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Assessment of Soil Fertility Improvement Potential of Water and Methanolic Sunflower (*Tithonia diversifolia* Hemsl.) Leaf Extract on the Growth and Yield of Tomato (*Solanum lycopersicon* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author OOC designed the study, performed the statistical analysis and wrote the protocol. Author AOS wrote the first draft of the manuscript and managed the analyses of the study. Author OOI managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The field work was carried out at the Screenhouse of Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria to determine the effectiveness of water and methanolic sunflower leaf extract as a fertilizer sources to improve growth and yield of tomato. The experiment consisted of six treatments which are sterilized soil with tomato, unsterilized soil with tomato, water sunflower extract with tomato in sterilized soil, water sunflower extract with tomato in unsterilized soil, methanolic sunflower leaf extract with tomato in sterilized soil and methanolic sunflower leaf extract with tomato in unsterilized soil. Treatments were in triplicate and arranged in randomized complete block design (RCBD). Twelve pots, each containing three kilograms of top soil were used in consideration to the planting duration. One hundred (100) ml of sunflower leaf extracts was added to each of the treatments except the controls.

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The growth results at Nine weeks after planting showed that leaf area and vine length was significantly higher in treatment with sunflower methanolic extract in sterilized soil with mean of 78.87 cm^2 while girth size and vine length were significantly higher in the control treatment with sterilized soil. The yield results showed that the treatment with methanolic sunflower in sterilized soil had 8 fruits at harvest while the least number of fruit was in treatment of methanolic sunflower in unsterilized soil which had one fruit. The treatment with water extract of sunflower with unsterilized soil had the highest fruit weight of 1.2 gram while the treatment with methanolic sunflower extract with unsterilized soil had the least value of 0.066 gram which was lower than the controls. The diameter of fruit showed that the treatment with methanolic sunflower extract with sterilized soil had the highest value with mean of 25.4 cm while treatment with methanolic sunflower extract in unsterilized had the least with mean of 6.5 cm. Nitrogen and potassium level in the post planting soil were reduced almost all across the treatments. Soil calcium increased in the post planting soil as well as the pH. The experiment concludes that methanolic sunflower extract improves soil fertility.

Keywords: Soil fertility; Sunflower extract; Sterilized soil; Unsterilized Soil; Water extract and Methanolic extract.

1. INTRODUCTION

Tomato (*Solanum lycopersicon*) is a herbaceous plant in the Solanaceae or the Night shade family. Tomato is the second largest vegetable food crop after onion and pepper and it is widely consumed around the globe. Tomato fruits contain various minerals and vitamins [1]. It was found that tomatoes and tomato products have numerous health benefits and also contribute to a well-balanced diet [3]. It is a one of the major condiments for food all around the world. There will be more demand for these vegetables with population growth, economic growth and urbanization [3]. Nigeria is the second largest producer in Africa and leads in West Africa sub region with an estimated output of 1.10 metric tonnes and average yield of 10 t ha¯1 [4].

Tithonia diversifolia known as sunflower is a woody herb or succulent (scandent) shrub which is a member of the family *Asteraceae* [5]. It had been observed to be widely spread in Nigeria where it is found growing on abandoned/waste lands, along major roads and waterways and on cultivated farmlands [6]. The green leaf biomass of *Tithonia* is high in nutrient, the average is about 3.5% nitrogen, 0.3% phosphorus and 4.1% potassium [6]. It has shown great potential in raising the soil fertility in soils depleted in nutrients [7]. As important as tomato is in terms of its nutritional content and economic value, its maximum yield had not been attained due to low soil fertility. Some soils are naturally low in specific nutrients due to their composition, and excessive, or unbalanced use of fertilizer which may cause some nutrients to be less available [8]. Research effort aimed at improving soil fertility in an environmental friendly way has lead to the use of extracts from leaves of sunflower (*Tithonia diversifolia*) which is considered as an invasive weed and are at the disposal of peasant farmers.

The objectives of this research are as follows:

(1) To determine the effect of methanolic and water extract of sunflower leaf on the growth of tomato.
(2) To examine the effect of the methanolic and water extract of sunflower leaf on the yield of tomato
(3) To evaluate the effect of methanolic and water extract of sunflower on the physicochemical properties of the soil.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

This research was carried out at the screenhouse of Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria (Latitude: 7º52´65´´N and Longitude: 4º52´83´´E).

