recorded the highest number of roots. It was noted, that there was no significant difference between all treatments at P = 0.05.

Table 1: Effect of treatments on some growth indices of mangrove seedlings *R. racemosa* at 18WAP.

Parameter	**C**	**PC**	**PCSEO**	**SSEO**	**LSD**
Area of leaves (cm^2)	8.85 ± 0.77^a	7.50 ± 0.93^a	11.07 ± 1.34^a	8.47 ± 0.58^a	NS
Chlorophyll content	0.06 ± 0.01^a	0.06 ± 0.02^a	0.01 ± 0.00^a	0.04 ± 0.01^a	NS
Dry weight (g)	31.30 ± 0.40^a	32.56 ± 4.74^a	34.05 ± 0.49^a	24.45 ± 1.23^a	NS
Fresh weight (g)	48.63 ± 0.42^b	58.63 ± 0.17^c	48.04 ± 0.49^b	36.06 ± 1.20^a	2.232
Plant girth (cm)	4.30 ± 0.20^a	4.77 ± 0.36^a	4.43 ± 0.31^a	4.24 ± 0.26^a	NS

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Plant height (cm)	27.95 ± 1.62^{b}	35.07 ± 2.96^{c}	27.32 ± 1.43^{b}	25.00 ± 1.20^{a}	1.576
Leaf length (cm)	4.94 ± 0.29^{a}	5.25 ± 0.44^{a}	5.84 ± 0.63^{a}	5.28 ± 0.35^{a}	NS
Root length (cm)	17.00 ± 2.08^{ab}	19.33 ± 1.20^{b}	12.33 ± 1.45^{a}	18.67 ± 1.45^{b}	5.16
Number of leaves	4.73 ± 0.57^{a}	5.20 ± 0.74^{a}	5.00 ± 0.62^{a}	4.00 ± 0.54^{a}	NS
Number of roots	27.33 ± 3.71^{a}	26.67 ± 6.01^{a}	25.67 ± 3.84^{a}	20.00 ± 2.89^{a}	NS

Mean ± Standard Error. Values followed by the same letter(s) across the row are not significantly different at 5% level using LSD. Garden soil only [Control (C)]; Garden soil + Charcoal (PC); Garden soil + Spent engine oil (SSEO); Garden soil + Charcoal + Spent engine oil (PCSEO); Garden soil + Spent Engine Oil (SEO)

DISCUSSION

The results from the research indicated that, the propagules pretreated with charcoal (PC) gave the highest values for plant height, number of leaves, fresh weight, plant girth, root length, when compared to the other treatments and the control (C). Control treatment gave higher values for growth parameters determined when compared to PCSEO and SSEO treatments. The SSEO treatment recorded the lowest values for growth indices determined. The result obtained was seen to be in line with other findings, that mangroves *R. racemosa* can be successfully raised in garden soil (Oji *et al.*, 2018) and the addition of charcoal in a ratio of 1:1 result in optimal increase in plant growth parameters.

Studies showed that high concentration of THC in soils negatively mitigates plant growth and productivity (Osuji *et al.*, 2004; Okolo *et al.*, 2005), thus, the concentration of hydrocarbon present in spent engine oil had negative impact on both polluted treatments (PCSEO and SSEO) when compared to PC and C, this is because heavy metals present in spent lubricants can accumulate in plants and affect metabolic processes (Prasad and Prassad, 1987). This suggests why the result showed reduction in the growth indices of *R. racemosa* in the polluted treatments at the end of the 18WAP. Iwuagwu *et al.* (2018) investigated the effect of charcoal on soil polluted with spent engine oil, the study found that soil treated with charcoal and polluted with spent engine oil (PCSEO) had higher values in area of leaves, dry weight, and leaf length, compared to untreated polluted soil. These results suggest that charcoal can mitigate the negative effects spent engine oil pollution on soil and promote plant growth in contaminated soils, this was evident in this research as the PCSEO had better growth indices than SSEO.

Further studies showed that, addition of charcoal to soil in a ratio of 1:1, has the potential of carbon sequestration, increase soil fertility, soil pH, reduce leaching, improve soil structures, improve water retention, reduce greenhouse gas emission and has the ability to improve soil quality in degraded or nutrient poor soil thus increasing microbial activity and increased soil respiration (Lehmann, 2007; Atkinson *et al.,* 2010; Major *et al.,* 2010; Zhang *et al.,* 2023). These changes could improve bioavailability of nutrients to the plants and even stimulate the release of plant-growth-promoting hormones. This therefore, will have positive impact on propagules grown on charcoal treatments by enhancing plant height, leaf number and leaf area (Kishimoto and Suguira, 1985; Chidumayo, 1994; Ishii and Kadoya, 1994; Rodriguez *et al.*, 2009; Sokchea and Preston, 2011). This observation was found to agree with the present study of *R. racemosa* as charcoal proved effective in the growth of propagules raised in charcoal treatments when compared to C and SSEO (PC > C and PCSEO > SSEO). Charcoal boosts the activity of beneficial fungi and bacteria in the soil, enhancing special fungi that infect a plant's roots and help it get more nutrients from the soil (Yamato *et al.,* 2006), which might be an explanation for the longer root lengths of the PC treatment. However, the chlorophyll content for all treatments seemed to be constant.

CONCLUSION

From this study, the use of charcoal in soil pretreatment, has shown to have positive effects on soil fertility, plant growth and survival. The optimum charcoal concentration in soil was in a ratio of 1:1. PC and PCSEO gave the highest values when respectively compared to the different treatments C and SSEO, as it was seen that charcoal addition in the different treatments, led to increase in plant growth, development and survival. Charcoal which was seen to be less important can be used in agricultural practices like plant nursery. The study recommends that, charcoal should be incorporated in reforestation and afforestation approaches of mangrove forests as charcoal has the potential for enhancing survival of propagules in contaminated soil. However, further research is needed to fully understand the mechanisms underlying these effects and to optimize the use of charcoal as a garden soil amendment tool in mangrove nurseries in the Niger Delta and the world over.

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