**International Journal of Advanced Science and Research**
**ISSN: 2455-4227; Impact Factor: RJIF 5.12**
**Received: 02-01-2021; Accepted: 20-01-2021; Published: 24-02-2021**
**www.allsciencejournal.com**
**Volume 6; Issue 1; 2020; Page No. 47-52**

# Effects of glomus mosseae on the growth parameters of solanum lycopersicum L. (Tomato) grown on polluted soil with spent engine oil

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**Abstract**
This study assessed the growth responses of *Solanum lycopersicum* grown on spent engine-oil-polluted soil and the effect of *Glomus mosseae* in degrading spent engine-oil-polluted soil were examined with a view to providing information on the efficacy of the use of *G. mosseae* in bioremediation. Tomato seedlings raised in nursery were transplanted into 18 pots each was contaminated at 3 levels (1, 3 and 5%), another 18pots each contaminated with spent engine oil + *G. mosseae*, and 12 pots (control) on 3kg sterilized and unsterilized soil with six replications. Data on growth parameters (plant height, leaf area and number of leaves) were recorded two weeks after transplanting and weekly for the duration of twelve weeks. Data were analysed with descriptive and inferential statistics. The results on contaminated soil without *G. mosseae* inoculation wilted at 6weeks after transplanting, while tomato plants on contaminated + *G. mosseae* had significantly higher growth parameters. Plant at 2 weeks after transplanting + *G. mosseae* had the highest numbers of leaves (27.33) but there was no significant difference (P>0.05) between those grown in sterilized and unsterilized soil. The least number of leaves (23.00) was recorded on the plant treated with 5% spent engine oil in unsterilized soil. Highest leaf area with mean value of 38.28 $m^{2.}$ The while the control with sterilized soil had an average leaf area 22.83 $m^2$, unsterilized soil +*G. mosseae (Gm)* had the highest plant height with mean value of 26.33cm. The polluted soil + *G. mosseae* improved this in low level of spent engine oil but good result were not recorded in the pot with higher concentration of spent engine oil (5%) for between 6-8 weeks after transplanting plant had wilted. The study concluded that *G. mosseae* could be used to upgrade low concentration spent engine oil polluted soil.

**Keywords:** spent, contamination, soil, growth, pollution

## Introduction
Bioremediation is a waste management technique that involves the use of plants to eradicate pollutants an area. The quality of life on earth is linked inextricably to the overall quality of the environment. In early times, it was believed that there was an unlimited abundance of land and resources; today, however, the carelessness and negligence in the use of these natural endowments have resulted in the degradation of the environment which in turn affects life negatively. The problem is worldwide distributed which needs a quick attention.

## Materials and Methods
The experiment was carried out at the Screen house of the Faculty of Agriculture, Obafemi Awolowo University (OAU), Ile-Ife, Osun State. The spent engine oil was collected from a mechanic workshop in Ile-Ife, Osun State. The spent engine oil was applied to the pots at the rate of 0, 1, 3 and 5% v\w. Forty grammes of soil containing the mycorrhizal inoculums was used for the soil inoculation. The *S. lycopersicum* L. seedlings were raised in the nursery for a period of 3 weeks before transplanting them to the pots. Eighteen experimental pots each were contaminated at 3 levels (1, 3 and 5%) with six replications for both sterilized and unsterilized soil. Another eighteen pots each contaminated with spent engine oil was inoculated with *G. mosseae* for both sterilized and unsterilized soil. The remaining twelve pots from both sterilized and unsterilized soil was used as control. Data on growth parameters (plant height, leaf area and number of leaves) were recorded two weeks after transplanting and weekly for the duration of twelve weeks.

## Experiment (Treatment Combination)
Percentage of soil contamination was determined after mixing spent engine oil with Sterilized and unsterilized soils using this formula; Percentage soil contamination = (Volume of pollutant/ volume of soil) x 100.