2.2 Preparation of Sunflower (*Tithonia diversifolia*) Extract

Mexican Sunflower was collected along Ede road (Latitude: 7º27´60´´N and Longitude: 4º33´60´´E) in Ile-Ife. The leaves were washed with water and air dried for four days after which it was grinded into pellets using electric blender. The extraction was done by measuring 30 ml of methanol into a conical flask which contained 70 ml of distilled water. One gram of ground

sunflower (*Tithonia diversifolia*) was measured into the conical flask containing the mixture of water and methanol for 48 hours after which it is filtered with Whatman filter paper. The water extract was done by measuring 100 ml of water into a conical flask. One gram of ground sunflower (*Tithonia diversifolia*) was measured into the conical flask for 48 hours after which it was filtered Whatman filter paper.

2.3 Preparation of Pots for the Experiment

Sterilized and unsterilized soils were used for this research. There were twelve (12) experimental pots, six pots contained 3 kg of sterilized soil while the other six pots contained 3 kg of unsterilized soil.

2.4 Raising of Tomato at Nursery and Transplanting

Tomato seedlings for this experiment were raised at the Screenhouse. An average sized bowls were filled with sterilized soil and the seeds of UC-82 tomato cultivar were carefully sown in it. The seedlings were allowed to grow in the nursery for a period of three weeks.

2.5 Methodology

One hundred (100) ml of methanolic sunflower extract was poured into holes made in the middle of a set of three (3) experimental pots containing sterilized soil and another set of three (3) experimental pots containing unsterilized soil before *Solanum lycopersicon* seedlings were transplanted into it. One hundred (100) ml of water extract of sunflower was poured into holes made in the middle of a set of three (3) experimental pots containing sterilized soil and another set of three (3) experimental pots containing unsterilized soil before *Solanum lycopersicon* seedlings were transplanted into it. There were six (6) controls, three (3) for sterilized soil and (3) for unsterilized soil. There were no extracts added to them before *Solanum lycopersicon* seedlings were transplanted. Thereafter, pots were arranged in a completely randomized design in the screenhouse. Each treatment of the experiment was replicated three times. Pots containing *Solanum lycopersicon* were watered regularly to ensure adequate moisture.

Growth data on number of leaves, girth size, vine length, leaf area and number of branches was collected weekly between three weeks after planting to nine weeks after planting. Number of fruit, weight of fruit and diameter of fruit was collected for yield data between week thirteen to week sixteen after planting.

2.6 Statistical Analysis of Data

The data were analyzed using SAS 9.2 statistical package by subjecting the data to descriptive statistics and Least Significant Difference (LSD).

3. RESULTS

The result of the extract shows that water extract of sunflower consist of 0.0040% calcium, 0.025% magnesium, 0.164% potassium, 0.008% total phosphorus and 0.089% nitrogen while the methanolic extract consist of consist of 0.0043% calcium, 0.009% magnesium, 0.127% potassium, 0.008% total phosphorus and 0.086% nitrogen.

The growth result showed that at the end of 9 WAP, the number of leaves was higher in control treatment with sterilized soil with mean of 68.33 while the least was in the treatment with sunflower water extract in sterilized soil with mean of 33.00. In the control treatments, the increase in number of leaves was not significant with their LSD until 9 WAP and for other treatments from 7 WAP and 9 WAP. Girth size and vine length were also higher in the control treatment with sterilized soil with girth size of 2.06 cm. The vine length, number of leaves and girth size had the least value in the water extract of sunflower in sterilized soil.

The leaf area had the higher value in treatment with methanolic extract of sunflower with mean of 78.87cm^2 and the least was in treatment with water extract of sunflower with mean of 12.05 cm^2. The number of branches had the highest value in treatment with water extract of sunflower in unsterilized soil with mean 14.67 while the least was in control treatment in unsterilized soil.

The yield results which were recorded between 13 WAP to 16 WAP showed that the treatment with methanolic sunflower extract in sterilized soil had a total of Eight (8) fruits which is the highest number of fruits and it was significantly higher than all other treatments (Fig. 1). The least number of fruit was in treatment with water extract of sunflower in the sterilized soil with a total of 1 fruit (Fig. 1). The weight of fruit had the highest value in treatment with water extract of sunflower in unsterilized soil with mean weight of

1.2 gram while the least was in treatment with methanolic extract of sunflower in the unsterilized soil with mean of 0.066 gram which was significantly lower than the two controls (Fig. 2). The result of the research also showed that diameter of fruit which is one of the parameters of yield had its highest value in the treatment with the methanolic sunflower extract with value of 25.4 cm.

