Peppermint productivity as affected by Vermicompost and calcium silicate under saline conditions

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ABSTRACT
Soil salinity is one of the most important a biotic stresses among the harmful environmental factors on the agricultural land sector. Field experiment was conducted at the Central laboratory for Agricultural Climate, Agricultural Research Center, Giza to study the effect of vermicompost fish fertilizer and calcium silicate treatments on mint grown under sandy soil during the two seasons of 2018 and 2019. Sandy soils were conducted from El Alamein, Western Sahara, worm fish fertilizer was added in a single dose; at rates of 0, 3.5, 4.5, and 7.5 ton/acre, it was incorporated into potted plants to a depth of 5-10 cm two weeks before the date of planting. Calcium silicate (CaSiO₃) treatments at 0, 3.5, 4.5, and 5.5 mM were added in a single dose, it was incorporated into the soil at a depth of 5-10 cm two weeks before planting the seedlings. The vegetative growth parameters were recorded: plant length (cm), number of branches/plant, green yield and dry weight (g) / plant. Chemical parameters: essential oils, carbohydrates percentage, proline, nitrogen, phosphorous, potassium, calcium, and sodium was determined in dry leaves. Soil temperature was determined in10cm depth. the results suggest that using 4.5 ton/ acre vermicompost with Calcium silicates concentration was 4.5 mM was the best treatment gave significant effect on plant length, number of branches/plant, green yield and dry weight, also gave highest total carbohydrates, nitrogen phosphorous, potassium and essential oil content. These results indicated that the vermicompost, reduce the effects of salinity by improving the physical, chemical, and biological properties of the soil. Calcium silicates which might directly enhance the plant's tolerance to deal with salt stress.

Keywords: Peppermint, saline soil, vermicompost fish, calcium silicate, soil temp, proline

1. Introduction
Soil salinity is one of the most important a biotic stresses among the harmful environmental factors on the agricultural land sector (Yadav et al., 2011). High levels of salt in the soil lead to hyperosmolarity, ion imbalance, nutrient imbalance, and production of reactive oxygen species (ROS), which inhibits plant growth through molecular damage (Nawaz et al., 2010). Global demand for peppermint Mentha x piperita oil is increasing in recent years. Major producing countries are Bulgaria, Italy, China, and USA, supplying about 90% of total peppermint oil production (Dwivedi et al., 2004). Mentha genus, amember of Lamiaceae, includes many high-value essential oil crops used widely in perfumery, cosmetic, and pharmaceutical industries. Approximatley 2000 tons of world essential oil is obtained from Mentha species being the second most important essential oil plant after Citrus species (Mucciarelli et al., 2001). Warmer climate gave higher fresh herbage yield with 37.0 t/ha and 36.8 t/ha, respectively (Isa Telci et al. 2011; Soonthorn Duriyaprapan, et al. 1986). Different temperature treatments did not appear to greatly affect the percentage of menthol oil. Antitranspirants reducing transpiration can play a useful role in this respect by preventing the excessive loss of water to the atmosphere via stomata (Khalil 2006). Silicon (Si) is the second most abundant element in soil; It is mostly inert and only slightly soluble. Although Si is not considered as an essential nutrient for plants (Jian Feng Ma 2004), this element is of value to higher plants, especially under stressful environments (Liu et al. 2009). Silicon plays a role in improving the ability of crops to deal with biotic and abiotic
stresses, Silicon can be a major role in improving crops abilities to withstand biotic and abiotic stresses, such as disease and pest resistance, heavy metal toxicity mitigation (Al, Mn, and Fe), salinity resistance, drought stress resistance, and freeze mitigation stress (Xiang et al., 2012). The positive effect of vermicompost on the growth of plants, including vegetables, ornamental plants, and flowers in the greenhouse and field conditions compared with combinations of soil and soilless culture media (Atiyeh et al., 2000; Ayyobi et al., 2014). Vermicompost has a very positive effect on soil and plants (Chinsamy et al., 2013). Due to the high cost and hazardous effects of chemical fertilizers, the use of solutions of organic compounds is developing. Moreover, restriction of nutrient supply and the application of silicon to mitigate negative effects of salinity on growth, essential oil production, and nutritional composition.

