Comparative study on nutrient availability and growth of tomato (*Lycopersicon esculentum*) seedlings in soils amended with palm oil mill effluent and rubber processing effluents

**Abstract:** This study investigates the effect of the palm oil mill effluent (POME) and rubber processing effluent (RPE) on some soil properties and growth of tomato (*Lycopersicon esculentum*) seedlings. Tomato (*Lycopersicon esculentum*) is one of the most important vegetables worldwide. It is a relatively short duration crop and gives a high yield. Tomato contributes to a healthy, well-balanced diet, as they are rich in minerals, vitamins, phytochemicals, etc., which enhances the protective properties of human health. To study these effects, a greenhouse trial was conducted at the faculty of Agriculture, University of Benin, Benin city, Nigeria. POME and RPE, respectively, were used as soil amendments at 0, 200, 400, 600 ml/3 kg soil in a completely randomized design in triplicate. Results from the pre-plant soils revealed that the soil organic carbon, nitrogen, phosphorus, magnesium and calcium increased with increasing effluent applications while the soil pH remained in the acidic region and the soil exchangeable acidity (EA) reduced. The plant height, number of leaves, leaf length, stem girth and total biomass yield by the plant increased with increasing effluent applications while the soil pH remained in the acidic region and the soil exchangeable acidity (EA) reduced. The plant height, number of leaves, leaf length, stem girth and total biomass yield by the plant
significantly increased (P < 0.05) with increasing effluent treatments. pH and EA were consistently higher in POME amended soils as compared to RPE in all the treatments while K, Mg and Ca were higher with RPE. Plant growth parameter suggests that the 600 ml POME treatment performed better for plant height and girth while number of leaves, leaf length and total biomass yield were better with RPE.

**Subjects:** Environment & Agriculture; Earth Sciences; Environmental Issues

**Keywords:** POME; RPE; soil properties; tomato growth; treatment; effluent; amended

1. Introduction

Oil palm and rubber are among the nation’s prominent cash crops. Product preparation from these crops generates a huge amount of unavoidable effluent (palm oil mill effluent POME and rubber processing effluent RPE) wastes which are generally not well managed. The usual and cheapest method of disposal is by discharges into nearby lands and rivers (Ogboghodo et al., 2001). These wastes are organic waste and are capable of releasing greenhouse gases (CO₂ and CH₄) into the atmosphere, and effluent that is discharged directly or indirectly into waterbodies reduces the dissolved oxygen in the waters, degenerating them into unsightly, foul-smelling and disease-causing conditions, thereby endangering the aquatic lives and the lives of nearby inhabitants. In Nigeria where environmental pollution laws are not strictly adhered to, the impact of such indiscriminate disposal can be more devastating. So far, report from WHO also estimated 335,200 deaths (representing a 16.70% of death cases occurring annually in Nigeria) as a result of poor sanitation, water and hygiene-related infection (Ojuri & Ola, 2010; Ojuri et al., 2014). Therefore, proper management of POME and RPE is a matter to be considered seriously for environmental concern and sustainable farming.

In spite of these challenges, research studies however reveal that POME and RPE contain a high amount of plant nutrient that could be useful for plant growth and as such can be used as organic fertilizer for arable farming. Controlled utilization of effluents for crop irrigation has wide recognition as a waste management method with an additional benefit of acting as an organic fertilizer (Swaminathan & Valdheeswaran, 1991). Osaigbovo and Orhue (2011) reported an increase in soil N, P, K, Mg, Ca and organic carbon with the application of increasing palm oil mill effluent. Increase in soil pH, K, Ca, Mg and organic matter has also been reported for soil amended with palm oil mill effluent (Onyia et al., 2001).

However, with the wide recognition gained by POME and RPE as soil amendment, not many studies have been done in comparing the effects of the effluents on soil properties and the growth of plants. Therefore, this study compares the nutrient availability and growth of tomato (*Lycopersicum esculentum*) seedlings in soils amended with palm oil mill effluent and rubber processing effluent.

Tomato (*Lycopersicum esculentum*) is one of the most important vegetables worldwide. It is a relatively short duration crop and gives a high yield. Tomatoes contribute to a healthy, well-balanced diet, as they are rich in minerals; vitamins A, B and C; iron; carotene; phosphorus; and phytochemicals which enhance the protective properties of human health (Chaudhary et al., 2018), and since in Nigeria a lot of children suffer from vitamin A deficiency, regular eating of fruit and green leafy vegetables can reduce the nutritional problem (South Pacific Foods, 1995).