Table 1 presents the physico-chemical properties of the soil before planting of tomato. The soil had 12.6 % and 14.6 % clay, 15.4 % and 7.4 % silt, and 72 % and 77 % sand respectively for sterilized and unsterilized soil, thus the soil is loamy sand in texture. The pH was 6.44 (slightly acidic) and 7.26 (slightly alkaline) for sterilized soil and unsterilized soil. The soil organic matter was 6.7 % and 5.3 %; the total nitrogen of the soil was 0.33 % and 0.32 %; and the available phosphorus was 17.9 mg/kg and 10.12 mg/kg for sterilized and unsterilized soil respectively (Table 1).

Soil pH was higher in all the treatments with sterilized soil except in treatment with water extract of sunflower in sterilized soil which was insignificantly lower than the initial pH value (Fig. 4). Calcium was significantly lower in the control treatments when compared with initial calcium level. Meanwhile, calcium was significantly higher in treatment with methanolic extract of sunflower in sterilized soil while it was insignificantly lower in other treatments with extracts of sunflower with unsterilized soil and sterilized soil (Fig. 5). Potassium was insignificantly higher in the treatment with water extract of sunflower in unsterilized soil but was significantly lower in all other treatments of both water and methanolic extracts of sunflower and in the controls (Fig. 6). Nitrogen was significantly low in the control treatments and in the treatments with water extract of sunflower in unsterilized soil but it was significantly higher in methanolic extract of sunflower both in sterilized, unsterilized soil and in water extract of sunflower in sterilized soil (Fig. 7). Phosphorus was significantly lower in treatment with methanolic extract of sunflower with sterilized soil and insignificantly low in the treatment with water extract of sunflower with sterilized soil (Fig. 8). All the treatment with unsterilized soils was insignificantly lower than their pre-planting status (Fig. 8). Magnesium were significantly lower in all the treatment with sterilized soil except in treatment with water extract of sunflower where the reduction was insignificant (Fig. 9). Hydrogen ion was insignificantly low in the control treatment and in the treatment with water extract of sunflower in unsterilized soil (Fig. 10). Although, hydrogen ion was significantly higher in treatment with methanolic extract of sunflower in unsterilized soil (Fig. 9). The cation exchangeable capacity (CEC) (Ca^{2+}, Mg^{2+} and K^{+}) of the soil was 1.75 cmol/ kg and 2.38 cmol/kg for Ca^{2+}, 1.32 cmol/kg and 1.51 cmol/kg for Mg^{2+}, 0.38 cmol/kg and 0.55 cmol/kg for K^{+} for sterilized and unsterilized soil respectively. H^{+} added to Al^{3+} in sterilized soil was 0.28 cmol/kg and 0.35 cmol/kg for unsterilized soil. The sterilized soil had the highest value for phosphorus with value of 17.9 mg/kg but its value for potassium was very low with value of 0.38 cmol/kg. Magnesium was found to have a higher value in the unsterilized soils when compared to sterilized soil (Table 1).

Table 1. Physicochemical properties of sterilized and unsterilized soil before planting

Parameters	Sterilized	Unsterilized
pH	6.44	7.26
Ca (cmol/kg)	1.75	2.38
Mg (cmol/kg)	1.32	1.51
K (cmol/kg)	0.38	0.55
Nitrogen g/kg	0.33	0.32
P (mg/kg)	17.9	10.12
H^{+}	0.18	0.22
Al^{3+}	0.10	0.13
Organic matter %	6.7	5.3
Clay %	12.6	14.6
Silt %	15.4	7.4
Sand %	72.0	77.0

3.1 Growth Result of Tomato

The growth data were collected on a weekly basis for a period of seven weeks after planting. The data collected include number of leaves, girth size, vine length, leaf area and number of branches. Treatments were arranged across the column while weakly measurement of each growth parameters as the week progresses was arranged in row in front of each treatment. The measurements were analyzed and the mean were separated with LSD (Least Significant Difference).