The aim of the study the effect of vermicompost fish and spraying calcium silicate under saline soil

2. Material and Methods

Field experiment was conducted at the Central laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Giza to study the effect of vermi fish fertilizer and calcium silicate treatments on mint grown under sandy soil during the two seasons of 2108 and 2019.

2.1. Plant material:

The mint cuttings used in this study were obtained from the Department of Medicinal and Aromatic Plants Research, Dokki, Giza. Transplanted on 15/20 March 2018 and 2019 in the two seasons respectively, when the height of cuttings was 8-10 cm, with 9-12 leaves.

2.2. Soil analysis:

Sandy soils were conducted from El Alamein, Western Sahara, and were placed into pots 30cm show that in table 1.

Table 1: Chemical analysis of soil

| Particulair | pH | EC ds/m | Cl⁻ | HCO₃⁻ | CO₃²⁻ | SO₄²⁻ | Na⁺ | K⁺ | Ca²⁺ | Mg²⁺ |
|-------------|----|---------|-----|-------|-------|-------|-----|----|------|------|
| Soil        | 7.89 | 3.8     | 12.6 | 2.6   | -     | 33.2  | 12.2 | 1.2 | 25   | 10   |

Table 2: Analysis of vermi fish manure content

| Particulair | Total nitrogen (%) | Total P₂O₅ (%) | Total K₂O (%) | Total Calcium (%) | Total Magnesium (%) | Total Sulphur (%) | Total Organic matter (%) | Total organic carbon (%) | Total moisture (%) |
|-------------|-------------------|----------------|----------------|------------------|--------------------|--------------------|-------------------------|-----------------------|--------------------|
| %           | 0.84              | 2.13           | 0.94           | 3.61             | 0.73               | 0.56               | 20                      | 13.3                  | 42.5               |

Table (3) presented the climate data under experimental conditions. The following data were recorded: maximum, minimum air temperature, maximum, minimum soil temperature in 10cm depth and maximum , minimum relative humidity were recorded by digital Thermo/hygrometer Art. No. 30.5000/30.5002 (Produced by TFA, Germany) placed at the middle of the greenhouse.

Table 3: Climatic data under experimental conditions

|          | Max. Temp. | Min. Temp. | Max. Rh. | Min. Rh. |
|----------|------------|------------|----------|----------|
| March    | 22.4       | 15.3       | 47.3     | 16       |
| April    | 23.8       | 17.6       | 45.9     | 17.6     |
| May      | 27.3       | 21.8       | 43.3     | 19.00    |
| June     | 28.3       | 24.3       | 45       | 20.2     |

|          | Max. Temp. | Min. Temp. | Max. Rh. | Min. Rh. |
|----------|------------|------------|----------|----------|
| March    | 23.1       | 15.7       | 47.7     | 16.5     |
| April    | 24.2       | 18.1       | 46.2     | 18.1     |
| May      | 27.8       | 22.3       | 43.8     | 2.3      |
| June     | 28.8       | 24.9       | 45.3     | 20.6     |
2.3. Treatments:
Worm fish fertilizer was obtained from the National Research Center. It was added in a single dose; at rates of 0, 3.5, 4.5, and 7.5 ton /acre, it was incorporated into potted plants to a depth of 5-10 cm two weeks before the date of planting. Calcium silicate treatments at 0, 3.5, 4.5, and 5.5 mM were added in a single dose, which was incorporated into the soil at a depth of 5-10 cm two weeks before planting the seedlings at the same time with worm fish manure.

2.4. Experiment design
The experimental design was a split-plot design experimental plot design divided by three replicates. Vermi fish compost was applied to the main plots at 0, 3.5, 4.5, and 7.5 t/acre. Calcium silicates were set in subsections at 0, 3.5, 4.5, and 5.5 mM. Therefore, the trial included 16 interaction treatments.