## Experimental layout
Treatment 1- sterilized soil + S. *lycopersicon* L.
Treatment 2- unsterilized soil + S. *lycopersicon* L.
Treatment 3- sterilized soil + mycorrhiza + S. *lycopersicon* L.
Treatment 4- unsterilized soil + mycorrhiza + S. *Lycopersicon* L.
Treatment 5- sterilized soil + spent engine oil + S. *lycopersicon* L.
Treatment 6- unsterilized soil + spent engine oil + S. *lycopersicon* L.
Treatment 7- sterilized soil + mycorrhiza + spent engine oil + S. *lycopersicon* L.
Treatment 8- unsterilized soil + mycorrhiza + spent engine oil + S. *lycopersicon* L.
Watering was done regularly to ensure adequate moisture for proper growth of the test plant.

### Agronomic Data

The following growth parameters of the plant were used to measure the effect of contamination and treatment in the experiment.

### Number of Leaves

Visual counting was done on the number of leaves weekly from the first day of pollution with spent engine oil till twelve week.

### Height of Plant

The plant height was measured from the shoot tip to the soil level, weekly (cm) with meter rule from the day of contamination to harvest time.

### Leaf Area

The leaf length was measured from the node to the tip of leaf and the width was measured weekly. This was determined by; Leaf Area ($m^2$) = L × W × 2.325. Where; L = leaf length, W = leaf width and 2.325 (correction factor).

## Results

Treatments had effect on the growth parameters of tomato used in this study. These growth parameters include: numbers of leaves, plant height and leaf area.

### Number of Leaf

Tomato grown in pot at two weeks after transplanting with sterilized soil inoculated with *Glomus mosseae (Gm)* had the highest number of leaves with mean value (27.33) followed by pot inoculated with *Gm* + unsterilized soil (26.33).The unsterilized control pot had (25.33) while the control with sterilized soil had an average number of 23.00 leaves. The pot treated with 1% spent engine oil (SEO) and the soil sterilized (SS) had an average leaf number of 19.67 while the unsterilized soil (US) with 5% SEO had 7.33. Unsterilized pots treated with 1% SEO had an average leaf number of 16.67, followed by 1% SEO polluted soil with unsterilized soil and inoculated with *Gm* (16.00). It was also recorded from the result that pots with 1% SEO polluted soil, inoculated with *Gm* and soil sterilized had a mean value of 15.33. 3% SEO + US and 3% + SEO + SS treated soil are next with had mean value of 9.33 and 9.00 respectively. 5%SEO +SS and 5% SEO +*Gm* +SS also had a mean value of 8.67 & 8.00 respectively. The least average number of leaves was recorded on the plant with treatment 5% SEO + US. At week 4, treatments *Gm*+ SS, *Gm* + US, the control pot with sterilized soil and *Gm* +US had the highest mean value when compared to others. The corresponding values for these treatments were higher than the recorded value in week two (Table 1). Also at week 4, treatments with the 5% contamination, had lower number of leaves. The addition of *Gm* to the soil at this week did not improve the leaf number of the plants. As the week progresses, the effect of the *Gm* became prominent as it improves the average number of the leaves observed on the plants. At 6 weeks after transplanting, the control pots with *Gm* +SS had the highest mean value, followed by *Gm* +unsterilized soil. The effect of the different levels of contamination became prominent as the treatments with lower level of contamination had appreciably higher values for the average number of leaves when compared with the treatment with higher percentage of contamination. At 8, 10 and 12 weeks after transplanting, the number of leaves reduced drastically for the contaminated treatments while the control still maintained higher number of leaves. It was also recoded that at these weeks, death of plants resulting in zero number of leaves was observed on treatments with 3 and 5 % contamination respectively.