2. Materials and methods

The experiment was conducted in the greenhouse at the Faculty of Agriculture, University of Benin, Benin City Nigeria. The palm oil mill effluent (POME) was obtained from the Nigeria Institute for oil Palm Research (NIFOR) while the rubber processing effluent (RPE) was obtained from Okomu Oil Mill. The effluents (POME and RPE) analyses were carried out before the experiment using standard
methods (APHA, 1999; Ademoroti, 1996; Rebacca, 2004). The tomato seeds were obtained from
the Plant Breeding Unit of the Department of Crop Science, University Benin, Benin City Nigeria.
Composite soil samples were collected using the auger at a depth of 0–30 cm from an uncultivated
land behind the Faculty of Agriculture, University of Benin, Benin City, Nigeria. The samples were
air-dried, sieved through 2 mm stainless steel sieve and thoroughly mixed to ensure uniformity
and then stored in polythene bags at room temperature. The soil analyses were carried out before
and after the experiment. The soil pH was determined in a 1:10 (w/v) ratio of soil to distilled water
using a pH meter. The soil textural analysis was determined by using the hydrometer method by
Day using sodium hexametaphosphate as the dispersant (Osaigbovo & Orhue, 2011). Organic
carbon was determined by the chromic acid wet oxidation method (Osaigbovo & Orhue, 2011).
Total nitrogen and available phosphorus were determined using the method described by Udo
et al. (2009). The metal content (Mg, Ca, Al and Zn) was determined using the atomic absorption
spectrophotometer (Bulk Scientific VGP 210 model) while K and Na were determined by flame
absorption spectrophotometer (Bulk Scientific model 200A). The summation of the exchangeable
cation (Na\(^+\), K\(^+\), Mg\(^{2+}\), Ca\(^{2+}\)) and exchangeable acidity (H\(^+\) and Al\(^{3+}\)) was reported as cation
exchange capacity (CEC). The % base saturation was determined by the summation of the cation
(K\(^+\), Mg\(^{2+}\), Ca\(^{2+}\)) divided by the CEC. Thereafter, 3 kg each of the soil samples was weighed and
separately treated with 0 ml, 200 ml, 400 ml and 600 ml of the palm oil mill effluent and rubber
processing effluent. The effluents applied were thoroughly mixed with the soil, watered and left for
8 weeks to allow for adequate mineralization and equilibration before transplanting of the seed-
lings. Physicochemical properties of the soil were analysed before and after soil treatment using
standard methods. Thereafter, 3-week-old uniform seedlings of tomato (Lycopersicum esculentum)
were selected and transplanted at two plants per pot. These pots were arranged in a completely
randomized design in triplicate. Weeding was carried out regularly. The experiment was monitored
for a period of 4 weeks during which the seedlings were watered regularly. Plant growth param-
eters in terms of plant heights, stem girth, leaf length and number of leaves were determined on
a weekly basis. Plant analyses in terms of nutrient uptake and total biomass yield were also
determined using standard methods. The total biomass yield was determined by weighing the
plant samples immediately after harvest from the screen house. Thereafter, the plant samples
were wrapped in aluminium foil and dried in an oven at 105°C to attain a constant weight. The
dried weight obtained was noted and recorded as the total biomass yield. The nutrient uptake of
the plants was calculated by multiplying the mean dry weight (g) of each plant by the plant
nutrient content (%) (Pal, 1991).

3. Results and discussion
The physicochemical properties of the effluents (Table 1) reveal that the effluents contain plant
nutrients such as nitrate, sulphate, K, P, Mg, Ca and Na in appreciable amount to enhance crop
yield. The pH values were low while total solids and COD values were high for both effluents. Plant
nutrients, COD and total solids were significantly higher in POME than RPE. POME was also more
acidic.