2.5. Recorded data
For each season, two cuttings were taken on May 17 and July 22 (2018 and 2019), respectively. Plants were harvested by cutting plant parts 10-15 cm above the soil surface. The following data were recorded for each cut. The vegetative growth parameters were: recorded plant length (cm), number of branches/plant, green yield and dry weight (g) / plant.

a) Determinants of essential oils
The essential oil was extracted from fresh herbs samples for each treatment by distillation according to the method, and the proportions of the oil were recorded. Then the oil yield of each plant was calculated. The essential oil samples extracted from the second batch of the second season of 2013 were subjected to gas-liquid chromatography (GLC) as was described to determine the percentages of the main components of the volatile oil.

b) Carbohydrates percentage and proline
The percentage of total carbohydrates in the dry leaves was determined using the method described by Bates, I. Set al. (1973).

c) Determination of mineral content
Determination of phosphorous, potassium, calcium, and sodium was determined in dry leaves by using a spectrophotometric atomic absorption scale (SP 1900). Total nitrogen was determined in the same solution using micro Kjeldahl methods according to Cottenie et al. (1980) Data were subjected to conventional methods of analysis of variance according to Snedecor and Cochran (1980). The data were statistically analysed for each season and the homogeneity of experimental error, in both seasons, was tested.

The least significant difference (L.S.D.) at 0.05 level of probability was calculated for each determined character under different assigned treatments.

3. Results
Soil temperature affected with Vermicompost and Calcium silicates by increasing the level of Vermicompost and Calcium silicates in the soil as shown in fig (1, 2).

Data in Tables (3 and 4) represented the effect of the vermicompost supply and calcium silicates on mint plant affected with saline soil. The results indicated that the application and combination of silicon foliar and vermicompost had a significant effect on plant length, number of branches/plant, green yield and dry weight, the level of vermicompost usage 4.5 ton/acre has the highest values and Calcium silicates concentration 4.5 mM has the best values. The highest interaction was found when 4.5 ton/acre vermicompost with Calcium silicates concentration was 4.5 mM. However, the lowest value was found in control treatment without vermicompost supply and Calcium silicates. The vermicompost, reduce the effects of salinity by improving the physical, chemical, and biological properties of the soil. Calcium silicates which might directly enhance the plant's tolerance to deal with salt stress.
Fig. 1: Effect of vermicompost supply and Calcium silicates concentration on soil temperature 2018.

Fig. 2: Effect of vermicompost supply and Calcium silicates concentration on soil temperature 2019.

Table 4: Effect of Vermicompost supply and silicon on mint plant length (cm) and green yield (g/plant).

|               | Plant length (cm) | Green yield (g/plant) |
|---------------|-------------------|-----------------------|
|               | CaS1  | CaS2  | CaS3  | CaS4  | Mean  | CaS1  | CaS2  | CaS3  | CaS4  | Mean  |
| **First season** |       |       |       |       |       |       |       |       |       |       |
| VM 1          | 18.4  | p     | 20.4  | o     | 32.5  | i     | 21.3  | n     | 23.2  | D     | 20.5  | i     | 21.6  | h     | 22.5  | h     | 21.8  | h     | 21.6  | D    |
| VM 2          | 24.6  | m     | 39.5  | f    | 47.5  | c     | 33.5  | h     | 36.3  | C     | 24.5  | g     | 27.6  | f     | 27.0  | f     | 26.5  | f     | 26.4  | C    |
| VM 3          | 26.4  | l     | 37.4  | g    | 52.3  | a     | 41.4  | e     | 39.4  | A     | 30.5  | d     | 32.6  | c     | 37.7  | a     | 35.4  | b     | 34.0  | A    |
| VM 4          | 28.4  | k     | 44.5  | d    | 49.5  | b     | 30.4  | j     | 38.2  | B     | 26.5  | f     | 28.9  | e     | 30.4  | d     | 30.5  | d     | 29.1  | B    |
| **Mean**      | 24.4  | D     | 35.5  | B    | 45.5  | A     | 31.7  | C     | 25.5  | D     | 27.7  | C     | 29.4  | A     | 28.5  | B     |       |       |
| **Second season** |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| VM 1          | 19.4  | m     | 20.5  | m    | 31.5  | i     | 22.3  | l     | 23.4  | D     | 20.1  | i     | 21.3  | h     | 22.3  | h     | 21.4  | h     | 21.3  | D    |
| VM 2          | 23.6  | k     | 34.3  | h    | 46.1  | c     | 40.5  | f    | 36.1  | C     | 24.1  | g     | 27.2  | f    | 26.6  | f    | 26.3  | f    | 26.1  | C    |
| VM 3          | 26.9  | j     | 37.5  | g    | 50.3  | a     | 44.3  | d    | 39.8  | A     | 30.1  | d     | 32.2  | c    | 37.4  | a    | 35.1  | b    | 33.7  | A    |
| VM 4          | 27.5  | j     | 42.5  | e    | 47.6  | b    | 32.5  | i    | 37.5  | B     | 26.1  | f    | 28.6  | e    | 30.1  | d    | 29.7  | d    | 28.6  | B    |
| **Mean**      | 24.3  | D     | 33.7  | C    | 43.9  | A    | 34.9  | B    | 25.1  | D     | 27.3  | C    | 29.1  | A    | 28.2  | B    |       |       |       |       |