**Table 1:** Effects of Treatments on Number of Leaves.

| Treatments number of leaves(weeks) | 2 | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|---|
| Control + Sterilize soil | 23.00 | 39.33 | 60.00 | 61.33 | 87.33 | 115.00 |
| Control + Unsterilized soil | 25.33 | 32.33 | 59.67 | 79.33 | 105.33 | 129.33 |
| *Gm* + sterilized soil | 27.33 | 49.00 | 88.33 | 107.33 | 134.33 | 160.67 |
| *Gm* + Unsterilized soil | 26.33 | 39.33 | 75.67 | 109.67 | 126.33 | 152.00 |
| 1%SEO + Sterilized soil | 19.67 | 38.00 | 60.00 | 77.33 | 48.67 | 54.00 |
| 1%SEO + Unsterilized soil | 16.67 | 22.67 | 31.00 | 42.00 | 66.67 | 94.33 |
| 3%SEO + Sterilized soil | 9.00 | 10.67 | 15.33 | 16.67 | 14.00 | 13.67 |
| 3%SEO + Unsterilized soil | 9.33 | 5.67 | 10.00 | 10.83 | 3.67 | 0.00 |
| 5%SEO + Sterilized soil | 8.67 | 3.00 | 1.33 | 1.33 | 0.00 | 0.00 |
| 5%SEO + Unsterilized soil | 3.67 | 3.33 | 2.33 | 1.00 | 0.00 | 0.00 |
| 1%SEO + *Gm* + Sterilized soil | 15.33 | 32.67 | 52.76 | 57.00 | 55.67 | 58.00 |
| 1%SEO + *Gm* + Unsterilized soil | 16.00 | 29.67 | 41.00 | 53.33 | 45.00 | 57.00 |
| 3%SEO + *Gm* + Sterilized soil | 7.33 | 7.33 | 10.33 | 10.00 | 3.33 | 3.00 |
| 3%SEO + *Gm* + Unsterilized soil | 15.67 | 14.00 | 24.67 | 24.67 | 21.67 | 24.33 |
| 5%SEO + *Gm* + Sterilized soil | 8.00 | 10.00 | 16.00 | 20.67 | 13.00 | 10.33 |
| 5%SEO + *Gm* + Unsterilized soil | 17.33 | 7.33 | 13.67 | 9.33 | 1.00 | 0.00 |
| LSD ($_{0.05}$) | 6.79 | 11.65 | 28.23 | 31.25 | 26.95 | 31.02 |

SEO =Spent engine oil; *Gm*= *Glomus mosseae*


US + *SL*

US + Gm + SL


SS + Gm +SL SS + SL

**Plate 1 (a & b):** Comparison between the treatment and the control as labeled at 6 WAP
SS= Sterilized Soil; US= Unsterilized Soil; SEO= Spent engine oil; GM= *Glomus mosseae;* SL= *Solanum lycopersicum*