3.1. Effect of treatment on soil physicochemical properties before and after transplanting
Table 2 shows the physicochemical properties of the soil before and after the treatment. From
the results, it is observed that the parent soil was in the acidic region, with medium organic matter and
low percentage base saturation. The low base saturation (which is less than 35%) suggests that it is
an ultisol (Orhue et al., 2005). Available phosphorus (3.19 mg/g) and nitrogen (0.33 g/kg) indicate
that the nutrient level of the soil is low and would not favour the growth of plant for high yield of
crops. Soil textural analysis shows that the soil is sandy and therefore needs soil nutrient enhance-
ment. After the treatment, the pre-plant soils had properties better than the control as various
treatments added nutrients to the soil. Soil organic carbon, N, P, K, Mg, Ca, Na and % base
saturation significantly increased (P < 0.05) with increasing levels of the treatment. Increase in
soil nutrient may be attributed to the application of the effluents. The result obtained agrees with
Orhue et al. (2005), Osaigbovo and Orhue (2011), Onyia et al. (2001), and Nwoko et al. (2010) who
reported an increase in soil nutrient after application of POME and RPE separately. The soil pH
however remained in the acidic region for all the treatment which may be due to the acidic nature of the effluents. Apart from the 400 ml RPE amendment, the CEC of the parent soil was higher than all the amended soils. The lower values of CEC of the amended soils suggest that nutrient bioavailability will be increased. The increase in soil nutrient also accounted for the reduction in the soil exchangeable acidity and CEC. Comparing the properties of the amended soils suggests that pH, Mg, Ca, K and Na levels were higher in soils amended with RPE while organic carbon, phosphorous and nitrogen were higher for POME.

The post-plant soil properties showed no particular trend. However, soil nutrient reduced only with some few exceptions in all the post-plant soil suggesting nutrient uptake by plants.

### 3.2. Effect of treatment on nutrient uptake by tomato (*Lycopersicum esculentum*) seedlings

There was no general pattern with regards to nutrient uptake in the trials (Table 3). However, the result reveals that nutrient levels were higher in plants grown in the treated soils with only a few exceptions. This result agrees with the result obtained from the soil CEC. Nutrient element became more available to the plants as a result of reduction in CEC. Nitrogen uptake was significantly different (*P* < 0.05) in the trials, with the 600 ml RPE treatment having the highest uptake while the lowest was obtained from the 600 ml POME treatment. Also, phosphorus uptake was significantly different (*P* < 0.05) with the 600 ml RPE treatment having the highest uptake while with the 200 ml POME treatment having the lowest. Potassium uptake at 200 ml and 600 ml POME treatment was not significantly different (*P* < 0.05) but better than the other treatments. Also, calcium uptake at 200 ml POME and RPE treatment was not significantly different (*P* < 0.05) but better than the other treatments. The 400 ml RPE, 400 ml POME and 600 ml POME treatment were not significantly different (*P* < 0.05) in the uptake of magnesium but better than the other treatments. In sodium uptake, 400 ml soil POME treatment was the highest while 600 ml POME was the lowest. The results show that nutrient uptake was more with the plant grown on RPE amended soils as compared to POME.

### Table 1. Physicochemical properties of the palm oil mill effluent (POME) and rubber processing effluent (RPE)

| Parameter          | Nifor POME mean ± SD | Okomu RPE mean ± SD |
|--------------------|-----------------------|----------------------|
| Temperature (°C)   | 86.00 ± 0.02          | 35.00 ± 0.03         |
| pH                 | 4.50 ± 0.02           | 6.65 ± 0.07          |
| Organic Carbon%    | 2.50 ± 0.02           | 0.31 ± 0.01          |
| COD                | 59,814.81 ± 0.02      | 1801.74 ± 0.02       |
| Total Solids       | 48,000.00 ± 0.02      | 1450.00 ± 0.28       |
| Volatile Solids    | 42,000.00 ± 0.75      | 143.00 ± 0.02        |
| Suspended Solid    | 18,178.18 ± 0.76      | 568.00 ± 0.20        |
| Oil and Grease     | 4200.00 ± 0.65        | 8.90 ± 0.10          |
| Calcium            | 280.43 ± 0.02         | 8860.20 ± 0.20       |
| Magnesium          | 674.87 ± 0.03         | 1.94 ± 0.02          |
| Phosphate          | 31.06 ± 0.03          | 0.85 ± 0.02          |
| Potassium          | 1800.41 ± 0.02        | 112.25 ± 0.02        |
| Sodium             | 120.65 ± 0.03         | 1.54 ± 0.01          |
| Nitrate            | 20.00 ± 0.14          | 0.05 ± 0.03          |
| Sulphate           | 180.85 ± 0.02         | 8.32 ± 0.03          |
| Copper             | 25.36 ± 0.02          | 20.12 ± 0.02         |
| Manganese          | 28.36 ± 0.03          | 37.48 ± 28.87        |