Chemical properties were shown in table (5, 6) of total carbohydrates, nitrogen phosphorous, and potassium. Calcium silicates concentration 4.5 mM has the highest values of carbohydrates, nitrogen phosphorous, and potassium content, however, vermicompost supply was different the highest carbohydrates was found in vermicompost level 3.5 ton. Nitrogen highest content in vermicompost level 4.5 ton, phosphorous and potassium highest content in vermicompost level in 7.5 ton. The interaction between all treatments was significant. the highest interaction was obtained in vermicompost level 4.5 ton with Calcium silicates concentration 4.5 mM except phosphorous was found in vermicompost level 7.5 ton with Calcium silicates concentration 4.5 mM.
VM 4
Mean
VM 1
10.2 i 10.3 i 11.3 h 11.3 h 10.8 C 3.0 j 4.4 i 4.7 hi 5.5 gh 4.4 C
VM 2 12.3 g 14.4 e 15.4 d 16.5 c 14.7 B 4.3 i 6.5 def 7.5 c 7.2 cd 6.4 B
VM 3 13.2 f 15.5 d 18.3 a 16.4 c 15.9 A 8.8 b 9.3 b 10.2 a 6.4 ef 8.7 A
VM 4 13.4 f 17.5 b 18.2 a 13.6 f 15.7 A 5.4 gh 5.7 fg 7.2 cde 6.3 f 6.1 B
Mean 12.3 C 14.4 B 15.8 A 14.5 B 5.4 C 6.5 B 7.4 A 6.3 B

Second season
VM 1 9.9 j 10.6 ij 11.3 hij 11.6 ghi 10.9 C 4.0 j 4.4 ij 5.1 gh 4.5 hij 4.5 C
VM 2 12.3 fgh 14.1 de 15.1 cd 16.2 bc 14.4 B 6.1 def 7.1 c 6.9 cd 8.4 b 7.2 A
VM 3 12.9 efg 15.1 cd 18.0 a 16.1 bc 15.5 A 9.0 ab 9.8 a 6.1 def 5.1 gh 7.5 A
VM 4 13.0 efg 17.1 ab 18.5 a 13.3 ef 15.5 A 5.4 fgh 6.7 cde 7.1 c 5.9 efg 6.3 B
Mean 12.0 C 14.3 B 15.7 A 14.3 B 6.1 BC 7.0 A 6.3 B 6.0 C

Calcium silicates concentration mM: 0 CaS1, 3.5 CaS2, 4.5 CaS3, 5.5 CaS4, Vermi fish compost 0 VM1, 3.5 VM2, 4.5 VM3, 7.5 VM 4.

Table 5: Effect of Vermicompost supply and silicon on mint branches number and dry weight (g/ plant).

| Branches No. | Dry weight (g/ plant) | CaS1 | CaS2 | CaS3 | CaS4 | Mean | CaS1 | CaS2 | CaS3 | CaS4 | Mean |
|-------------|-----------------------|------|------|------|------|------|------|------|------|------|------|
| First season |                       |      |      |      |      |      |      |      |      |      |      |
| VM1         |                       |      |      |      |      |      |      |      |      |      |      |
| VM 2        |                       |      |      |      |      |      |      |      |      |      |      |
| VM 3        |                       |      |      |      |      |      |      |      |      |      |      |
| VM 4        |                       |      |      |      |      |      |      |      |      |      |      |
| Mean        |                       |      |      |      |      |      |      |      |      |      |      |

Table 6: Effect of Vermicompost supply and silicon on mint Carbohydrate % and N (mg g-1 shoot DM).