Table 2. Number of leaves of *Solanum lycopersicon* at different ages

	Week after planting							
Treatment	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**LSD**
1 - SS+TP	9.00	12.00	16.67	17.33	32.33	38.67	68.33	27.73
2 - US+TP	6.67	7.00	10.33	12.33	17.67	19.67	39.33	13.37
3-SF+METHCD+SS+TP	7.67	14.33	22.00	26.33	33.00	59.00	85.00	21.66
4 -SF+METHCD+US+TP	8.67	6.33	11.67	9.00	11.33	24.00	36.67	10.00
5 - SF+H_2O CD+SS+TP	9.00	10.00	12.33	13.67	18.67	31.67	33.00	9.56
6 - SF+H_2O CD+US+TP	8.00	11.33	15.00	20.00	32.67	54.67	55.67	12.44

Legend: SS: Sterilized soil; US: Unsterilized soil; SF: Sunflower; METH: Methanol; CD: Cold; TP: Test plant

Table 3. Girth size of *Solanum lycopersicon* (cm) at different ages

	Week after planting							
Treatment	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**LSD**
1 - SS+TP	0.60	1.20	1.30	1.51	1.60	1.80	2.06	0.19
2 - US+TP	0.53	0.80	1.06	1.50	1.56	1.73	2.00	0.14
3 -SF+METHCD+SS+TP	0.56	0.66	0.93	1.16	1.36	1.66	1.93	0.19
4 -SF+METHCD+US+TP	0.56	0.80	1.06	1.30	1.40	1.43	1.73	0.62
5 - SF+H_2O CD+SS+TP	1.06	1.43	0.53	0.40	0.50	0.73	1.00	0.12
6 - SF+H_2O CD+US+TP	1.00	1.13	1.00	0.47	1.00	1.30	1.50	0.29

Legend: SS: Sterilized soil; US: Unsterilized soil; SF: Sunflower; METH: Methanol; CD: Cold; TP: Test plant

Table 4. Vine length of *Solanum lycopersicon* (cm) at different ages

	Week after planting							
Treatment	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**LSD**
1 - SS+TP	9.83	10.67	15.33	17.23	21.00	27.33	35.50	10.43
2 - US+TP	7.33	8.23	9.47	11.93	12.67	13.50	15.00	3.37
3 -SF+METHCD+SS+TP	11.00	13.60	17.33	18.00	20.00	27.33	36.67	3.17
4 -SF+METHCD+US+TP	9.33	10.16	12.50	14.83	17.00	26.67	29.33	3.20
5 - SF+H_2O CD+SS+TP	2.16	5.26	4.55	7.52	11.36	10.11	12.05	5.81
6 - SF+H_2O CD+US+TP	2.87	3.30	6.50	3.48	15.54	18.21	19.59	3.71

Legend: SS: Sterilized soil; US: Unsterilized soil; SF: Sunflower; METH: Methanol; CD: Cold; TP: Test Plant

Table 5. Leaf area of *Solanum lycopersicon* (cm^2) at different ages

	Week after planting							
Treatment	3	4	5	6	7	8	9	LSD
1 -SS+TP	7.30	9.97	12.43	21.10	35.23	39.10	49.06	13.13
2 -US+TP	4.43	6.16	7.06	8.67	9.87	16.00	22.23	10.65
3-SF+METHCD+SS+TP	5.10	6.37	10.43	12.20	25.33	57.33	78.87	23.62
4 - SF+METHCD+US+TP	5.40	8.00	8.56	9.40	12.06	21.06	26.17	10.16
5- SF+H_2O CD+SS+TP	2.16	5.26	4.55	7.52	11.36	10.11	12.05	5.81
6- SF+H_2O CD+US+TP	2.87	3.30	6.50	3.48	15.54	18.21	19.59	3.71

Legend: SS: Sterilized soil; US: Unsterilized soil; SF: Sunflower; METH: Methanol; CD: Cold

Table 6. Number of branches of *Solanum lycopersicon* at different age

	Week after planting							
Treatment	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**LSD**
1 - SS+TP	2.33	4.00	5.33	5.67	8.66	9.67	12.33	3.50
2 - US+TP	2.00	3.33	3.66	4.67	6.00	6.66	7.00	1.91
3 -SF+METHCD+SS+TP	2.67	4.00	6.67	7.33	7.67	9.33	11.00	2.35
4 - SF+METHCD+US+TP	2.33	2.33	3.33	2.67	4.00	7.33	8.00	2.45
5- SF+H_2O CD+SS+TP	2.00	3.33	4.67	4.33	8.67	6.00	7.00	3.56
6- SF+H_2O CD+US+TP	2.33	3.67	3.00	6.33	8.33	13.67	14.67	3.20