All units are in mg/l except otherwise stated.
Table 2. Soil physicochemical properties before and after transplanting

| Sample Code | pH | T. Org. C g/Kg | Org. Mat. g/Kg | Ca cmol/kg | Mg cmol/kg | Av. P mg/g | K cmol/kg | Na cmol/kg |
|-------------|----|----------------|---------------|------------|------------|------------|-----------|------------|
| BEFORE TRANSPLANTING |
| 0 ml | Control | 5.14 ± 0.01 | 6.41 ± 0.01 | 11.07 ± 0.01 | 0.42 ± 0.01 | 3.19 ± 0.02 | 0.15 ± 0.02 | 0.11 ± 0.00 |
| 200 ml | POME | 5.24 ± 0.01 | 20.33 ± 0.02 | 35.06 ± 0.02 | 0.66 ± 0.01 | 7.03 ± 0.02 | 0.24 ± 0.03 | 0.13 ± 0.02 |
| RPE | 5.91 ± 0.15 | 6.42 ± 0.10 | 23.79 ± 0.02 | 0.68 ± 0.01 | 6.27 ± 0.01 | 0.34 ± 0.02 | 0.16 ± 0.02 |
| 400 ml | POME | 5.24 ± 0.02 | 30.33 ± 0.06 | 52.56 ± 0.02 | 0.58 ± 0.01 | 7.03 ± 0.02 | 0.24 ± 0.01 | 0.13 ± 0.02 |
| RPE | 5.47 ± 0.02 | 22.13 ± 0.02 | 38.26 ± 0.02 | 0.64 ± 0.01 | 4.01 ± 0.02 | 0.31 ± 0.01 | 0.19 ± 0.02 |
| 600 ml | POME | 5.13 ± 0.02 | 39.33 ± 0.03 | 68.00 ± 0.02 | 0.46 ± 0.01 | 7.12 ± 0.02 | 0.23 ± 0.02 | 0.11 ± 0.00 |
| RPE | 5.29 ± 0.02 | 25.17 ± 0.03 | 43.52 ± 0.02 | 0.63 ± 0.03 | 6.83 ± 0.10 | 0.30 ± 0.02 | 0.17 ± 0.02 |
| AFTER TRANSPLANTING |
| 0 ml | Control | 5.57 ± 0.02 | 5.66 ± 0.02 | 9.78 ± 0.02 | 0.83 ± 0.02 | 1.15 ± 0.02 | 0.17 ± 0.02 | 0.12 ± 0.01 |
| 200 ml | POME | 5.80 ± 0.10 | 13.81 ± 0.01 | 23.75 ± 0.02 | 0.58 ± 0.02 | 5.66 ± 0.10 | 0.24 ± 0.02 | 0.17 ± 0.01 |
| RPE | 5.57 ± 0.02 | 12.14 ± 0.04 | 20.96 ± 0.02 | 0.64 ± 0.02 | 4.01 ± 0.01 | 0.31 ± 0.01 | 0.19 ± 0.02 |
| 400 ml | POME | 5.30 ± 0.20 | 19.34 ± 0.49 | 34.53 ± 0.02 | 0.51 ± 0.02 | 6.11 ± 0.02 | 0.74 ± 0.02 | 0.11 ± 0.00 |
| RPE | 5.73 ± 0.16 | 13.43 ± 0.02 | 23.74 ± 0.04 | 0.69 ± 0.01 | 6.27 ± 0.02 | 0.34 ± 0.02 | 0.17 ± 0.02 |
| 600 ml | POME | 5.31 ± 0.01 | 19.96 ± 0.04 | 34.53 ± 0.10 | 0.51 ± 0.01 | 6.11 ± 0.03 | 0.74 ± 0.02 | 0.11 ± 0.00 |
| RPE | 5.92 ± 0.07 | 13.96 ± 0.02 | 24.07 ± 0.03 | 0.64 ± 0.02 | 7.02 ± 0.02 | 0.34 ± 0.02 | 0.17 ± 0.01 |