| Carbohydrate% | N (mg g-1 shoot DM) | CaS1 | CaS2 | CaS3 | CaS4 | Mean | CaS1 | CaS2 | CaS3 | CaS4 | Mean |
|---------------|---------------------|------|------|------|------|------|------|------|------|------|------|
| First season  |                     |      |      |      |      |      |      |      |      |      |      |
| VM1           |                     |      |      |      |      |      |      |      |      |      |      |
| VM 2          |                     |      |      |      |      |      |      |      |      |      |      |
| VM 3          |                     |      |      |      |      |      |      |      |      |      |      |
| VM 4          |                     |      |      |      |      |      |      |      |      |      |      |
| Mean          |                     |      |      |      |      |      |      |      |      |      |      |

Second season
VM 1 11.6 g 12.4 f 13.4 e 14.3 d 12.9 D 20.5 i 21.6 h 22.5 h 21.8 h 21.6 D
VM 2 14.4 d 15.5 c 16.5 b 17.5 a 16.0 A 24.5 g 27.6 f 27.0 f 26.5 f 26.4 C
VM 3 13.6 e 14.5 d 17.7 a 13.4 e 14.8 C 30.5 d 32.6 c 37.7 a 35.4 b 34.0 A
VM 4 13.4 e 16.7 b 17.9 a 14.4 d 15.6 B 26.5 f 28.9 c 30.4 d 30.5 d 29.1 B
Mean 13.2 C 14.8 B 16.4 A 14.9 B 25.5 D 27.7 C 29.4 A 28.5 B

Calcium silicates concentration Mm: 0 CaS1, 3.5 CaS2, 4.5 CaS3, 5.5 CaS4, Vermi fish compost 0 VM1, 3.5 VM2, 4.5 VM3, 7.5 VM 4.

Essential oil content in shoots presented in table (7) the essential oil increased with the increasing of the level of vermicompost (7.5 ton) and increasing of Calcium silicates concentration (7.5) Proline content in shoots was presented in table (7) proline content was reduced with the increasing of the level of vermicompost (7.5 ton) and increasing of Calcium silicates concentration proline mainly dry g-1 which obtained (5.5mM) silicon and which scored the lowest values.

Table 7: Effect of Vermicompost supply and silicon on mint P (mg g-1 DM), and K (mg g-1 shoot DM).

| P (mg g-1 DM) | K (mg g-1 shoot DM) | CaS1 | CaS2 | CaS3 | CaS4 | Mean | CaS1 | CaS2 | CaS3 | CaS4 | Mean |
|--------------|---------------------|------|------|------|------|------|------|------|------|------|------|
| First season  |                     |      |      |      |      |      |      |      |      |      |      |
| VM 1         |                     |      |      |      |      |      |      |      |      |      |      |
| VM 2         |                     |      |      |      |      |      |      |      |      |      |      |
| VM 3         |                     |      |      |      |      |      |      |      |      |      |      |
| VM 4         |                     |      |      |      |      |      |      |      |      |      |      |
| Mean         |                     |      |      |      |      |      |      |      |      |      |      |

Second season
VM 1 2.4 i 2.7 i 3.3 h 4.7 g 3.3 D 3.6 h 4.4 g 6.4 c 4.5 g 4.7 D
VM 2 5.4 f 6.5 e 7.6 c 7.1 d 6.6 C 6.1 e 8.6 d 13.5 a 7.2 d 8.8 B
VM 3 5.7 f 7.3 ed 10.9 a 7.7 c 7.9 B 6.5 e 5.7 ef 12.6 a 9.5 e 8.5 C
VM 4 6.3 e 9.7 b 11.0 a 7.4 cd 8.6 A 9.4 c 11.5 b 11.8 b 9.0 c 10.4 A
Mean 4.9 D 6.6 C 8.2 A 6.7 B 6.4 C 7.5 B 11.1 A 7.5 B

