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EFFECT OF ROOT ZONE TEMPERATURE ON NUTRIENT UPTAKE IN SOILLESS CULTIVATION SYSTEMS

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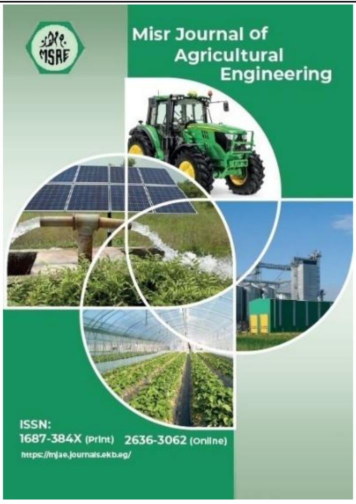

Keywords:
Nutrients, soilless culture, fertigation, irrigation, root zone.

ABSTRACT

The main objective of this research is to evaluate the Effect of root zone temperature on nutrient uptake in soilless cultivation systems and to obtain the best reused rate for nutrients after treatment and Fertigation management in closed soilless culture systems and Fertilizer calculator for each element's at long time of plant. The experiment was carried out in a multi-Spanish agricultural greenhouse covered with polyethylene film and aspects covered with fiberglass. There is a cooling system for evaporation (pad and fan), a heating system roots and a control in the irrigation and fertilization process. Agricultural soil is composed of bitmous, perlite and vermiculite. The obtained results indicated that the closed soilless culture systems with intermittent irrigation and heating the root zone (T1) the best from than all treatments systems closed soilless culture systems with intermittent irrigation (T2), closed soilless culture systems with irrigation once and heating the root zone (T3) and closed soilless culture systems with irrigation once (T4) in terms of uptake nutrients (Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg) and The best absorption of water was the treatment of the closed soilless culture systems with intermittent irrigation and heating the root zone and the best growth parameters which include plant height, internode length, stem diameter, number of leaves, leaf area, mass of fruit and yield was the treatment of the closed soilless culture systems with intermittent irrigation and heating the root zone.

1. INTRODUCTION

The root zone of soilless cropping systems is a complex world of microorganisms which play important roles as both beneficial or deleterious entities. Designing soilless cropping systems has traditionally involved little consideration for this except to disinfect any constructed root zone or its components. There are possibilities for improving the overall approach to dealing with microbes in the root zone to harness them for greater benefits. To this end, it is important to know: What life forms are present there, where do they come from, what do they do, and how do they interact with the components of the root zone environment? To understand the whereabouts and functionality of the microbiota associated with soilless systems, these systems must be viewed from the perspective of a microbe or a consortium of microorganisms and in terms of habitat stratification, such as the rhizosphere and its different layers. Due to the interactions between microbes and their environment, the quantity, structure, and function of the microbial community may vary widely over time. Standard growth factors such as light, temperature, humidity, available water, and nutrition are obvious components of good plant management practice **(Beatrix and Wohanka, 2019).**

Moderate root-zone warming (20 C - 25 C) may have a beneficial effect in many cases and is routinely practiced in many propagation nurseries during the rooting stage of stem and leaf cuttings. Elevated temperatures, on the other hand, lead to a significant increase in root respiration rates. Since this is coupled with a sharp decrease in DO levels in the root-zone solution, the result may be detrimental **(Kafkafi, 1990).**

Root-zone environmental factors such as nutrient concentration, pH, dissolved oxygen, and temperature directly affect the growth of hydroponically grown plants. For real-time measurement of these factors, corresponding sensors are required. By assuming that the electric current increases with an increase of ionized nutrients in the nutrient solutions, electrical conductivity (EC) sensors are used to measure nutrient concentrations. Nutrient solutions absorbed by transpiration can be measured by water-level sensors in large nutrient solution tanks and by load cells in relatively small tanks. Ultrasonic wave or laser sensors can also be conveniently used for noncontact measurement of the water level in the tanks. The process of controlling the water and nutrient supplies is as follows: determine the amounts of stock nutrient solutions and water, inject them into the nutrient solution tank and mix them, and supply the mixed nutrient solutions to the plants. Nutrient control systems consisting of sensors and controllers are used commercially in hydroponic farms **(Son et al., 2020).**

2. MATERIALS AND METHODS

2.1. Materials:

2.1.1. Greenhouses:

The experiment was carried out at the Agricultural Research and Experiment Center of Faculty of Agriculture, Benha University (30° 21` N and 31° 13` E). A multi-Spanish greenhouse used for experiment with dimensions 24 m width and 40 m length; walls were covered with 200 µm polyethylene and the aspects were covered with fiberglass. The greenhouse was cooled with evaporative cooling system (pad and fan system). The root zone was heated by hot water plastic pipes system. The planting was carried out in agricultural root zone media putted on plastic media with dimensions 25 cm width, 30 cm height and 6 m length and was installed on the ground with approximately tilt angle of 20º to collect the drainage water in plastic hole. The planting media consisted from 50:25:25 of bitmous, perlite and vermiculite, respectively. The cucumber (*Cucumis sativus L*) plant was selected in this experiment.