Sample Code | EA cmol/kg | CEC cmol/kg | % BASE SAT | SAND % | CLAY% | SILT % | N g/Kg |
|-------------|------------|-------------|------------|--------|-------|--------|-------|
| BEFORE TRANSPLANTING |
| 0 ml | Control | 1.86 ± 0.02 | 2.88 ± 0.10 | 31.94 ± 0.02 | 87.15 ± 0.03 | 6.32 ± 0.10 | 6.5 ± 0.20 | 0.33 ± 0.02 |
| 200 ml | POME | 1.16 ± 0.00 | 2.36 ± 0.03 | 45.34 ± 0.02 | 87.73 ± 0.10 | 6.07 ± 0.02 | 5.2 ± 0.10 | 0.96 ± 0.02 |
| RPE | 0.66 ± 0.02 | 2.34 ± 0.10 | 64.96 ± 0.03 | 84.87 ± 0.15 | 7.03 ± 0.02 | 9.03 ± 0.02 | 0.77 ± 0.02 |
| 400 ml | POME | 1.16 ± 0.02 | 2.30 ± 0.02 | 43.48 ± 0.20 | 86.18 ± 0.02 | 5.51 ± 0.10 | 8.31 ± 0.01 | 0.97 ± 0.00 |
| RPE | 1.69 ± 0.10 | 3.05 ± 0.02 | 28.89 ± 0.10 | 84.88 ± 0.01 | 6.06 ± 0.02 | 9.03 ± 0.02 | 0.87 ± 0.02 |

(Continued)
| Sample Code | EA cmol/kg | CEC cmol/kg | % BASE SAT | SAND % | CLAY% | SILT % | N g/Kg |
|-------------|------------|-------------|------------|--------|-------|--------|--------|
| 600 ml      |            |             |            |        |       |        |        |
| POME        | 1.18 ± 0.02| 2.13 ± 0.02 | 39.44 ± 0.20| 85.08 ± 0.13| 6.13 ± 0.02| 8.53 ± 0.10| 1.26 ± 0.02|
| RPE         | 1.33 ± 0.10| 2.66 ± 0.03 | 43.61 ± 0.10| 86.08 ± 0.78| 5.17 ± 0.02| 8.30 ± 0.20| 0.97 ± 0.01|
| 0 ml        |            |             |            |        |       |        |        |
| POME        | 1.90 ± 0.00| 3.36 ± 0.02 | 39.88 ± 0.20| 87.33 ± 0.10| 7.03 ± 0.03| 5.23 ± 0.02| 0.47 ± 0.02|
| RPE         | 1.69 ± 0.01| 3.05 ± 0.02 | 38.36 ± 0.20| 88.33 ± 0.02| 7.33 ± 0.02| 4.33 ± 0.12| 1.27 ± 0.02|
| 200 ml      |            |             |            |        |       |        |        |
| POME        | 1.16 ± 0.20| 2.33 ± 0.02 | 42.89 ± 0.15| 76.00 ± 0.00| 5.33 ± 0.03| 8.67 ± 0.12| 0.74 ± 0.10|
| RPE         | 0.65 ± 0.20| 2.11 ± 0.02 | 61.14 ± 0.40| 88.19 ± 0.01| 7.41 ± 0.11| 4.41 ± 0.20| 0.71 ± 0.01|
| 400 ml      |            |             |            |        |       |        |        |
| POME        | 0.99 ± 0.00| 2.55 ± 0.20 | 57.23 ± 0.20| 83.20 ± 0.02| 8.10 ± 0.21| 3.70 ± 0.20| 0.98 ± 0.01|
| RPE         | 0.65 ± 0.20| 2.11 ± 0.02 | 61.14 ± 0.40| 88.19 ± 0.01| 7.41 ± 0.11| 4.41 ± 0.20| 0.71 ± 0.01|
| 600 ml      |            |             |            |        |       |        |        |
| POME        | 0.97 ± 0.20| 2.55 ± 0.10 | 57.25 ± 0.30| 83.20 ± 0.08| 8.10 ± 0.02| 8.63 ± 0.20| 0.98 ± 0.01|
| RPE         | 0.72 ± 0.20| 2.20 ± 0.02 | 58.64 ± 0.10| 86.13 ± 0.12| 5.53 ± 0.21| 8.83 ± 0.11| 0.79 ± 0.01|