Calcium silicates concentration Mm: 0 CaS1, 3.5 CaS2, 4.5 CaS3, 5.5 CaS4, Vermi fish compost 0 VM1, 3.5 VM2, 4.5 VM3, 7.5 VM 4.
Table (9) presented calcium and sodium content. The sodium content has the same performance as proline, Calcium silicates -supplying plants decreased from 0.9 to 0.5 mg Na g⁻¹ dry and from 10 down to 4.4 mg. Calcium content has the same performance as nitrogen and potassium. Vermicompost, Calcium silicates application, and their mixture had a significant effect on the concentration of N, P, K, and Ca in the shoot of marjoram plants (tables 6, 7; table 8). The application of worm compost increased the N and Ca concentrations in the plant shoots. The nitrogen concentration tripled due to the addition of vermicompost. Calcium concentration increased 50% more than control plants. In this study, the addition of vermicompost to the soil combined with the addition of Calcium silicates had a significant effect on mint plants. Both factors (vermicompost and Calcium silicates) independently increased the growth parameters, nutrient content, total carbohydrate, and oil content (table7). As a variety of organic matter, vermicompost can be used as an amendment to enhance and preserve soil fertility or to treat saline soils (Chinsamy et al., 2013, Sandoval et al., 2015). Compared with other organic materials, worm compost binds to higher nutrients available to plants (Chinsamy et al., 2013; Arancon et al., 2005), so the use of vermicompost reduced the sodium concentration in the plant leading to an increase in the concentration of other substances. Nutrients because they are rich in humus, phosphorous, potassium, calcium, and micronutrients (Chinsamy et al., 2013, Arancon et al., 2005), and as a result, the salt stress within the plant shoot was reduced, and the reduction of proline confirmed this assumption. Previous studies reported several strategies for using silicon to enhance the abiotic stress tolerance of higher plants (Liang, 2006), (Parveen et al., 2010). Also, application of Si to alleviate salt stress showed satisfactory results in barley (Liang and Ding, 2002).

Table 8: Effect of Vermicompost supply and silicon on mint Essential oil (ml.K⁻¹ shoot) and Proline (mg g⁻¹ shoot DM)

| CaS1 | CaS2 | CaS3 | CaS4 | Mean | CaS1 | CaS2 | CaS3 | CaS4 | Mean |
|------|------|------|------|------|------|------|------|------|------|
| VM 1 | 3.7  | h    | 4.4  | g    | 4.5  | g    | 5.3  | f    | 4.5  | C    | 11.5 | a    | 10.3 | b    | 9.4  | c    | 8.6  | d    | 10.0 | A    |
| VM 2 | 4.5  | g    | 4.8  | e    | 5.7  | d    | 6.4  | c    | 5.3  | B    | 8.4  | d    | 6.5  | f    | 4.7  | g    | 2.7  | i    | 5.6  | B    |
| VM 3 | 4.6  | g    | 6.4  | c    | 7.6  | b    | 9.3  | a    | 7.0  | A    | 7.6  | e    | 4.7  | g    | 2.5  | i    | 3.6  | h    | 4.6  | C    |
| VM 4 | 5.5  | d    | 5.7  | d    | 7.6  | b    | 5.5  | e    | 6.1  | A    | 4.5  | g    | 3.7  | h    | 2.8  | f    | 6.5  | f    | 4.4  | C    |
| Mean | 4.6  | D    | 5.3  | C    | 6.3  | B    | 6.6  | A    | 6.0  | A    | 8.0  | C    | 6.3  | B    | 4.9  | D    | 5.4  | C    |

| Mean | 4.3  | f    | 4.5  | f    | 4.6  | f    | 5.4  | e    | 4.7  | D    | 12.3 | a    | 10.6 | b    | 10.4 | b    | 9.6  | c    | 10.7 | A    |
| VM 2 | 4.3  | f    | 5.6  | e    | 6.5  | c    | 7.1  | be   | 5.9  | C    | 9.1  | c    | 6.7  | f    | 5.4  | h    | 3.6  | i    | 6.2  | B    |
| VM 3 | 5.2  | e    | 6.6  | c    | 8.4  | b    | 9.6  | a    | 7.5  | A    | 8.4  | d    | 5.5  | g    | 2.5  | j    | 4.4  | h    | 5.2  | C    |
| VM 4 | 5.7  | e    | 6.6  | c    | 7.8  | b    | 7.1  | d    | 6.6  | B    | 4.7  | h    | 3.8  | hi   | 3.5  | i    | 7.3  | e    | 4.8  | D    |
| Mean | 4.9  | D    | 5.8  | C    | 6.8  | B    | 7.1  | A    | 8.6  | A    | 6.0  | B    | 5.5  | D    | 6.2  | C    |