2.2.Methods:

2.2.1.Design of Experiment:

The treatments were arranged in a randomized complete design in three replicates. Four treatments were used and named as follow; **T1** is the closed soilless culture systems with intermittent irrigation and heating the root zone, **T2** is the closed soilless culture systems with intermittent irrigation, T3 is the closed soilless culture systems with one time irrigation and heating the root zone, and T4 is the closed soilless culture systems with one time irrigation. The cultivated area for each treatment was 1.5 m^2 (6.0 m long × 0.25 m width) and the volume of the soil mixture was 450 L for each replicate. In this experiment, drip irrigation system was used and water consumptive use (mm / day) was calculated according to the Penman-Monteith method **(FAO, 1991)** using the collected local weather data from weather station that located in Moshtohor, Egypt. **For fertilization,** the fertilizer requirements of cucumber were applied according to recommendations of Agronomy Research Institute (ARC), Ministry of Agriculture and Land Reclamation, Egypt. The irrigation and fertilization systems were the same for all treatments.

2.2.2. Experiment measurements:

The samples (air temperature, relative humidity, Soil temperature, agricultural media, irrigation and drainage water, plant) were taken for tests. The agricultural media samples was collected before planting for mechanical and chemical analysis. The water samples were taken before and after each irrigation time. The plant samples were collected after 12 day from planting and then every weak. For air temperature and relative humidity were recorded continuously daily each half an hour. By using Data logger. And Soil temperature was measured daily on all-day at 15 cm deep by using Soil temperature sensor. For Total nutrients tests, the total nitrogen (TN) content was measured by using semi-micro Kjeldahl method. The total phosphorus (TP) content was measured by using a spectrophotometer and Potassium (K), calcium (Ca) and magnesium (Mg) contents were determined using flam photometer. Total content of nutrients were measured before and after each watering calculate the amount of elements uptake by the plant and Measurement PH and EC by using PH and EC meter.

2.2.2.1. Plant growth parameters:

Three plants were randomly selected from each treatment for measuring growth parameters, which include plant height, internode length, stem diameter, leaf area, and yield. The plant height from cotyledons level to the terminal bud, the fifth internode length from the top of the plant after the branches, and the fifth internode diameter from the top of the plant after the branches were measured weekly. Additionally, the number of leaves and the fifth single leaf area from the top of the plant were counted and measured weekly, respectively. Finally, the total fruit weight per plant were determined for each harvest and the total yield of one plant for each replicate also was estimated.

2.3. Statistical analysis:

The statistical analysis for the obtained data was examined using SPSS software (IBM SPSS Statistics 21, American) and the treatments were compared at 0.05 level probability of significances.

3. RESULTS AND DISCUSSION

3.1. Environmental Parameters:

3.1 .1. Air Temperature:

Figure (3.1) show the air temperatures for all treatments (T1, T2, T3 and T4) in comparison with the outside air temperature. The temperature was recorded every half an hour throughout the day along the life of the plant from the date of planting until the end of the life of the plant and the temperature was recorded inside and outside the greenhouse and the greenhouse planted in it is controlled by the evaporative cooling system. Note that all transactions have the same temperatures inside the greenhouse.

These include the air temperatures recorded outside and inside. The results indicate that the daylight air temperature for all treatments (T1 to T4) during the growing period were 27.905 to 33.431°C,and outside were 16.796 to 42.983°C, while the nightly air temperature results for all treatments (T1 to T4) during the growing period were 9.015 to 22.417°C, and outside were 5.565 to 21.485°C.

As is evident in the Figure (3.1) the air temperatures inside the greenhouse and these conditions are suitable for plant life throughout the day and the length of the night, on the contrary, the temperature outside the greenhouse is different in the day and at night and these conditions outside are not suitable for plant life.