Legend: SS: Sterilized soil; US: Unsterilized soil; NM: Neem; METH: Methanol; CD: Cold; TP: Test plant

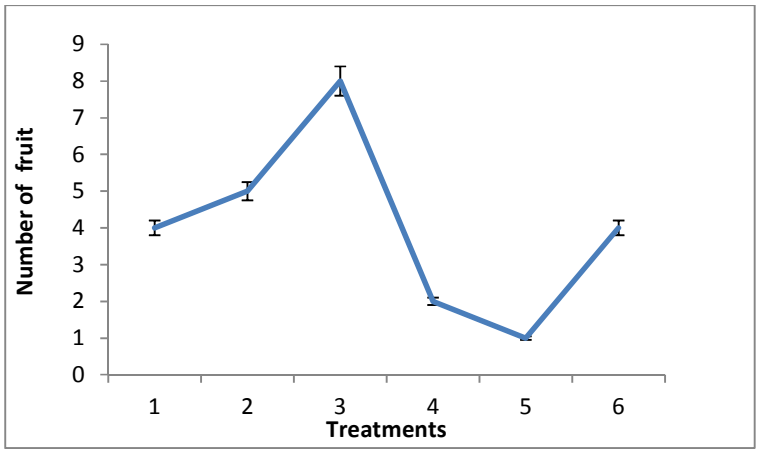

Fig. 1. Number of fruit of *Solanum lycopersicon* (cm)

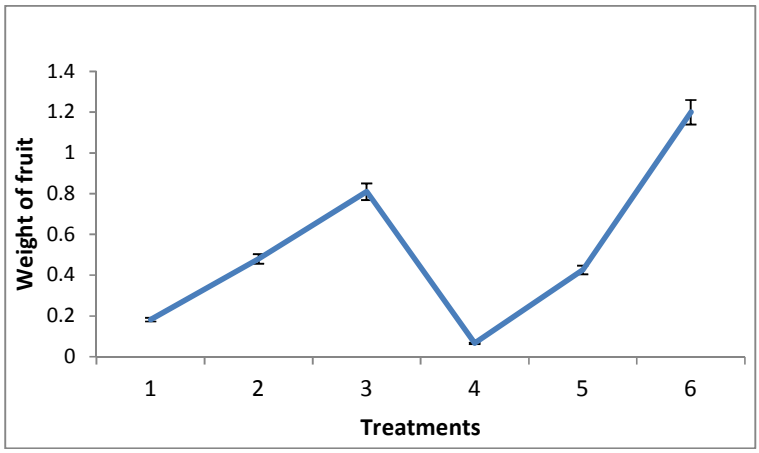

Fig. 2. weight of fruit of *Solanum lycopersicon* (gm)

