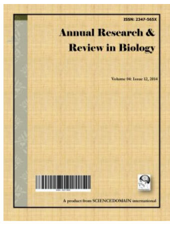

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Morphological and Biochemical Response of Cassava (*Manihot esculentus*, Crantz) to Spent Carbide and Diesel Oil Wastes

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Authors' contributions

This work was carried out in collaboration between both authors. Author FBGT designed the study, wrote the protocol, interpreted the data, managed the literature searches and produced the initial draft. Author SIM anchored the field study, gathered the initial data and performed preliminary data analysis. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: To determine the morphological and biochemical response of cassava (*Manihot esculentus*, Crantz) to spent carbide (SC) and diesel oil (DO) wastes.
Place and Duration of Study: The 14 week experimental trial was conducted at University of Port Harcourt Ecological Centre field.
Methodology: The treatments consisted of 8 concentrations of SC and DO wastes alongside a control. These were: A – Control (no pollutant application); B – 50 g SC and 100 ml DO; C – 100 g SC and 50 ml DO; D – 100 g SC and 100 ml DO; E – 50 g SC and 50 ml DO; F – 100 ml DO; G – 50 ml DO; H – 50 g SC; I – 100 mg SC were used in a 2 kg soil each and laid in a completely randomized design with 5 replications.
Results: Results showed that 50 g and 100 g SC treatments improved the shoot length, leaf area and number; and biomass (fresh weight, dry weights and shoot-root ratio) yields of cassava while reductions were observed in DO (single or mixed application) as compare to the control. The

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chlorophyll and carbohydrate contents of cassava were negatively affected with the exception of 100 g SC/50 ml DO treatment in which the chlorophyll content was significantly higher than the control.

Conclusion: Therefore, SC at 50 and 100 g single treatments have stimulatory effect while DO have inhibitory effect on cassava. Hence, designated sites should be created for the dumping of such wastes to avoid dumping on nearby farmlands.

Keywords: Biomass; cassava; diesel oil; spent carbide; plant morphology; pollution.

1. INTRODUCTION

Cassava is the major staple food in the developing countries of the world and the third largest source of carbohydrate food after maize and rice especially in the tropical region of the world [1]. Food and Agriculture organization reported Nigeria to be the largest producer of cassava in the world with a production record of about 34 million metric tonnes per annum [2]. Cassava is regarded as the most important root crop in terms of its production and it is grown throughout the tropics [3]. Human activities have continuously hampered the cultivation of this crop. High technological standard and rise in civilization have worsened the situation.

Pollution arising from artisanal automobile workshops has increase tremendously due to the increase number of automobiles and automobile workshops in the country. More attention is only given to the major sources of pollution such as crude oil spill and neglecting this very important source of pollution. The indiscriminate waste disposal of diesel oil and spent carbide waste is a major problem to the environment. Soil pollution arising from these small and common sources may pose serious environmental threats to living organisms [4]. This exposes the plants around the polluted environment to the toxicity of these pollutants which affect the plants in their germination and biomass yield. This could also lead to the extinction of the plants or may also affect human and livestock that consume these plants.

Spent carbide waste is the end-product of calcium carbide after usage in oxy-acetylene gas during welding and fabrication works. They are usually discarded into the nearby environment. There is reduction in water infiltration in the soil in a spent carbide waste polluted environment [5]. Spent carbide waste has also been reported to cause reduction in agronomic performance of *Zea mays* and *Arachis hypogea* [6]; and *Vigna unguiculata* and *Sphenostylis stenocarpa* [7]. Regeneration ability of vegetation has been known to be affected by carbide waste application [8].

Diesel oil has been known to be phytotoxic to plants even at relatively low concentrations [9]. Ogbo [10] observed a reduction in the length of radicals of *Arachis hypogea*, *Sorghum bicolor*, *Zea mays* and *Vigna unguiculata* in a diesel polluted soil. Akujobi et al. [11] attributed the reduction in yield and growth parameters of plants in a diesel polluted soil to no availability of nutrient especially Nitrogen. Diesel as a petroleum product has been observed to significantly reduced nitrogen and organic carbon contents of soil [12,4].

Several works have been done on the effect of these pollutants especially diesel on plants but little has been done on effect of the pollutants in a mixed form on plant such as cassava. This study is relevant as it will unravel the effects of spent carbide waste and diesel oil (either in single or mixed application) on the yield of cassava. This will further help artisans and the general public in taking caution in the disposal of these wastes to enhance a friendlier environment to plants.

2. MATERIALS AND METHODS

2.1 Study Site

The experiment was conducted at the Ecological Centre, University of Port Harcourt, Nigeria located at Latitude 4° 00N and 5° 00N and Longitude 6°E and 7°E.