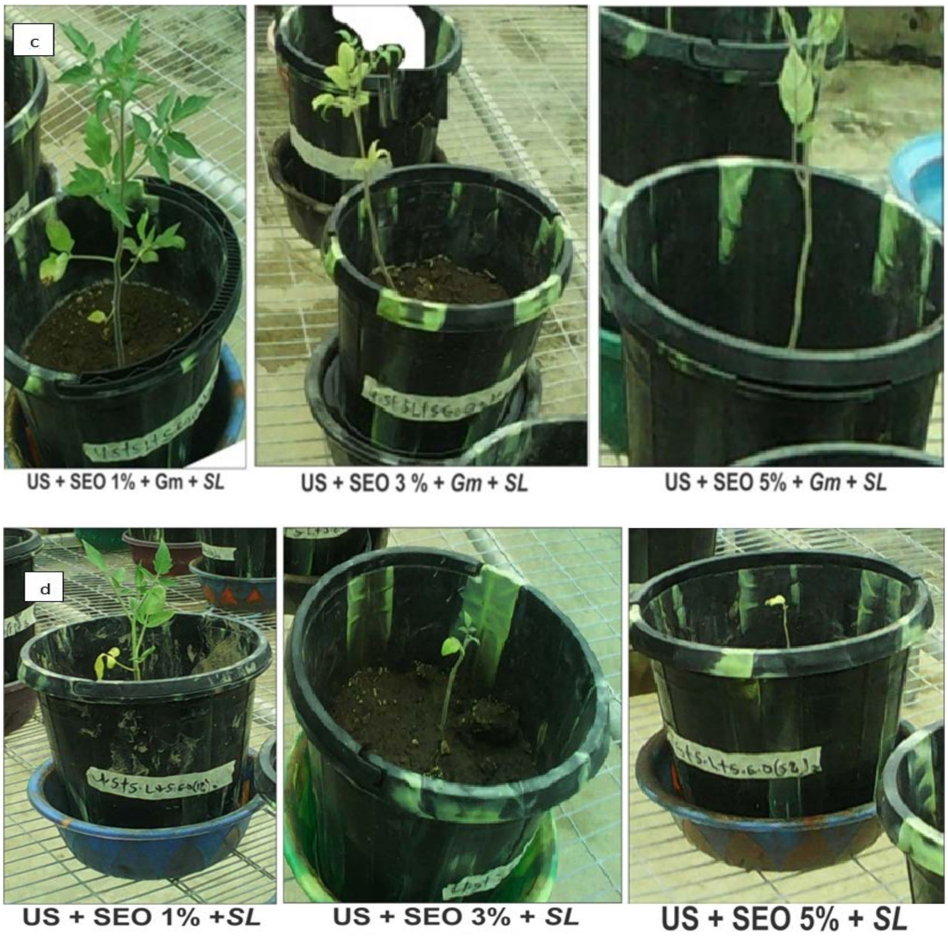


**Plate 2 (c & d):** Comparison between different treatments as labeled at 6 WAT
SS= Sterilized Soil; US= Unsterilized Soil; SEO= Spent engine oil; GM= *Glomus mosseae;* SL= *Solanum lycopersicum*

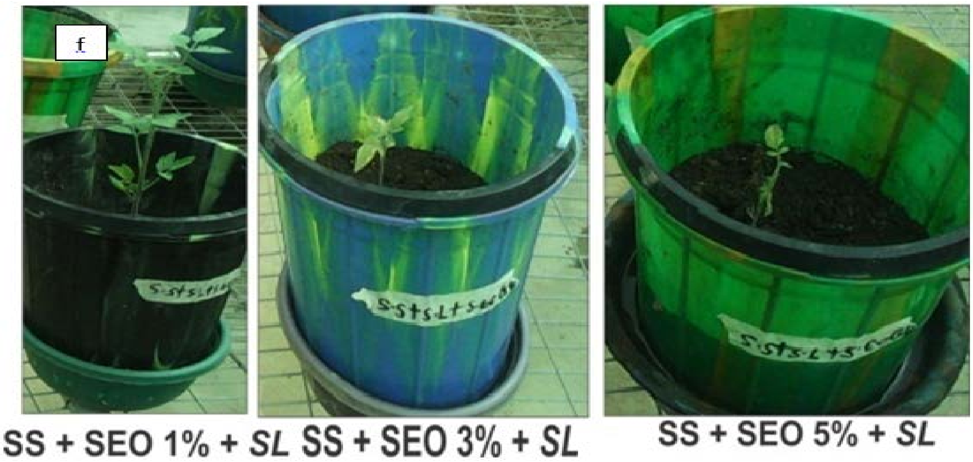


**Plate 3 (E & F):** Comparison between different treatments at 6 WAT
SS= Sterilized Soil; US= Unsterilized Soil; SEO= Spent engine oil; GM= *Glomus mosseae;* SL= *Solanum lycopersicum*

### Effect of the Treatments on the Leaf Area

Tomato grown in pot at two weeks after transplanting with sterilized soil inoculated and *Glomus mosseae (Gm)* had the highest leaf area with mean value of 38.28 $m^2$ (Table 3). The pot inoculated with *Gm* + unsterilized soil is the next (31.07 $m^2$). The unsterilized control pot had (25.30 $m^2$) while the control with sterilized soil had an average leaf area of 22.83 $m^2$ (Table 3).

The contaminated pots generally have a lower value of leaf area when compared to the control pots and the pots with *Gm* only. Pots treated with 1% spent engine oil (SEO) with sterilized soil (SS) had an average leaf area of 10.7 $m^2$ (Table 3). Unsterilized pots treated with 1% SEO had an average leaf area of 8.49 $m^2$ (Table 3). Pots containing 1% SEO polluted soil with unsterilized soil inoculated with *Gm* had a leaf area of 14.82 $m^2$ although not significantly different from the sterilized counterpart with 8.95 $cm^2$ leaf area (Table 3). It was also recorded from the result that pots with 3% SEO polluted soil, inoculated with *Gm* had lower mean value of 8.66 and 10.70 $m^2$ for sterilized and unsterilized soil respectively (Table 3). The least leaf area observed at this week was recorded on 5% SEO + US and 5% + SEO + SS treated soil.