Means with different alphabet remarks in the same column are significantly different at 5% probability level (P < 0.05).

a corresponds to the lowest value through b, c, d, e, f, to g which corresponds to the highest level.
Table 3. Effect of treatment on nutrient uptake by tomato (Lycopersicum esculentum) seedlings

| Treatment (ml/3 kg of soil) | N (mg/kg) mean ± SD | P (mg/kg) mean ± SD | K (mg/kg) mean ± SD | Ca (mg/kg) mean ± SD | Mg (mg/kg) mean ± SD | Na (mg/kg) mean ± SD |
|----------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Control                    | 1.50 ± 0.02         | 103.30 ± 0.02       | 8294.67 ± 0.02      | 300.30 ± 0.02       | 400.30 ± 0.02       | 80.07 ± 0.06        |
| 200 ml POME                | 2.22 ± 0.02         | 27.60 ± 0.02        | 14,032.87 ± 0.02    | 400.40 ± 0.02       | 400.30 ± 0.02       | 145.20 ± 0.02       |
| 200 ml RPE                 | 2.08 ± 0.02         | 115.50 ± 0.02       | 11,943.00 ± 0.02    | 400.30 ± 0.02       | 400.30 ± 0.02       | 195.00 ± 0.02       |
| 400 ml POME                | 1.46 ± 0.03         | 104.21 ± 0.04       | 7668.00 ± 0.02      | 360.00 ± 0.03       | 400.30 ± 0.02       | 169.97 ± 0.02       |
| 400 ml RPE                 | 1.54 ± 0.03         | 127.60 ± 0.04       | 11,930.00 ± 0.02    | 360.00 ± 0.03       | 400.30 ± 0.02       | 170.47 ± 0.02       |
| 600 ml POME                | 1.18 ± 0.01         | 140.19 ± 0.02       | 14,003.37 ± 0.02    | 360.31 ± 0.03       | 400.30 ± 0.02       | 205.50 ± 0.02       |
| 600 ml RPE                 | 2.41 ± 0.01         | 140.19 ± 0.02       | 11,943.00 ± 0.02    | 360.31 ± 0.03       | 400.30 ± 0.02       | 145.40 ± 0.03       |

Means with different alphabet remarks in the same column are significantly different at 5% probability level (P < 0.05).
3.3. Effect of treatment on plant growth parameters

Plant heights (Table 4) suggest that effluent treatment of soils was better than the control. In the 200 ml treatment, plant heights were not significantly different; however, RPE (50.06 ± 0.03) performed better than POME amended soil. The plant height performed better in the 400 ml and 600 ml POME amended soils. Here, 400 ml POME treatment had a value of 57.41 ± 0.02 which was statistically not different from RPE treatment (56.95 ± 0.02). Also, 600 ml POME treatment had a value of 59.36 ± 1.03. However, plant girths were comparable in nearly all the trials and had no major disparity.

Increase in plant height on soil amended with POME and RPE is similar to findings of Aziz et al. (2010) who reported an increase in plant height due to the application of organic manure and Budhan et al. (1991) reported an increase in plant height on the application of cattle manure. The results of this study reveal that apart from the 200 ml treatment, soil amended with POME performed better for plant height as compared to RPE.

Plant girths (Table 5) were comparable in nearly all the trials as there was little significant difference observed among the trials. This study is not consistent with Osagbovo et al. (2010) where stem girth increased in soils amended with fishpond effluent.

The result from plant leaf length (Table 6) showed that the leaf length varied among the different treatments and was better than the control. The highest leaf length was observed in the treatment that received the 600 ml RPE (7.46 cm), followed by the 400 ml RPE and POME (7.44 cm). The study also revealed that the soil treated with RPE had leaf length longer than the POME. Studies conducted by Orhue et al. (2005) reported no significant difference (P < 0.05) on