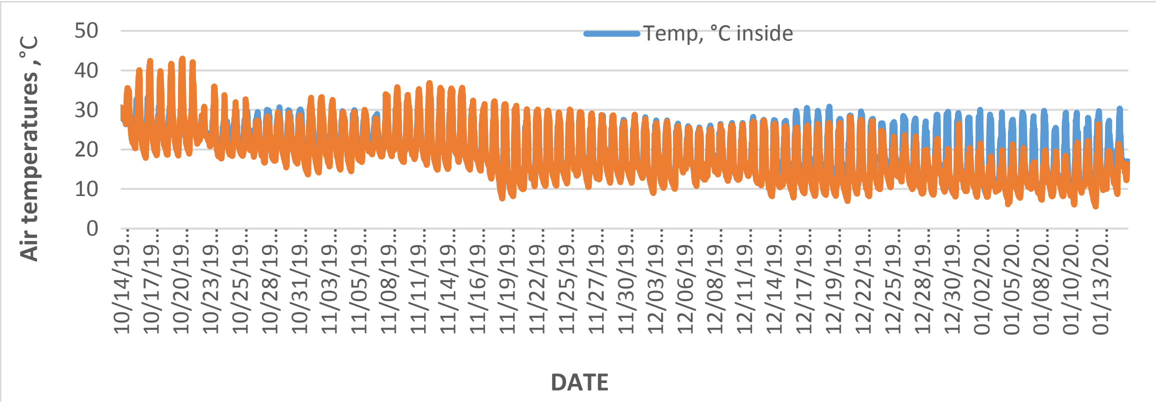

Figure (3.1): day and night of the air temperatures for cucumber plant during the growth period plant.

3.1.2. Relative humidity:

Figure (3.2) show the air relative humidity for all treatments (T1, T2, T3 and T4) in comparison with the outside air relative humidity. The relative humidity was recorded every half an hour throughout the day along the life of the plant from the date of planting until the end of the life of the plant and the relative humidity was recorded inside and outside the greenhouse and the greenhouse planted in it is controlled by the evaporative cooling system. Note that all transactions have the same relative humidity inside the greenhouse.

These include the air relative humidity recorded outside and inside. The results indicate that the daylight air relative humidity for all treatments (T1 to T4) during the growing period were 78.917 to 89.518 %, and outside were 39.029 to 93.029 %, while the nightly air relative humidity results for all treatments (T1 to T4) during the growing period were 23.778 81.170 %, and outside were 18.279 to 52.791%. These results agreed with those obtained by **Saleh (2002).**

3.1.3. Soil temperature:

Figure (3.3) show the soil temperatures for treatments (T1 to T4) with the presence of heating in some treatments (T1and T3) and other treatments, normal without heating (T2 and T4), and the heating temperature was provided with a heat diffuser and a thermostat set at a temperature of 24 °C. The highest daylight average of soil temperatures recorded during the full season was 26.94°C for all treatments and the nightly soil temperatures during the full season was 15.055°C for treatments (T2 and T4), and 23.407°C for treatments (T1 and T3) was higher by 35.68% than the (T2 and T4) treatment.

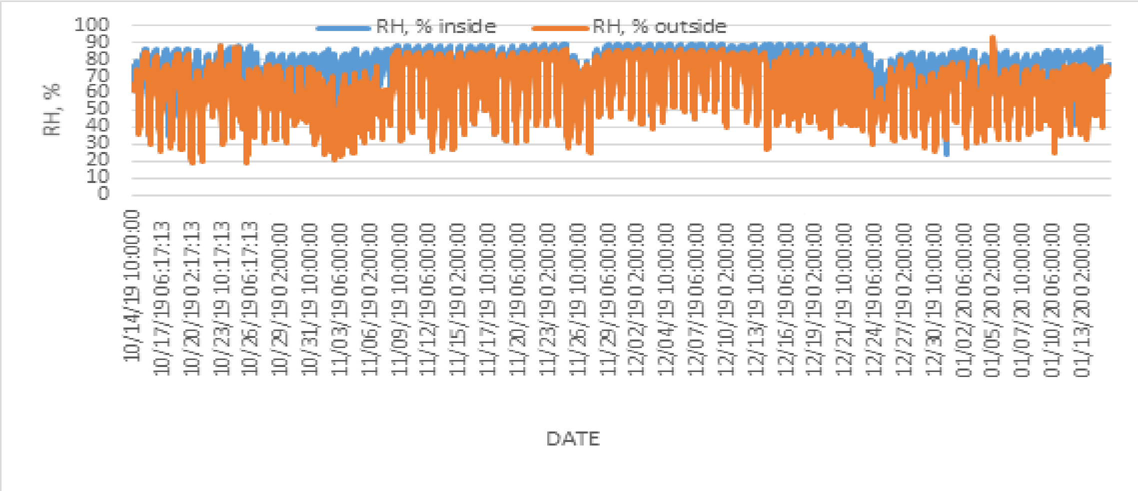

Figure (3.2): day and night of the air Relative humidity for cucumber plant during the growth period plant.