2.2 Soil Collection

Loamy soils was collected in bulk from a fallow farm near the Institute of Agriculture Demonstration farm were homogenised and 2 kg each filled into 45 nursery bags obtained from Agricultural Development programme (ADP), Port Harcourt; with all the stones and other unwanted materials removed. The 45 soil filled bags were separated into 9 set designated A – I. That represented the 8 treatments and control.

2.3 Experimental Design and Pollution Application

The treatments and control were laid out in a completely randomized design with 5 replicates. Diesel oil (DO) and spent carbide (SC) wastes (SCW) obtained from Ucheson artisanal automobile workshop, Ada-George Road, Port Harcourt, were applied as the pollutants in this order:

A Control (no pollutant application) – 0 g SC: 0 ml DO
B – 50 g SC : 100 ml DO
C – 100 g SC : 50 ml DO
D – 100 g SC : 100 ml DO
E – 50 g SC : 50 ml DO
F – 0g SC : 100 ml DO
G – 0 g SC : 50 ml DO
H – 50 g SC : 0 ml DO
I – 100 g SC : 0 ml DO

The Spent Carbide waste (SC) was first air dried to remove moisture and ground into powdering form for easy percolation into the soil. The pollutants were thoroughly mixed with the soil in the bags to obtained homogeneity. The set up was allowed for one week before cassava planting.

2.4 Cassava Planting

Mature stems (8 month old) of cassava (*Manihot esculentus*, Crantz) var. TMS 30572 obtained from the Institute of Agriculture Demonstration farm, University of Port Harcourt were cut into 20 cm each. Each stem cutting was planted in a slanting position in each bag with half of the stem (with not less than 4 buds) above the soil surface. One stem cutting was planted in each bag. The experiment was monitored for 14 weeks.

2.5 Parameters Measured

Shoot length, leaf number and leaf area were measured at 2 weeks interval starting from the 4^{th} week after planting (4 WAP) to the 14^{th} week (14 WAP) while the fresh biomass, dry biomass, chlorophyll content and leaf carbohydrate content were obtained at the termination of the experiment (14 WAP).

Shoot length was measured from the soil surface to the shoot tip using a meter rule calibrated in cm. Foliage production (leaf number) was done by counting the total number of leaves in each plant per bag. The leaf area was obtained according to the method of Bradfield (1962) cited in Okon et al. [13] using the formula.

Leaf area (LA) = L x W x r

Where

L = Leaf length
W = Leaf width
r = Correction coefficient (0.72).

The plants were harvested after 14 week of planting. The plants were harvested in the early hours of the morning to avoid water loss due to evapotranspiration which can be caused by high intensity of sunlight or temperature, thereby reducing moisture content of the plant which can affects the fresh weight of the plant. Harvesting was done with the hand. The planting bags were destroyed gently and the soil was scattered, as the plants were technically pulled out with some quantity of soil still attached to the plant roots. The soil attached roots were removed as they were rinsed in water to prevent root destruction. As the plants were rinsed, they were also damped with a clean whatman paper to remove water. The shoots and roots were detached from the main stem to separate the root from the shoot. They were immediately weighed with an analytical weighing balance (model no: JD300-3) to obtain the fresh biomass (shoot and root). The fresh biomass was oven-dried for 24 hrs at 80℃ to obtain the dry biomass. The total biomass (dry) was calculated by summing the shoot dry weight and the root dry weight. The shoot-root ratio was obtained by dividing the shoot dry weight by the root dry weight.

The chlorophyll content was measured according to the method of Comar and Zschelle [14] in which the chlorophyll was extracted with acetone, transferred into ether and the optical density measured at 660 nm and 643 nm. The carbohydrate content (%) was measured using the Clegg [15] Anthrone method in which 1.0 g of dry sample was extracted and digested with1.3 ml of 62% Perchloric acid and the sugar was determined colorimetrically.

2.6 Statistical Evaluation

Analysis of Variance (ANOVA) and Least Significant different (LSD) were used to separate means using SPSS 2014 version at p=0.05.

3. RESULTS

The results for the growth yield are presented in Figs. 1- 7 while the biochemical properties are as shown in Figs. 8 and 9.

Shoot length increases with increase in weeks after planting (WAP). Stunted growth (shoot length) was observed in Diesel oil polluted soil (either single or in combinations) than SC. Accelerated growth rate (shoot length) was observed in SC single treatment (50 g and 100 g). At 14 WAP, highest shoot length was observed in 100 g SC while lowest was in 50 g SC /100 ml DO treatment (Fig. 1).