**Table 4. Effect of treatment on plant height**

| Samples | WK1 (cm) mean ± SD | WK2 (cm) mean ± SD | WK3 (cm) mean ± SD | WK4 (cm) mean ± SD |
|---------|-------------------|-------------------|-------------------|-------------------|
| 0 ml    | Initial soil      | 36.67 ± 0.02      | 38.72 ± 0.02      | 40.38 ± 0.03      | 40.65 ± 0.48      |
| 0 ml    | POME              | 44.27 ± 0.03      | 47.23 ± 0.03      | 47.87 ± 0.55      | 49.83 ± 0.02      |
| 0 ml    | RPE               | 45.56 ± 0.04      | 48.59 ± 0.02      | 49.57 ± 0.03      | 50.06 ± 0.02      |
| 400 ml  | POME              | 46.38 ± 0.03      | 53.07 ± 0.04      | 55.95 ± 0.02      | 57.41 ± 0.02      |
| 400 ml  | RPE               | 46.25 ± 0.02      | 48.70 ± 0.02      | 52.85 ± 0.02      | 56.95 ± 0.02      |
| 600 ml  | POME              | 55.81 ± 0.02      | 57.06 ± 1.70      | 57.26 ± 0.80      | 59.36 ± 1.03      |
| 600 ml  | RPE               | 53.15 ± 0.02      | 54.04 ± 6.35      | 56.09ef ± 0.01    | 57.84 ± 0.01      |

Means with different alphabet remarks in the same column are significantly different at 5% probability level (P < 0.05).

**Table 5. Effect of treatment on stem girth**

| Samples | WK1 (cm) mean ± SD | WK2 (cm) mean ± SD | WK3 (cm) mean ± SD | WK4 (cm) mean ± SD |
|---------|-------------------|-------------------|-------------------|-------------------|
| 0 ml    | Initial soil      | 2.47 ± 0.02       | 2.54 ± 0.02       | 2.61 ± 0.02       | 2.55 ± 0.02       |
| 0 ml    | POME              | 2.47 ± 0.02       | 2.65 ± 0.02       | 2.73 ± 0.03       | 2.75ab ± 0.02     |
| 0 ml    | RPE               | 2.47 ± 0.02       | 2.65 ± 0.02       | 2.68 ± 0.02       | 2.83 ± 0.03       |
| 400 ml  | POME              | 2.32 ± 0.02       | 2.6 ± 0.02        | 2.67 ± 0.02       | 2.72ab ± 0.02     |
| 400 ml  | RPE               | 2.67 ± 0.03       | 2.67 ± 0.02       | 2.7 ± 0.04        | 2.7ab ± 0.41      |
| 600 ml  | POME              | 2.46 ± 0.02       | 2.61 ± 0.14       | 2.63 ± 0.16       | 2.69ab ± 0.41     |
| 600 ml  | RPE               | 2.35 ± 0.02       | 2.44 ± 0.01       | 2.49 ± 0.03       | 2.59ab ± 0.02     |

Means with different alphabet remarks in the same column are significantly different at 5% probability level (P < 0.05).
collar girth, number of leaves, leaf area and plant height on soil amended with rubber effluent. This could be attributed to the short period of time that the effluent was left to mineralize in the soil before planting (2 weeks). In this study, enough time was given to the effluent to mineralize in the soil (8 weeks).

Although studies conducted by Orhue et al. (2005) observed no significant changes in the number of leaves on plant sown on rubber effluent amended soils, results from this study (Table 7) showed that the number of leaves varied and increased with increasing treatment. The maximum was observed in the treatment that received 600 ml RPE (65.77 cm) followed by 600 ml POME (63.75 cm). The result obtained in this study is consistent with Kant and Kumar (1994) who reported an increase in the number of rice tiller in soil amended with organic manure. The result also shows that the number of leaves performed better with plant sown in RPE amended soils.

### 3.4. Effect of treatment on total biomass yield

The results from Table 8 reveal that plant weight varied among the different treatments and was better than the control only with the exception of 200 ml POME treatment. The highest plant weight was obtained in the treatment that received 600 ml RPE (6.18 g). The lower yield from the control could be attributed to the effect of poor nutrient status of the sandy soil, which is less effective in providing the plant with the necessary nutrients. In a similar report, Ozyazici (2013) reported a significant increase in the yield of all the components of wheat, white head cabbage and tomato on sewage sludge amended soil as compared to control. The pot experiment also showed higher biomass yield on soil amended with RPE as compared with POME, only with the exception of 200 ml POME treatment.