Legend: 1 - SS+TP; 2 - US+TP; 3 - SF+METH CD+SS+TP; 4 - SF+METH CD+US+TP; 5 - SF+H_2O+CD+SS+TP; 6 - SF+H_2O+CD+US+TP

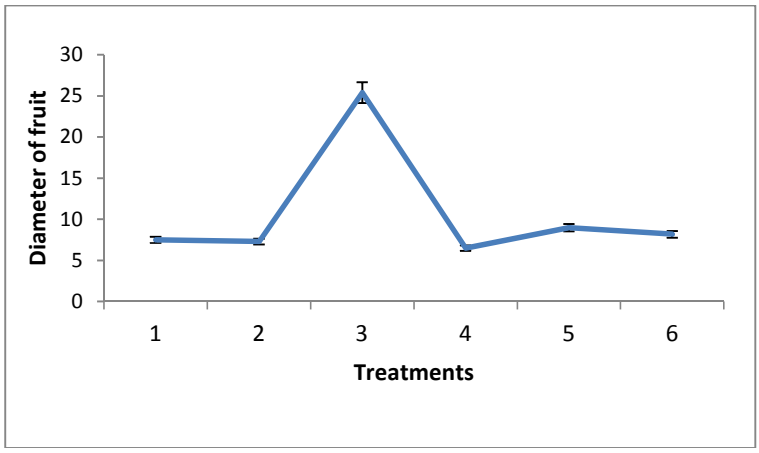

Fig. 3. Diameter of *Solanum lycopersicon* fruit

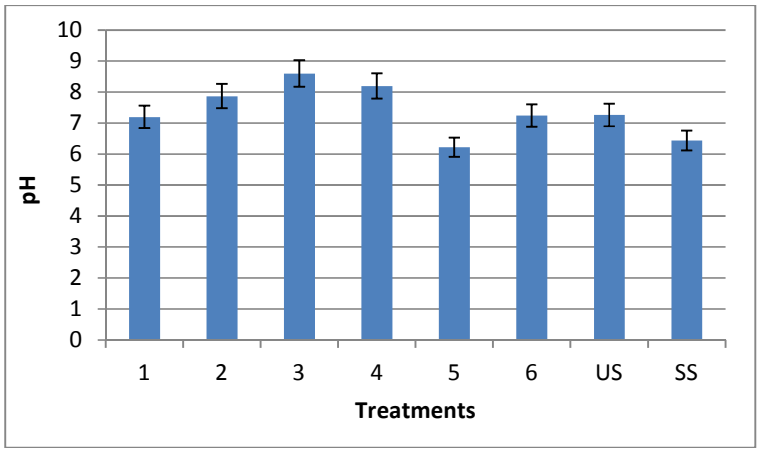

Fig. 4. pH of pre planting and post planting soil samples

Legend: 1 - SS+TP; 2 - US+TP; 3 - SF+METH CD+SS+TP; 4 - SF+METH CD+US+TP; 5 - SF+H_2O+CD+SS+TP; 6 - SF+H_2O+CD+US+TP; US=Pre-planting unsterilized soil; SS=Pre-planting sterilized soil

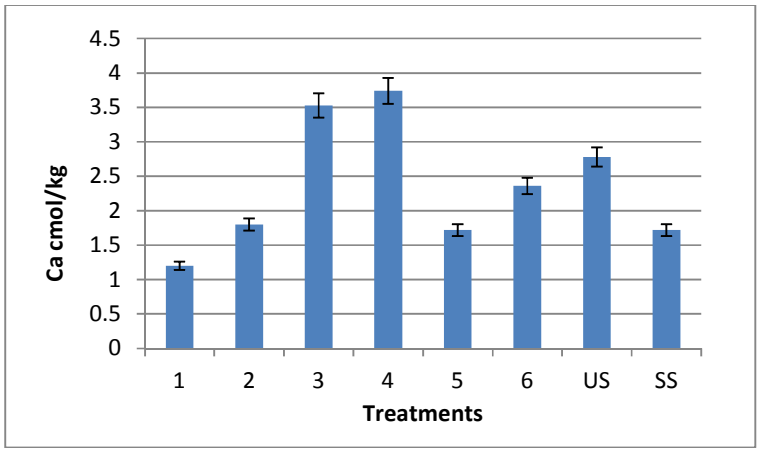

Fig. 5. Calcium content of pre planting and post planting soil samples

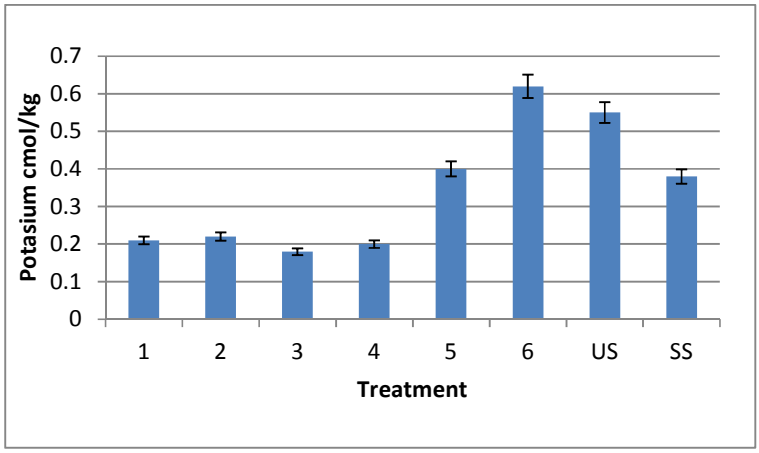

Fig. 6. Potassium content of pre planting and post planting soil samples

Legend: 1 - SS+TP; 2 - US+TP; 3 - SF+METH CD+SS+TP; 4 - SF+METH CD+US+TP; 5 - SF+H_2O+CD+SS+TP; 6 - SF+H_2O+CD+US+TP; US=Pre-planting unsterilized soil; SS=Pre-planting sterilized soil