The result showed progressive increase in foliage production (leaf number) in all the treatments from 4 WAP and peaked at 10 WAP. At 12 WAP and 14 WAP, reductions in the foliage occurred (Fig. 2). Significant highest foliage yield was observed in SCW (50 g and 100 g) at 10 WAP as compared to other treatments and control. While the least yield was recorded in 50 g/ 100 ml SCW: DO treatment combinations.

Leaf area followed similar pattern as leaf number. The leaf area showed a progression in the different treatments from 4 WAP to 10 WAP. The progression was more pronounced in the SC without DO treatments (Fig. 3). The leaf area in the treatment combinations of SC and DO; and DO without SC treatments were significantly less than the control.

Figs. 4–6 showed the results of the biomass (fresh weight and dry weight) at 14 WAP. 50g and 100 g SCW single treatments showed higher shoot fresh weight and dry weight yields than the other treatments and control. The control recorded a higher shoot dry weight than the mixed and DO single treatments (Fig. 4). Reductions in root fresh weight yields were observed in the control, 50 g/ 100 ml SC and DO treatment and 100 ml DO treatment. While the other treatments showed improved root fresh weight yields with the highest at 100 g/100 ml, 50 g/50 ml SC and DO treatments; and 100 g SC single treatment. Similar pattern was observed for the root dry weight yield in which the highest yield was recorded in 100 g SC treatment (Fig. 5). The total biomass (dry weight) yield in 50 g SC/50 ml DO, 50 g SC and 100 g SC were significantly higher than the control while 50 g SC/100 ml DO, 100 g SC/50 ml DO, 100 g SC/100 ml DO, 100 ml DO and 50 ml DO were lower than the control. Highest significant ($p=0.05$) total biomass yield (dry weight) was recorded in 50 g and 100 g SC treatments, while 50 g SC/100 ml DO recorded the least (Fig. 6). Shoot – root ratio (dry weight) showed that the values were all above one (1) except in 50 ml DO and 50 g SC/100 ml DO treatment which were 0.47 and 0.11, respectively. Control treatment had the highest shoot- root ratio value (Fig. 7).