The average daily soil temperature for T1 and T3 treatments during the growing period ranged from 23.407 to 26.94 °C, while, the average daily soil temperature for (T2) and (T4) ranged from 15.055 to 26.94 °C. These results agreed with those obtained by **Bakker (1989) and Bastías *et al.* (2012)** who found that the optimum soil temperature for vegetative growth cucumber is aver average 24°C with the optimum temperature for fresh yield. The heating of the soil led to the provision of suitable conditions for the plant, especially the root zone, and good spread of the root system, which helped the root to absorb nutrients in the nutrient solution.

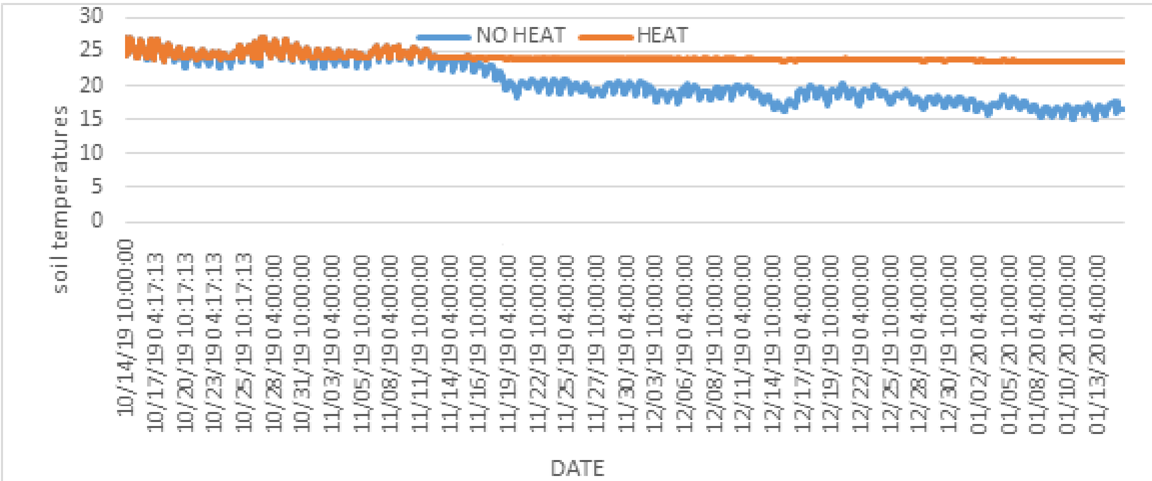

Figure (3.3): day and night of the Soil temperature for cucumber plant during the growth period plant.

Moderate root-zone warming (20 C-25 C) may have a beneficial effect in many cases and is routinely practiced in many propagation nurseries during the rooting stage of stem and leaf cuttings. Elevated temperatures, on the other hand, lead to a significant increase in root respiration rates. Since this is coupled with a sharp decrease in DO levels in the root-zone solution, the result may be detrimental **(Kafkafi, 1990).**

3.2. Nutrients Consumption Rate:

Nitrogen, phosphorus, potassium, calcium and magnesium consumption rates were determined during the growth period of cucumber at soilless culture close systems and different Irrigation periods and soil heating. Any removal of nutrients from the solution can be equated with uptake by plants, provided that the system does not leak.

3.2.1. Nitrogen consumption rate:

Figures (3.4) show the nitrogen (N) consumption rate by cucumber plants during the growth period. Knowing that the cultivated soil is fertile, consisting of betmos, perlite and vermiculite. The nitrogen content in the nutrient solution added to the plant at time intervals with a different ratio of the absorption element Length of plant life. The results indicate that the average nitrogen consumption rate was increased in T1 (58.50 ppm) treatment over those of all treatment T2, T3 and T4, 52.00, 55.75 and 46.00 ppm, respectively. The higher the absorption of the element due to the availability of environmental conditions appropriate for the roots of the plant appropriate to absorb the elements.