Calcium silicates concentration Mm: 0 CaS1, 3.5 CaS2, 4.5 CaS3, 5.5 CaS4, Vermi fish compost 0 VM1, 3.5 VM2, 4.5 VM3, 7.5 VM 4

Table 9: Effect of Vermicompost supply and silicon on mint Na (mg g⁻¹ shoot DM) and Ca (mg g⁻¹ DM)

| Na (mg g⁻¹ shoot DM) | Ca (mg g⁻¹ DM) |
|---------------------|----------------|
| CaS1 | CaS2 | CaS3 | CaS4 | Mean | CaS1 | CaS2 | CaS3 | CaS4 | Mean |
|------|------|------|------|------|------|------|------|------|------|
| VM 1 | 1.3  | a    | 0.8  | b    | 0.8  | b    | 0.7  | c    | 0.9  | A    | 4.5  | e    | 6.3  | c    | 5.9  | e    | 3.8  | c    | 5.1  | C    |
| VM 2 | 0.6  | d    | 0.5  | e    | 0.5  | c    | 0.3  | h    | 0.5  | B    | 4.0  | c    | 9.8  | b    | 9.4  | b    | 11.7 | a    | 8.7  | B    |
| VM 3 | 0.6  | d    | 0.5  | e    | 0.3  | h    | 0.4  | g    | 0.5  | B    | 7.7  | c    | 8.8  | b    | 11.3 | b    | 9.9  | b    | 9.4  | A    |
| VM 4 | 0.6  | d    | 0.4  | g    | 0.3  | h    | 0.5  | e    | 0.5  | B    | 7.8  | c    | 10.6 | b    | 11.0 | b    | 8.1  | b    | 9.4  | A    |
| Mean | 0.8  | A    | 0.6  | B    | 0.5  | C    | 0.5  | C    | 0.5  | C    | 6.0  | C    | 8.9  | B    | 9.4  | A    | 8.4  | B    | 5.1  | C    |

Calcium silicates concentration Mm: 0 CaS1, 3.5 CaS2, 4.5 CaS3, 5.5 CaS4, Vermi fish compost 0 VM1, 3.5 VM2, 4.5 VM3, 7.5 VM 4
This may be due to higher levels of vermicompost and Calcium silicates, which may lead to increased soil temperature as shown in fig.1 casing more available minerals into the soil, thus causing salt stress. Calcium silicate's role is limited to alleviating salt stress within plant tissues, and potential explanations for these results include the reduction of transpiration by accumulating Si in leaves and the formation of complexes. Reducing exchangeable sodium in large quantities (Sandoval et al., 2015). High rates of vermicompost did not affect growth parameters when used with high rates of silicate salts, and the effect on growth was noticeable under lower rates of silicate salts (Akhzari et al., 2016). Previous studies also confirmed the role of silicon in alleviating salt stress within plants (Mohsen et al., 2016). This explains why the increase in growth, nutrient, and oil production in plants remained an increased supply of highly improved silicon worm fertilizer for most variants. They used worm compost and calcium silicate on the same plant (marjoram plants) they added both to the soil, in our approach instead of adding silicon to the soil, the silicon was sprayed directly onto the plant leaves after which Si accumulated in the leaves leading to a reduction in transpiration, protects cell (Liang et al., 2003). The amount of Si, falling to the ground, can form a complex with Na roots (Ahmad et al., 1992). Therefore, worm compost enhances soil fertility. Meanwhile, silicon relieves salt stress within plant tissues. The results showed that soil temperature increasing when the level of levels of vermicompost and Calcium silicates was sufficient to obtain the highest values of plant growth factors, nutrient content, carbohydrate ratio, and the essential oil yield.

Conclusion

It may be concluded that using 4.5 ton/acre vermicompost fish with Calcium silicates concentration was 4.5 mM was the best treatment gave significant effect on plant length, number of branches/plant, green yield and dry weight, also gave highest total carbohydrates, nitrogen phosphorous, potassium and essential oil content. These results indicated that the vermicompost, reduce the effects of salinity by improving the physical, chemical, and biological properties of the soil. Calcium silicates which might directly enhance the plant's tolerance to deal with salt stress.

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