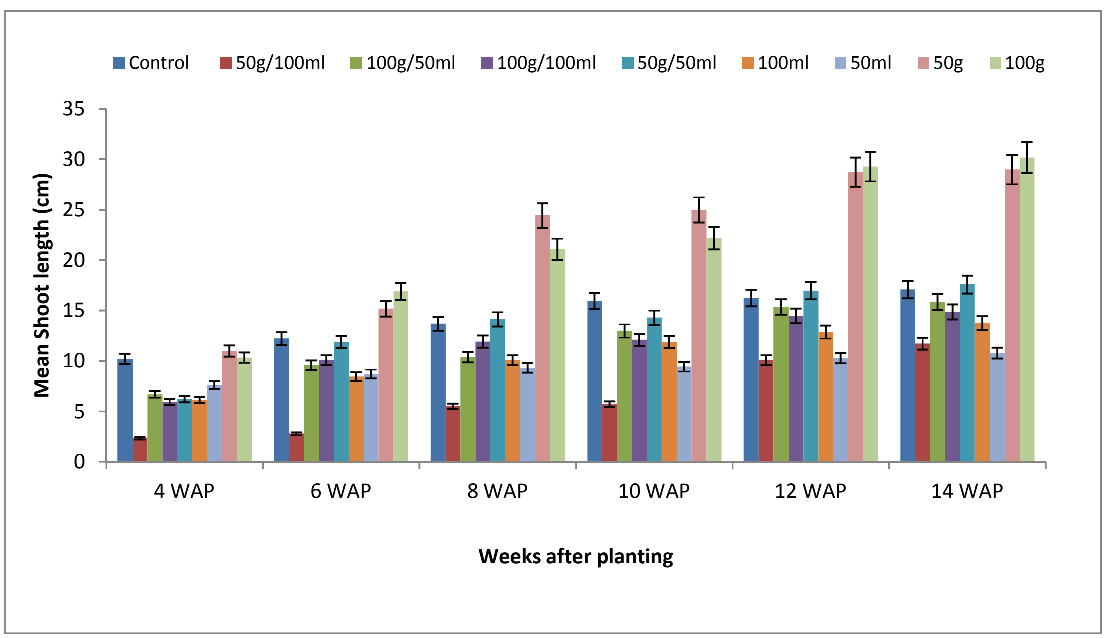

Fig. 1. Shoot length (Mean ± SEM) in the different treatments

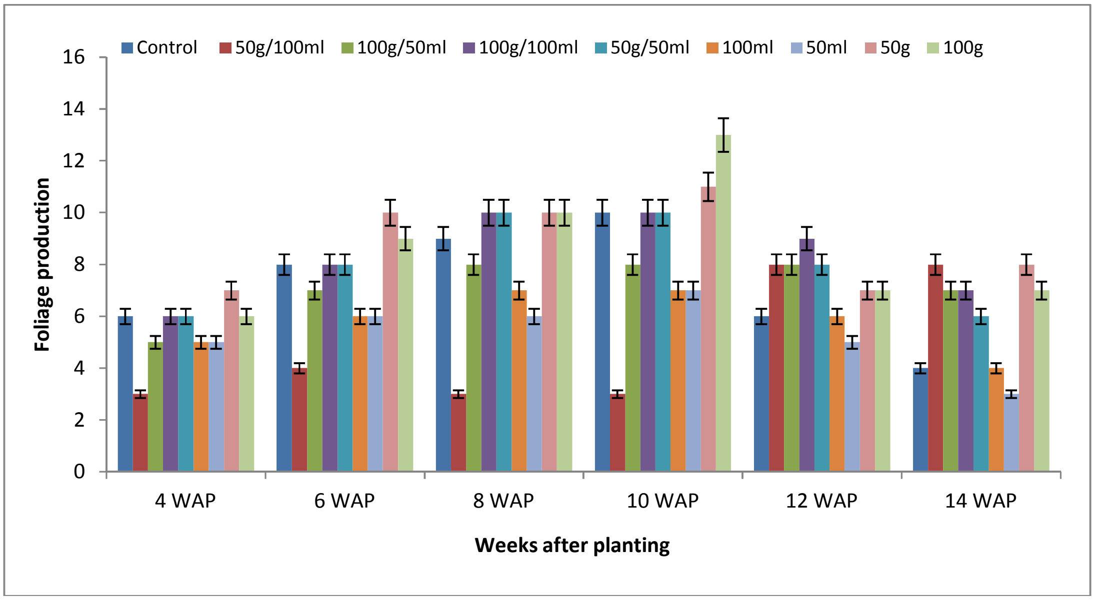

Fig. 2. Foliage production (Mean ± SEM) in the different treatments

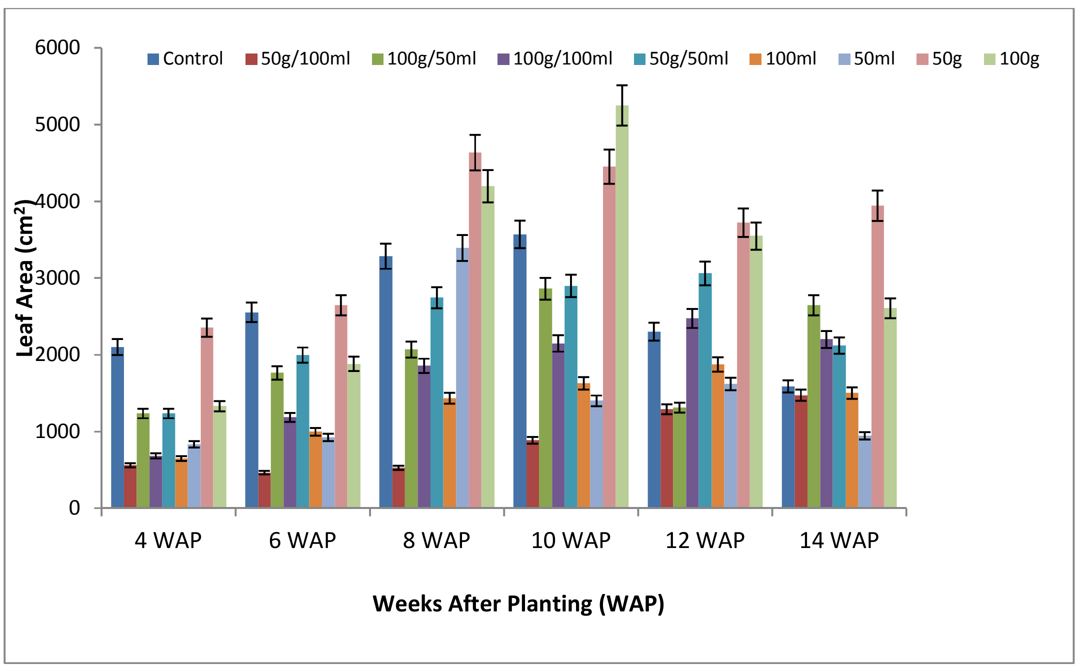

Fig. 3. Leaf area of cassava at the different treatments

Result showed that the pollutants especially in mixed form affected the leaf chlorophyll content of cassava with the exception of 100 g SC/50 ml DO in which the chlorophyll content was significantly higher than the control. No significant differences ($p=0.05$) were observed between 50 g SC/100 ml DO, 100 g SC/100 ml DO, 50 g SC/50 ml DO, 100 ml DO, 50 ml DO and 100 g SC in their chlorophyll content (Fig. 8). All the pollution treatment options drastically reduced the carbohydrate content of cassava. The carbohydrate content of all the treatments was significantly lower than the control. The 100 g SC treatment was the most affected (Fig. 9).