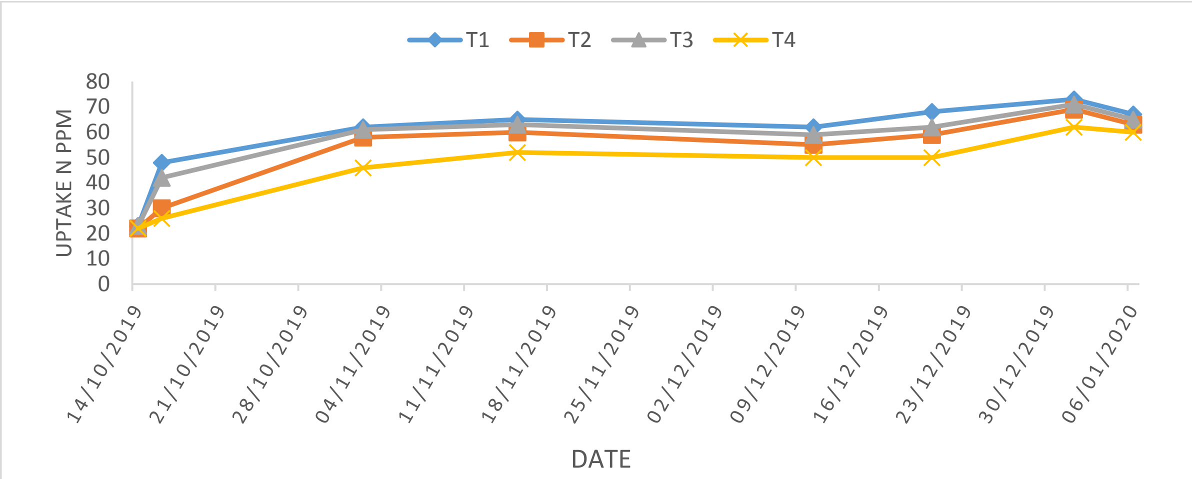

Figure (3.4): Nitrogen consumption rate for cucumber plant during the growth period plant.

3. 2. 2. Phosphorus consumption rate:

Figures (3.5) show the Phosphorus (P) consumption rate by cucumber plants during the growth period. Knowing that the cultivated soil is fertile, consisting of betmos, perlite and vermiculite. The Phosphorus content in the nutrient solution added to the plant at time with a different ratio of the absorption element Length of plant life.

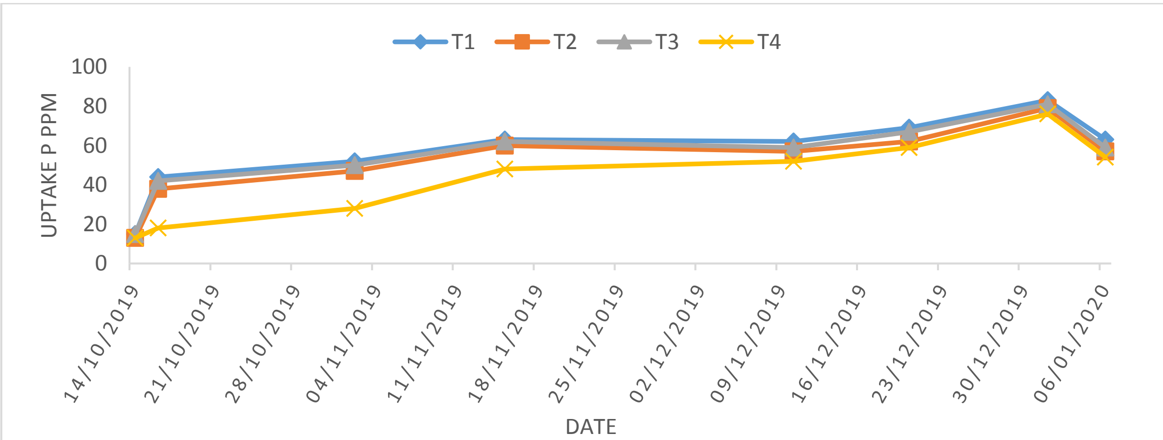

Figure (3.5): Phosphorus consumption rate for cucumber plant during the growth period plant.

The results indicate that the average Phosphorus consumption rate was increased in T1 (56.38 ppm) treatment over those of all treatment T2, T3 and T4 for 51.63, 54.38 and 43.50 ppm, respectively. The higher the absorption of the element due to the availability of environmental conditions appropriate for the roots of the plant appropriate to absorb the elements.