As the leaf number decreased at week 4, the leaf area also significantly dropped for the contaminated treatments when compared with pots containing *Gm*+ SS, *Gm* + US, the control pot with sterilized soil (Table 3). Also at this week, treatments with the 5% contamination had reduced area of leaves. The addition of *Gm* to the soil at this week did not significantly improve the number also improve the area of leaves of the plants. As the week progresses, the effect of the *Gm* became prominent as it also improves the average area of the leaves observed on the plants. At 6 weeks after transplanting, the control pots with *Gm* +SS have the highest average value for the area of leaves, followed by *Gm* +unsterilized soil. There was a decline in the area of leaves observed at this week for 3% contamination for both sterilized and unsterilized soil with the corresponding values of (1.74 and 1.55 $m^2$). At 8, 10 and 12 weeks after transplanting, the area of leaves reduced drastically for the contaminated treatments while the control still maintained higher number of leaves. It was also recoded that at these weeks, death of plants resulting in zero area of leaves was observed on treatments with 3 and 5 % contamination without *Gm* for both sterilized and unsterilized soil respectively.

**Table 2:** Treatment Effects on leaf area

| Treatments Leaf area at different Ages | 2 | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|---|
| Control + Sterilize soil | 22.83 | 44.92 | 40.88 | 48.24 | 81.57 | 95.52 |
| Control + Unsterilized soil | 25.30 | 31.78 | 44.02 | 56.63 | 71.30 | 68.27 |
| *Gm* + sterilized soil | 38.28 | 57.55 | 55.14 | 38.36 | 74.40 | 90.67 |
| *Gm* + Unsterilized soil | 31.07 | 33.32 | 34.88 | 33.23 | 65.49 | 76.13 |
| 1%SEO + Sterilized soil | 10.70 | 28.10 | 33.71 | 39.76 | 59.68 | 69.75 |
| 1%SEO + Unsterilized soil | 8.49 | 17.90 | 16.28 | 19.34 | 24.03 | 18.19 |
| 3%SEO + Sterilized soil | 3.22 | 5.81 | 3.29 | 4.26 | 3.89 | 1.74 |
| 3%SEO + Unsterilized soil | 7.75 | 7.36 | 1.74 | 2.71 | 1.55 | 0.00 |
| 5%SEO + Sterilized soil | 5.35 | 3.87 | 1.55 | 0.77 | 0.00 | 0.00 |
| 5%SEO + Unsterilized soil | 7.67 | 3.29 | 2.33 | 0.54 | 0.00 | 0.00 |
| 1%SEO + *Gm* + Sterilized soil | 8.95 | 16.14 | 16.47 | 14.34 | 15.89 | 6.07 |
| 1%SEO + *Gm* + Unsterilized soil | 14.82 | 13.95 | 15.50 | 15.75 | 20.15 | 10.46 |
| 3%SEO + *Gm* + Sterilized soil | 8.66 | 8.14 | 5.04 | 6.01 | 1.55 | 0.39 |
| 3%SEO + *Gm* + Unsterilized soil | 10.70 | 10.08 | 6.01 | 6.67 | 1.86 | 3.68 |
| 5%SEO + *Gm* + Sterilized soil | 9.07 | 14.11 | 7.94 | 5.62 | 3.10 | 2.01 |
| 5%SEO + *Gm* + Unsterilized soil | 10.78 | 8.90 | 8.14 | 7.75 | 1.55 | 0.00 |
| LSD ($_{0.05}$) | 10.09 | 15.21 | 15.43 | 12.21 | 12.99 | 7.84 |

Leaf area ($m^2$) at different ages of plants (tomato) in weeks

**Effect of Treatments on Plant Height**

Tomato grown in pot at two weeks after transplanting with unsterilized soil inoculated and *Glomus mosseae (Gm)* had the highest plant height with mean value of 26.33cm (Table 4). This is followed by pot inoculated with *Gm* + sterilized soil (23.00cm). The sterilized control pot had (19.00 cm) while the control with unsterilized soil had an average plant height of 17.83cm (Table.4). The contaminated pots generally have a lower value of plant height when compared to the control pots and the pots with *Gm* only. Pots treated with 1% spent engine oil (SEO) with sterilized soil (SS) had an average plant height of 13.17cm (Table 4). Unsterilized pots treated with 1% SEO had an average plant height of 12.50cm. Pots containing 1% SEO polluted soil with unsterilized soil inoculated with *Gm* had a plant height of 11.33cm although not significantly different from the sterilized counterpart with 10.17cm plant height (Table 4).