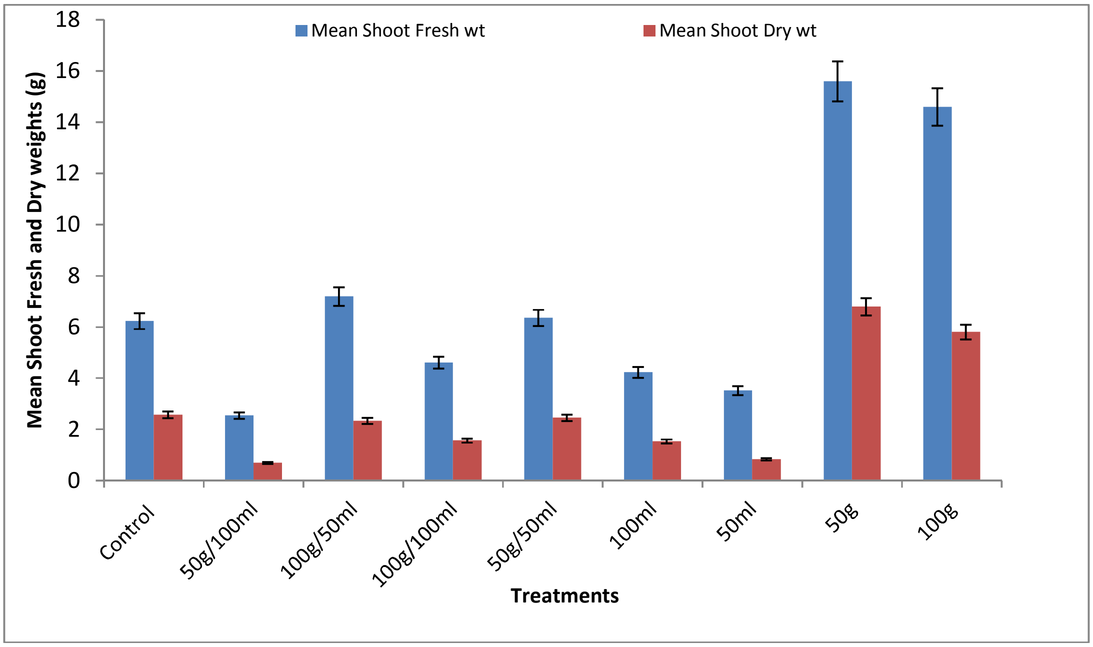

Fig. 4. Shoot fresh and dry weights (Mean ± SEM)

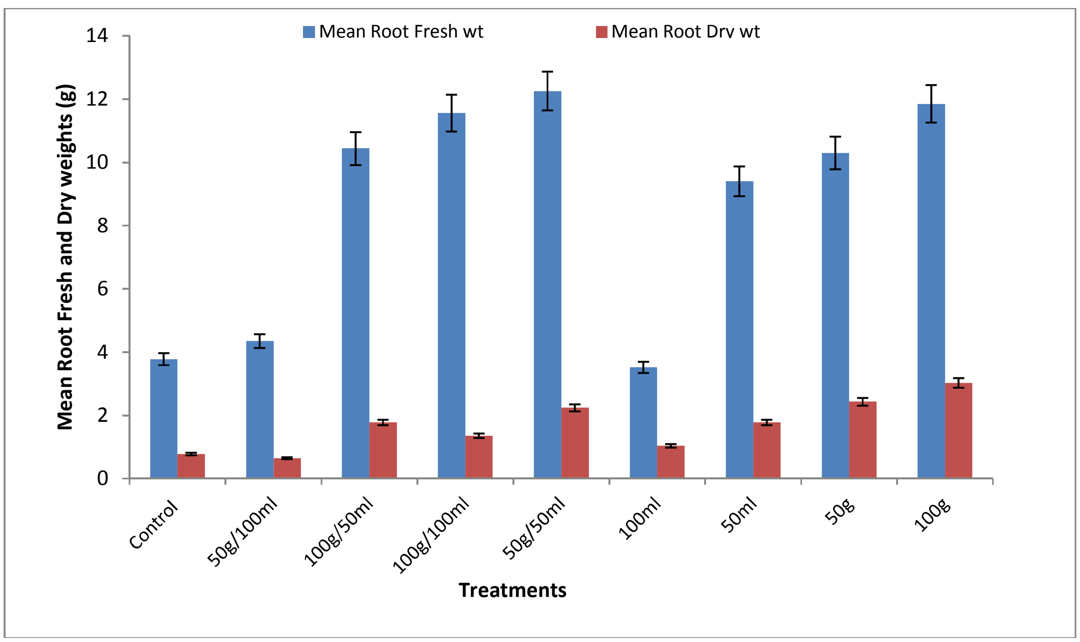

Fig. 5. Root dry and fresh weights (Mean ± SEM)