3. 2. 3. Potassium consumption rate:

Figures (3.6) show the Potassium (K) consumption rate by cucumber plants during the growth period. Knowing that the cultivated soil is fertile, consisting of betmos, perlite and vermiculite. The Potassium content in the nutrient solution added to the plant at time with a different ratio of the absorption element Length of plant life. The results indicate that the average Potassium consumption rate was increased in T1 (82.88 ppm) treatment over those of all treatment T2, T3 and T4 for 76.25, 80.25 and 70.88 ppm, respectively. The higher the absorption of the element due to the availability of environmental conditions appropriate for the roots of the plant appropriate to absorb the elements.

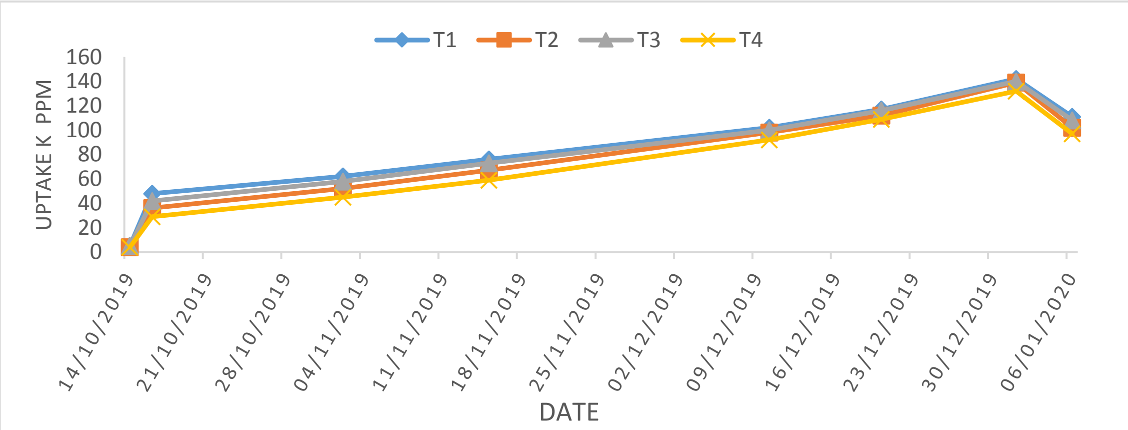

Figure (3.6): Potassium consumption rate for cucumber plant during the growth period plant.

3. 2. 4. Calcium consumption rate:

Figures (3.7) show the Calcium (Ca) consumption rate by cucumber plants during the growth period. Knowing that the cultivated soil is fertile, consisting of betmos, perlite and vermiculite. The Calcium content in the nutrient solution added to the plant at time intervals with a different ratio of the absorption element Length of plant life. The results indicate that the average Calcium consumption rate was increased in T1 (97.75 ppm) treatment over those of all treatment T2, T3 and T4 for 92.63, 96.00 and 87.75 ppm, respectively. The higher the absorption of the element due to the availability of environmental conditions appropriate for the roots of the plant appropriate to absorb the elements.

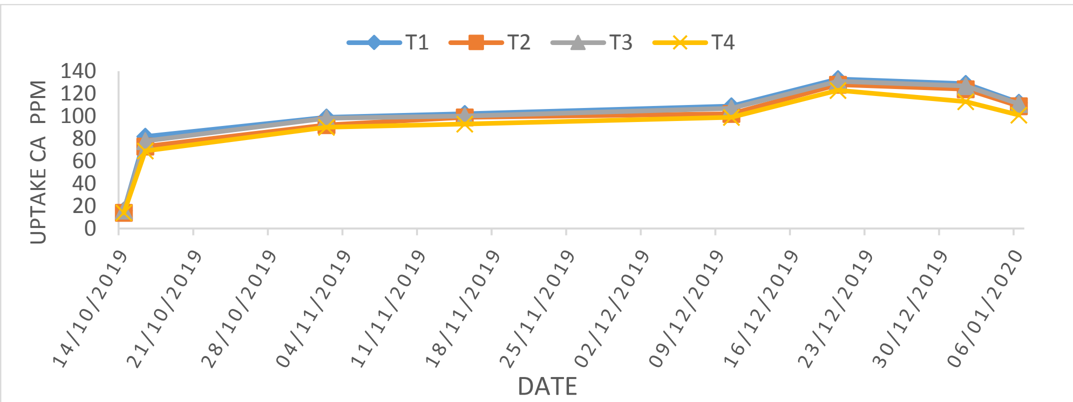

Figure (3.7): Calcium consumption rate for cucumber plant during the growth period plant.