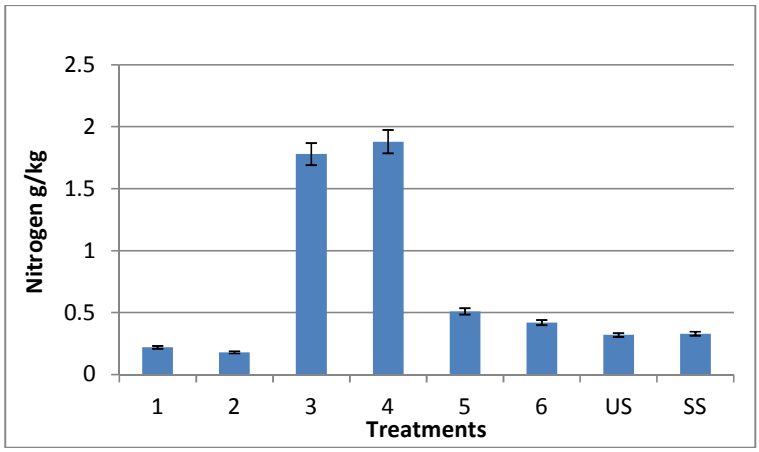

Fig. 7. Nitrogen content of pre planting and post planting soil samples

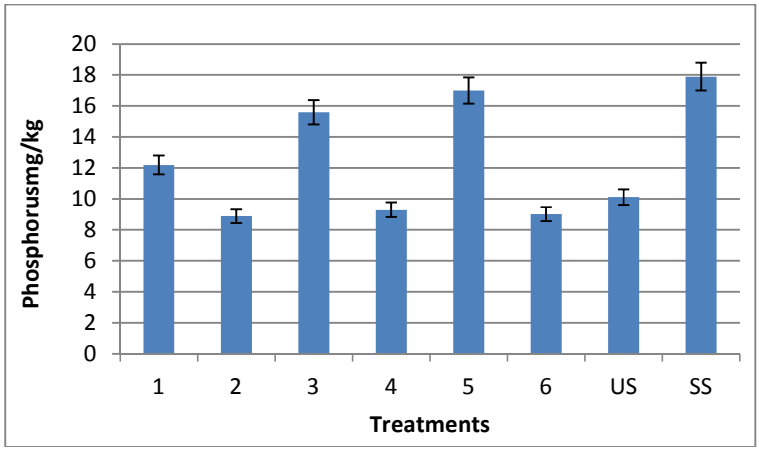

Fig. 8. Phosphorus content of pre planting and post planting soil samples

Legend: 1 - SS+TP; 2 - US+TP; 3 - SF+METH CD+SS+TP; 4 - SF+METH CD+US+TP; 5 - SF+H_2O+CD+SS+TP; 6 - SF+H_2O+CD+US+TP; US=Pre-planting unsterilized soil; SS=Pre-planting sterilized soil