4. DISCUSSION

Certain environmental factors impact on the performance of living organisms (plant and animal) in a particular ecosystem. Some of these factors may be natural or introduced by the activities of man. Such effect is manifested in the growth and development of these organisms which may either be stimulatory or inhibitory. Spent carbide waste and diesel oil are some of such substances introduced by man into the environment. Results showed that SC and DO affected the morphology, chlorophyll and carbohydrate contents of cassava at different concentrations in either single or mixed treatments. The effects of the different concentrations differ. Some have has stimulatory effect while some have inhibitory effect. The magnitude of the effect also depends on the dosage and mixture of the pollutant.

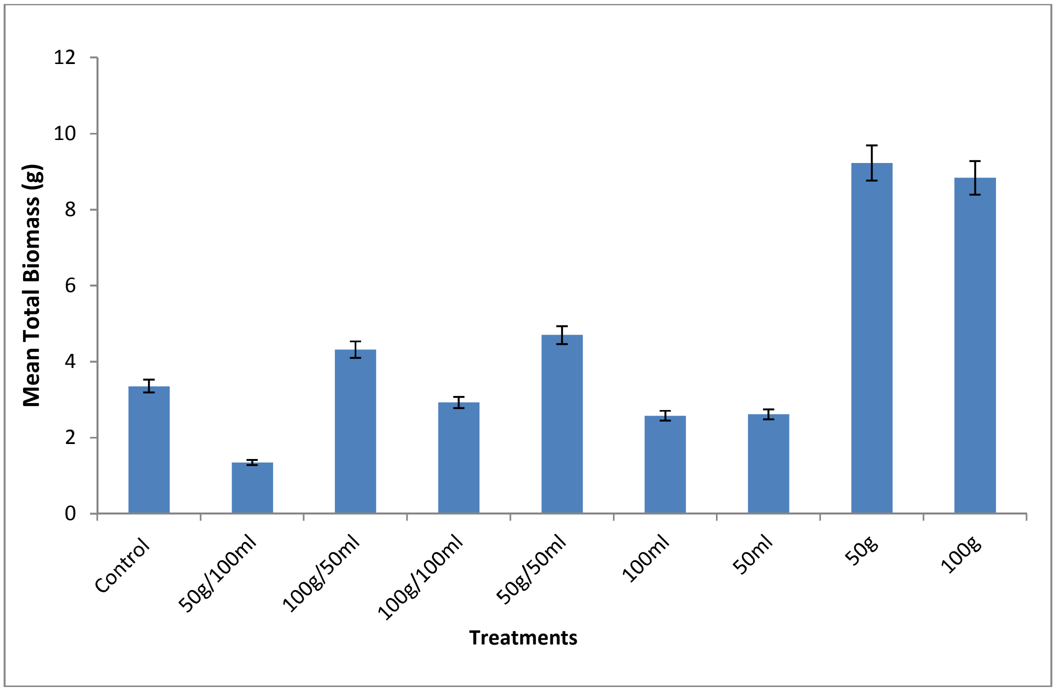

Fig. 6. Mean ± SEM total biomass (Dry weight of cassava)