3. 2. 5. Magnesium consumption rate:

Figures (3.8) show the Magnesium (Mg) consumption rate by cucumber plants during the growth period. Knowing that the cultivated soil is fertile, consisting of betmos, perlite and vermiculite. The Magnesium content in the nutrient solution added to the plant at time intervals with a different ratio of the absorption element Length of plant life. The results indicate that the average Magnesium consumption rate was increased in T1 (13.75 ppm) treatment over those of all treatment T2, T3 and T4 for 9.75, 12.38 and 7.50 ppm, respectively. The higher the absorption of the element due to the availability of environmental conditions appropriate for the roots of the plant appropriate to absorb the elements.

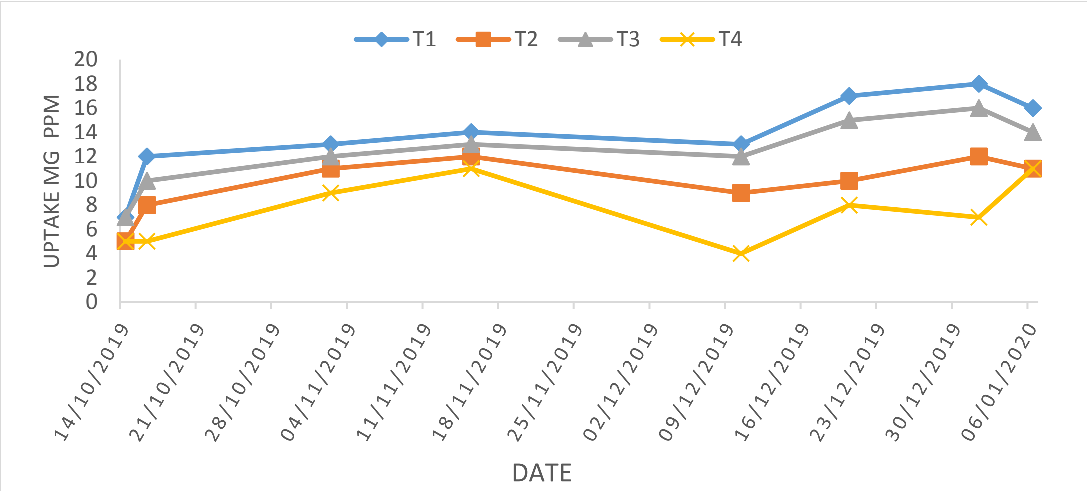

Figure (3.8): Magnesium consumption rate for cucumber plant during the growth period plant.

3. 2. 6. PH

Figures (3.9) show the PH number for Nutrient solution of plant cucumber plant during the growth period. Knowing that the cultivated soil is fertile, consisting of betmos, perlite and vermiculite and PH number for it 6.4. The best pH number, which helps to absorb most of the major nutrients and micro nutrients ranges between 5.5 to 6.5 The PH number in the nutrient solution added to the plant at time intervals with a different PH number of the Length of plant life. The average pH number of the nutrient solution added to the plant was 6.76, 6.57, 6.69 and 6.5 for T1 to T4, respectively. The results indicate that the average PH number was decreased in T1 (6.76) treatment over those of all treatment T2, T3 and T4 for 6.57, 6.69 and 6.5, respectively. The lower the PH number, the higher the nutrient absorption rate.

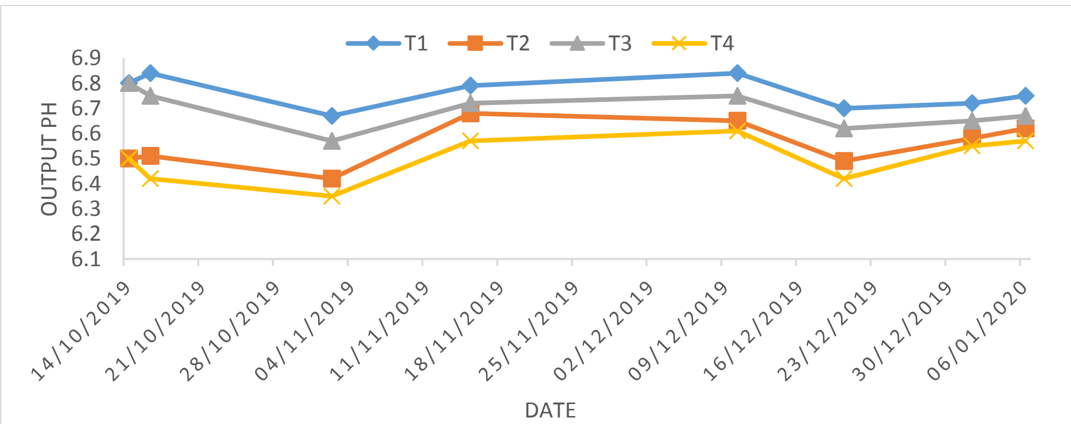

Figure (3.9): PH number for Nutrient solution of cucumber plant during the growth period plant.