### Table 6. Effect of treatment on plant leaf length

| Samples | WK1 (cm) mean ± SD | WK2 (cm) mean ± SD | WK3 (cm) mean ± SD | WK4 (cm) mean ± SD |
|---------|-------------------|-------------------|-------------------|-------------------|
| 0 ml    | Initial soil      | 5.86± 0.02        | 5.97± 0.02        | 6.20± 0.03        | 6.43± 0.03        |
| 200 ml  | POME              | 6.68± 0.02        | 6.74± 0.04        | 6.94± 0.03        | 7.00± 0.03        |
|         | RPE               | 6.44± 0.02        | 6.87± 0.02        | 7.13± 0.02        | 7.28± 0.03        |
| 400 ml  | POME              | 5.67± 0.02        | 6.94± 0.02        | 7.37± 0.02        | 7.46± 0.02        |
|         | RPE               | 6.73± 0.03        | 6.91± 0.09        | 7.20± 0.02        | 7.46± 0.02        |
| 600 ml  | POME              | 6.78± 0.01        | 7.06± 0.08        | 7.23± 0.04        | 7.33± 0.02        |
|         | RPE               | 6.84± 0.02        | 6.77± 0.15        | 7.20± 0.03        | 7.46± 0.03        |

Means with different alphabet remarks in the same column are significantly different at 5% probability level (P < 0.05).

### Table 7. Effect of treatment on the number of leaves

| Samples | WK1 (cm) mean ± SD | WK2 (cm) mean ± SD | WK3 (cm) mean ± SD | WK4 (cm) mean ± SD |
|---------|-------------------|-------------------|-------------------|-------------------|
| 0 ml    | Initial soil      | 7.66± 0.02        | 14.40± 0.01       | 21.68± 0.02       | 25.33± 0.02       |
| 200 ml  | POME              | 15.33± 0.03       | 18.35± 0.03       | 26.44± 0.02       | 36.25± 0.04       |
|         | RPE               | 15.17± 0.02       | 19.34± 0.03       | 31.67± 0.03       | 38.33± 0.03       |
| 400 ml  | POME              | 14.33± 0.03       | 20.23± 0.03       | 40.35± 0.03       | 51.99± 0.05       |
|         | RPE               | 13.32± 0.03       | 25.46± 0.02       | 38.44± 0.02       | 50.65± 0.02       |
| 600 ml  | POME              | 14.65± 0.02       | 16.38± 0.02       | 40.67± 0.03       | 63.75± 0.02       |
|         | RPE               | 13.44± 0.00± 002  | 19.35± 0.02       | 43.70± 0.02       | 65.77± 0.02       |

Means with different alphabet remarks in the same column are significantly different at 5% probability level (P < 0.05).
Table 8. Effect of treatment on total biomass yield

| Treatment | 0 ml (g) mean ± SD | 200 ml (g) mean ± SD | 400 ml (g) mean ± SD | 600 ml mean ± SD |
|-----------|--------------------|----------------------|---------------------|-----------------|
| Before drying (g)          |                    |                     |                    |                 |
| POME      | 15.44 ± 0.01       | 14.76 ± 0.01         | 20.26 ± 0.01        | 41.16 ± 0.01    |
| RPE       | 15.44 ± 0.01       | 36.98 ± 0.01         | 34.66 ± 0.01        | 43.76 ± 0.01    |
| After drying (g)           |                    |                     |                    |                 |
| POME      | 2.45 ± 0.01        | 1.99 ± 0.01          | 2.93 ± 0.01         | 5.95 ± 0.01     |
| RPE       | 2.45 ± 0.01        | 2.54 ± 0.006         | 2.88 ± 0.02         | 6.18 ± 0.01     |

4. Conclusions

There was evidence that the treatments altered the soil properties better than the control. Plant growth parameters also suggest that effluent treatment of soil was also better than the control. However, comparison of the different rates of the effluent amended soils, it was observed that that the pH values were higher in RPE amended soil as compared to POME amended soils in all the pre-plant soils. Also, Mg and Ca were higher with RPE pre-plant soils. Plant growth parameters suggest that the 600 ml POME treatment performed better for plant height. Number of leaves, leaf length and total biomass yield were better with RPE amended soils, while no considerable effect was observed on stem girth by the treatment.

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