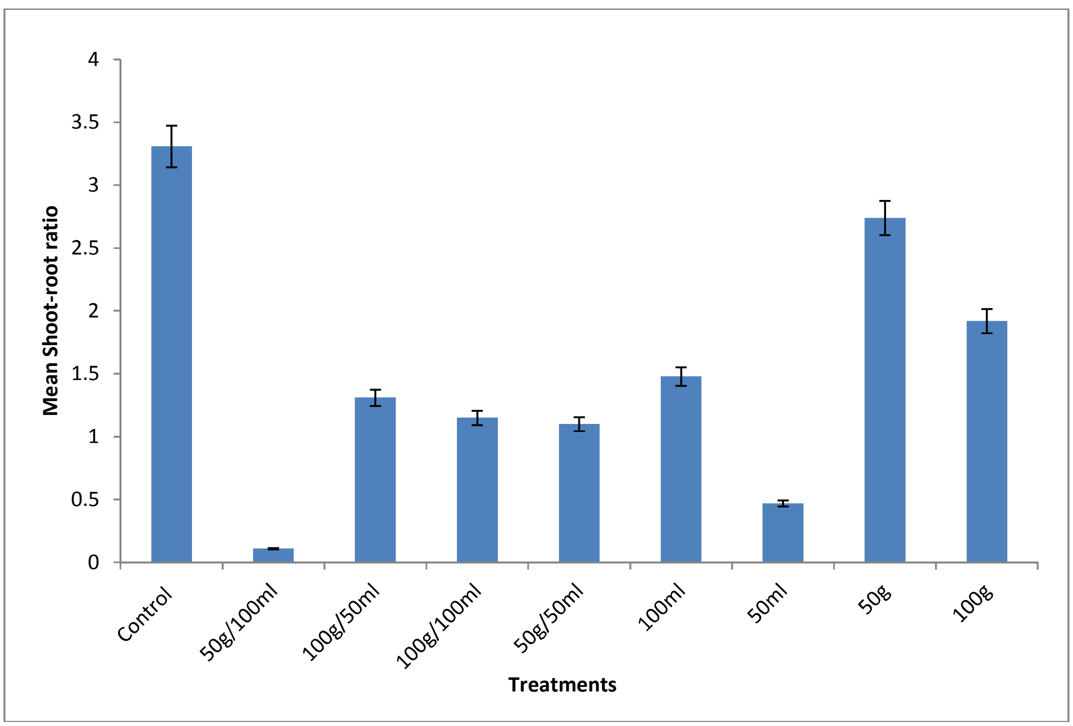

Fig. 7. Mean ± SEM shoot-root ratio

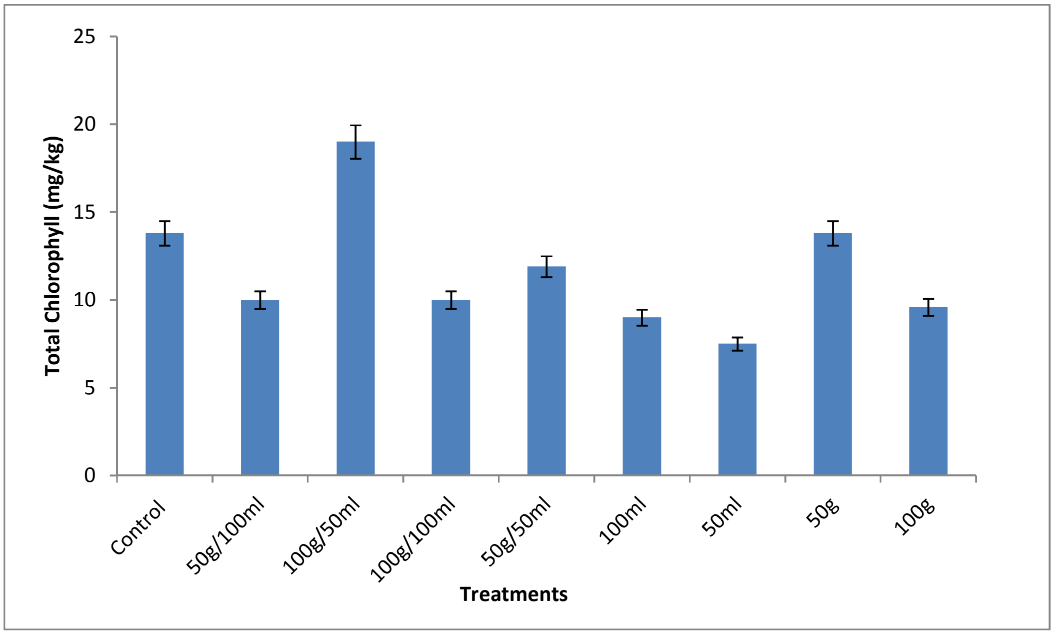

Fig. 8. Chlorophyll content of cassava

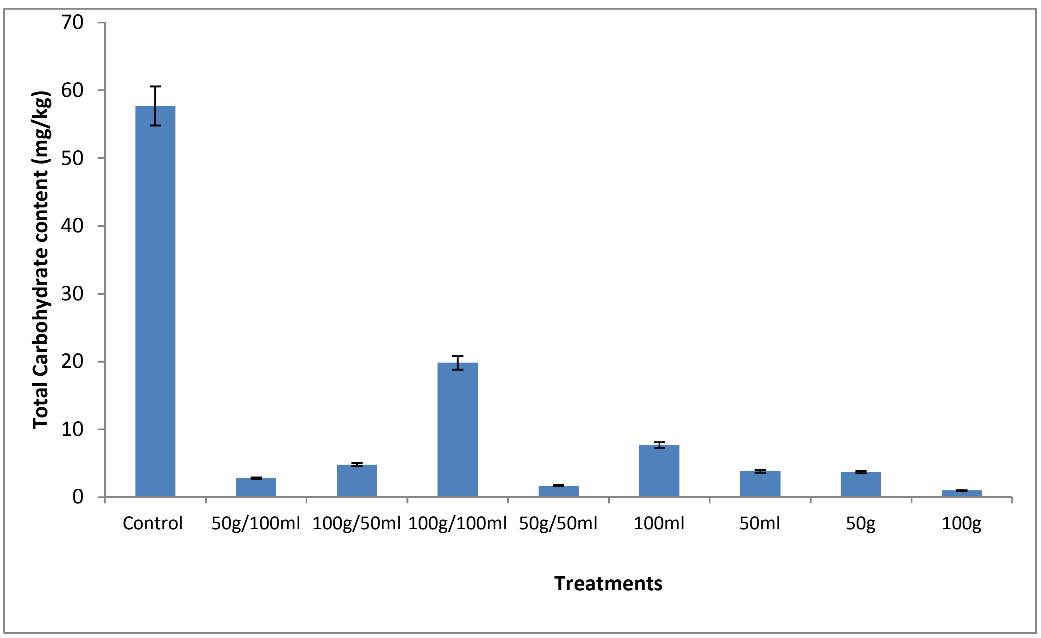

Fig. 9. Carbohydrate content of cassava

Results showed that the treatments especially at 50 g SC and 100 g SC have stimulating effect on the shoot length and foliage production as compared to the control; while the mixed treatments and single treatments of DO have inhibitory effect. Similar results were obtained in the biomass production (fresh and dry weight of shoot and root). This suggests that SC has the ability to stimulate growth of cassava. Analysis of SC showed that it is alkaline in nature (pH of above 7) with high amount of calcium [5,16,6]. This showed that it addition to soil will increase the soil pH and calcium content. Kathleen [16] and Tanee and Ochekwu [6] have reported increase in soil pH in spent carbide waste polluted environment. Cassava has been known to tolerate a wide range of pH especially (alkaline medium) [17]. Cassava also requires high amount of calcium as a requirement for normal growth [18]. So the improved growth (stimulatory effect) of the cassava in the SC single treatments (50g and 100 g) soil may be attributed to the increase pH and calcium supplied by the SC to the soil. This result is contrary to the observation of which SC has been reported to inhibit growth of maize and groundnut [6]; and *Vigna unguiculata* and *Sphenostylis stenocarpa* [7]. The reason for the differences in their response may be due to the type, habit and growth requirements by the plants. Cassava is a shrub while the other plants are herbs and as a result their growth requirement such as soil pH and calcium may differ. The inhibitory effect experienced in the mixed treatments and single DO treatment may be due to the toxic characteristics of diesel oil as a hydrocarbon product. Molina-Baharoma et al. [19] explained that the reduction in the morphological yields of plant in a diesel polluted soil was due to the immobilization of nutrients essential for plant