It was also recorded from the result that pots with 3% SEO polluted soil, inoculated with *Gm* had lower mean value of 6.83 and 11.50cm for sterilized and unsterilized soil respectively.3% +SEO +US and 5% SEO +US was observed to have same mean value of 8.83cm (Table 4). The least plant height observed at this week was recorded on 5% SEO + US and 5% + SEO + *Gm* +SS treated soil. As the number of leaves and leaf area decreased at week 4, the plant height also significantly dropped for the contaminated treatments when compared with pots containing *Gm*+ SS, *Gm* + US, the control pot with sterilized soil. Also at this week, treatments with the 5% contamination had reduced the plant height. The addition of *Gm* to the soil at this week did not significantly improve the number of leaves and leaf area, also improve the height of the plants. As the week progresses, the effect of the *Gm* became prominent as it also improves the average height of the plants observed on the plants (Table 4).

At 6 weeks after transplanting, the control pots with *Gm* +SS have the highest average value for the plant height, followed by control + sterilized soil. There was a decline in the height of plants observed at this week for 3% contamination for both sterilized and unsterilized soil with the corresponding values of (9.67 and 12.00cm). At 8, 10 and 12 weeks after transplanting, the height of plants reduced drastically for the contaminated treatments while the control still maintained higher plant height. It was also recoded that at these weeks, death of plants resulting in zero area of leaves was observed on treatments with 3 and 5 % contamination without *Gm* for both sterilized and unsterilized soil respectively (Table 4).

**Table 3:** Effects of Treatments on Plant Height of Tomato

| Treatments Leaf area at different Ages | 2 | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|---|
| Control + Sterilize soil | 22.83 | 44.92 | 40.88 | 48.24 | 81.57 | 95.52 |
| Control + Unsterilized soil | 25.30 | 31.78 | 44.02 | 56.63 | 71.30 | 68.27 |
| *Gm* + sterilized soil | 38.28 | 57.55 | 55.14 | 38.36 | 74.40 | 90.67 |
| *Gm* + Unsterilized soil | 31.07 | 33.32 | 34.88 | 33.23 | 65.49 | 76.13 |
| 1%SEO + Sterilized soil | 10.70 | 28.10 | 33.71 | 39.76 | 59.68 | 69.75 |
| 1%SEO + Unsterilized soil | 8.49 | 17.90 | 16.28 | 19.34 | 24.03 | 18.19 |
| 3%SEO + Sterilized soil | 3.22 | 5.81 | 3.29 | 4.26 | 3.89 | 1.74 |
| 3%SEO + Unsterilized soil | 7.75 | 7.36 | 1.74 | 2.71 | 1.55 | 0.00 |
| 5%SEO + Sterilized soil | 5.35 | 3.87 | 1.55 | 0.77 | 0.00 | 0.00 |
| 5%SEO + Unsterilized soil | 7.67 | 3.29 | 2.33 | 0.54 | 0.00 | 0.00 |
| 1%SEO + *Gm* + Sterilized soil | 8.95 | 16.14 | 16.47 | 14.34 | 15.89 | 6.07 |
| 1%SEO + *Gm* + Unsterilized soil | 14.82 | 13.95 | 15.50 | 15.75 | 20.15 | 10.46 |
| 3%SEO + *Gm* + Sterilized soil | 8.66 | 8.14 | 5.04 | 6.01 | 1.55 | 0.39 |
| 3%SEO + *Gm* + Unsterilized soil | 10.70 | 10.08 | 6.01 | 6.67 | 1.86 | 3.68 |
| 5%SEO + *Gm* + Sterilized soil | 9.07 | 14.11 | 7.94 | 5.62 | 3.10 | 2.01 |
| 5%SEO + *Gm* + Unsterilized soil | 10.78 | 8.90 | 8.14 | 7.75 | 1.55 | 0.00 |
| LSD $_{(0.05)}$ | 10.09 | 15.21 | 15.43 | 12.21 | 12.99 | 7.84 |