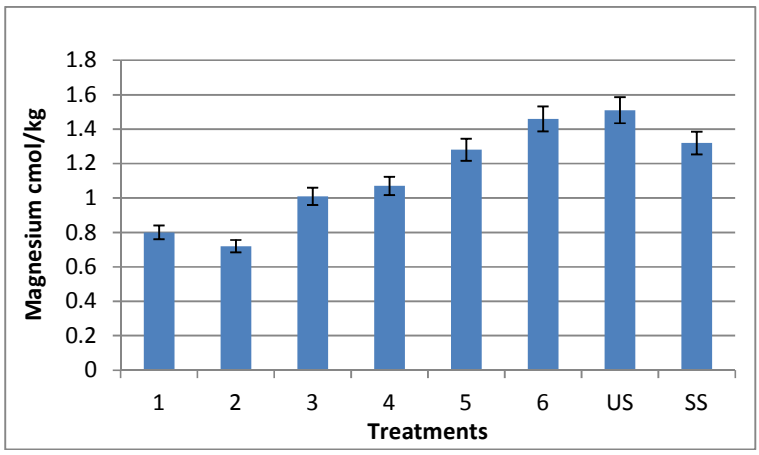

Fig. 9. Magnessium content of pre planting and post planting soil samples

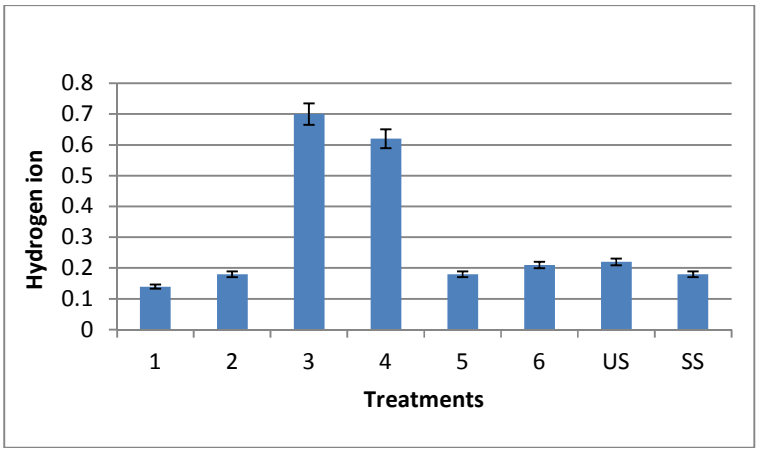

Fig. 10. Hydrogen ion content of pre planting and post planting soil samples

Legend: 1 - SS+TP; 2 - US+TP; 3 - SF+METH CD+SS+TP; 4 - SF+METH CD+US+TP; 5 - SF+H_2O+CD+SS+TP; 6 - SF+H_2O+CD+US+TP; US=Pre-planting unsterilized soil; SS=Pre-planting sterilizrd soil

4. DISCUSSION

This study revealed that there were varying responses of Tomato (*Solanum lycopersicon*) to the applied extract of sunflower leaf which acted as organic fertilizers on the soil and were available for plant uptake. The improved vegetative growth recorded in the methanolic extract of sunflower in sterilized soil agreed with [9] who confirmed the significant contributions of organic fertilizers in improving vegetative growth and marketable yield of vegetables. Moreover, the poor growth in the control treatment agreed with [10] who reported poor growth and yield in soil that was poorly fertilized.

The poor growth in the unsterilized control could be as a result of the competition on the little available nutrients by the weeds and other micro-organisms growing within the soil during the planting period [11]. Soil pH is usually one of the determinants of growth response of plants also established in this study. The better growth performance of tomato in the sterilized soil agreed with [12] who opined that tomato grows well within the soil pH range of 5.5 to 6.8, with optimum being between 6.0 and 6.5. The higher number of fruits as well as the fruit weight in the treatment with methanolic sunflower extract in sterilized soil agreed with [13] reported in his work that higher yield was obtained in treatments with calcium in *Mangifera indica* and [14] who reported an increase in weight of mango in treatment with 30 and 20 g of calcium.

Magnesium was significantly reduced across all the treatments and controls in post planting soil. This could indicate the easy uptake of the mineral nutrient in the soil due to its liquid state. Nitrogen status of the soil after planting revealed that there was a reduction in the control treatments but the improved nitrogen content in the treatment with sunflower suggested a superior nitrogen content of the extract. The reduction of nitrogen in the control treatments agrees with [15] who reported that nitrogen is used by plant for growth and leaf expansion needed for photosynthesis. There was an increase in the pH of the soil after planting. This could be as a result of the extracts added into it. The increase in the pH agreed with [16] who said that extracts of botanicals can be extracted and applied to soil to raise the pH as well as improving soil fertility which will lead to higher farm produce. The absence of Aluminium ion and the reduction of hydrogen ion in the post planting soil could be as a result of the increase in the pH of the soil. This suggests, according to [17] that organic substances can be used to manage soil pH leading to substantial reduction in the Aluminium ion content of the soil.

5. CONCLUSSION

The study concluded that methanolic extract of sunflower in sterilized soil was able to increase the growth and yield of tomato. With this, farmers will be able to produce more tomato which will resultantly stabilizes food security without the use of synthetic fertilizer which is bulky and expensive.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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