growth (eg. Nitrogen) and impermeability effect coupled with the inhibitory effect of some polycyclic aromatic compound present in the diesel oil. Similar findings on the inhibitory effect of diesel oil on plants have been reported by [20,10,11]. The toxicity of diesel oil and other petroleum hydrocarbon products on plants were found to be directly proportional to the concentration or volume applied [21]. This confirmed the result of this study in which the morphological yields of cassava in 50 ml DO treatment was significantly higher than 100 ml DO treatment. Shoot-root ratios in almost the treatments were greater than one (1). This showed that the plant reserve-products were more at the shoot than root. This suggestion is true since within 14 week period, the plant was still at the growing (vegetative) stage, therefore channelling it food reserve to the shoot system for more leaves, stem and branches.

Results showed that there were reductions in the chlorophyll and carbohydrate contents of cassava in the treated soil than in the control. This showed that SC and DO have adverse effect on biochemical properties of cassava. Similar finding on chlorophyll content in spent carbide waste and spent engine oil interaction polluted soil has been reported by Ihimikaiye and Tanee [7]. The reduction in leaf number and leaf area especially at the 14 WAP might have been responsible for the reduction in carbohydrate content, since leaf characteristics and number have direct effect on photosynthesis.

5. CONCLUSION

From the result obtained, it is a clear fact that SC and DO (either in single or mixed applications) can have either inhibitory or stimulatory effect on the morphology, chlorophyll and carbohydrate contents of cassava (*Manihot esculentus*, Crantz). SC at single treatment was observed to have stimulatory effect (ie improved growth) while DO had inhibitory property on the plant. Therefore care should be taken in the disposal of these wastes into nearby farmlands.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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