SEO =Spent engine oil; *Gm*= *Glomus mosseae*

**Discussions**

*Solanum lycoperscium* L. grown in the soil without spent engine oil (SEO) contamination thrived well. The effect of waste disposal on plant which is generated from mechanical workshop may serve as impediment to its growth; this is partly because the released SEO contains heavy metals which may block the soil pores and water passages to the soil which are conditions necessary for plant germination and growth of plants. This is in line with the report of Chikere *et al.* (2009) who reported that, leafy vegetable crops are sensitive to Zn toxicity, especially spinach and beet, because of their inherent high Zn uptake capacity. High concentrations of polycyclic aromatic hydrocarbons (PAHS) in the SEO contaminated soil can also limit plant growth and survival by affecting water and nutrient uptake to the roots. This is in line with the report of Abii and Nwosu (2009) [1], which inferred that soils mixed with spent engine oil were having poor fertility and did not sustain sufficient plant development.

The results on leaf area revealed that the control pots and pots with *Glomus mosseae* alone showed a significantly higher means in terms of leaf area development compared to those treated with SEO under sterilized and unsterilized soil. At week 8 and 10 after transplanting, control pots and *Glomus mosseae* alone treated pots were significantly better in leaf area development over other treatments. At 12 weeks after transplanting sterilized control pot and sterilized *Glomus mosseae* treated pots showed a significantly wider leaf area over other treatments. Soil treated with 3% and 5 % SEO and mycorrhizal had the least effect on leaf area and those without mycorrhizal died. The reduction of leaf area could be due to SEO effluent at 3% and 5% which aggravated the plant stress thereby reducing the photosynthetic activities leading to poor growth. The lower performance of plant however resulted into the death of the plant at those levels. It was observed in this study that the values of the growth parameters decreased as SEO increased. There was a decline of these values as a result of changes in soil condition, which interfered with gaseous exchange and water up take resulting in physiological drought (Anoliefo and Edagbai, 2001) [2]. The study also revealed that the values of growth parameters reduced at high SEO concentration (0% - 5%). This could be due to the SEO forming a hydrophobic layer over the root of test plants. In the control, *Solanum lycoperscium* L. grown on soil polluted with SEO at 3% level of concentration on unsterilized soil died at 12th week after planting while those grown on soil polluted at 5% both sterilized and unsterilized soil died at 10th week after planting. This death might be due to the toxicological stress of heavy metals uptake of SEO on *Solanum lycoperscium* L.

Considering the serious consequences of heavy metal pollution of the soil on human health and the ecosystem, it has become imperative to create suitable means of overcoming these problems. *Glomus mosseae* used in this study played a significant role in this research in providing an environmentally friendly and economical approach to amelioration of this menace. The fungal inoculums can be produced in large quantities by current simple technique used for the propagation and such will provide viable spores.

This study concluded that spent engine oil polluted soil is toxic to *S. lycopersicum* L. plant as it negatively affected its growth. The use of *Glomus mosseae* conferred on the plant some form of resilience from stress as a result of the spent engine oil pollution thus improving the growth of test plant (*Solanum lycopersicum* L.) used in this study. Despite the effectiveness of *Gm* remediating spent engine oil polluted soil, the concentration (v/w) of the pollutant also affect the activity of the organism. As the percentage of contamination increased, the effectiveness of the organism decreased

## Conclusion

This study concluded that spent engine oil polluted soil is toxic to *S. lycopersicum* L. plant as it negatively affected its growth. The use of *Glomus mosseae* conferred on the plant some forms of resilience from stress as a result of the spent engine oil pollution thus improving the growth of *Solanum lycopersicum* L. The presence of *Glomus mosseae* in polluted soil is effective in the degradation of spent engine oil polluted soil thus increasing plant growth.

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