The statistical analysis showed that there was a significant difference between the average PH number of cucumber for all treatments. The results also indicate that the average PH number was 6.76, 6.57, 6.69 and 6.5 for T1 to T4, respectively. The lowest value of PH number was found with a treatment of T1, while the highest value of PH number was found with a treatment of T4 decreasing of cucumber plant for treatments T1 may be due to intermittent irrigation and Soil heating for these treatments more than treatment T2, T3 and T4.

3. 2. 7. Electrical conductivity

Figures (3.10) show the EC for Nutrient solution of plant cucumber plant during the growth period. Knowing that the cultivated soil is fertile, consisting of betmos, perlite and vermiculite and EC for it 1120 ppm. The EC in the nutrient solution added to the plant at time intervals as shown in the table (4.0) with a different EC of the Length of plant life. The average EC of the nutrient solution added to the plant was 514.875, 682.625, 555.75 and 736.625 ppm for T1 to T4, respectively. The results indicate that the average EC was decreased in T1 514.875 ppm treatment over those of all treatment T2, T3 and T4 for 682.625, 555.75 and 736.625 ppm respectively. The lower the EC, the higher the nutrient absorption rate.

The statistical analysis showed that there was a significant difference between the average EC of cucumber for all treatments. The results also indicate that the average EC was 514.875, 682.625, 555.75 and 736.625 ppm for T1 to T4, respectively. The lowest value of EC was found with a treatment of T1, while the highest value of EC was found with a treatment of T4. decreasing of cucumber plant for treatments T1 may be due to intermittent irrigation and Soil heating for these treatments more than treatment T2, T3 and T4.

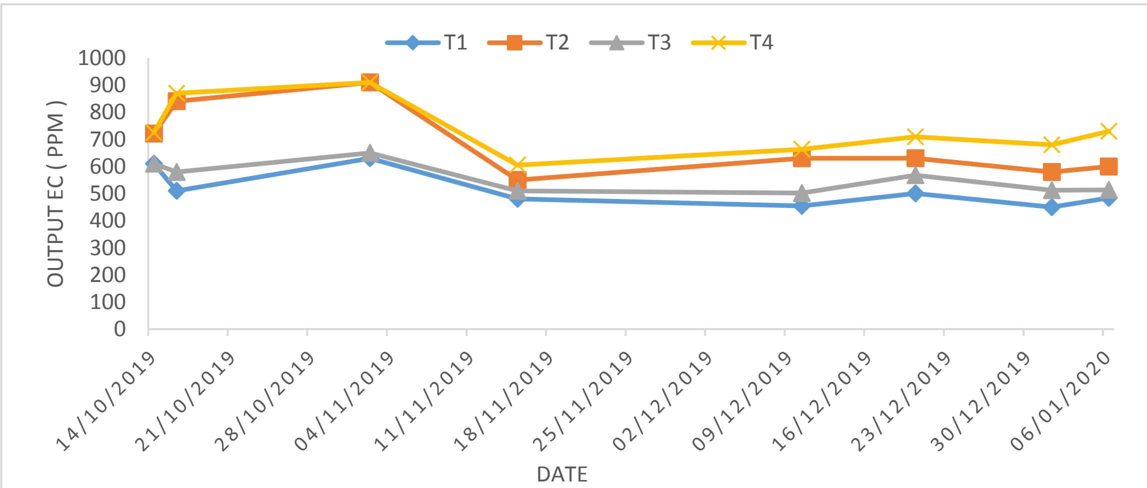

Figure (3.10): Electrical conductivity EC for Nutrient solution of cucumber plant during the growth period plant.

3. 3. Yield and yield components of cucumber plant:

3. 3. 1. Yield of cucumber plant:

Figure (3.11) show the fresh yield of cucumber for all treatments (T1 to T4) at the end of growing period. The results indicate that the total fresh yield values of cucumber crop ranged from 7474.278 to 4276.49 g plant^{-1} for different treatments. The highest value of total fresh yield (7474.28 g plant-1) was achieved with a treatment T1 because this treatment recorded the intermittent irrigation and soil heating, while the lowest value of total fresh yield (4276.49 g plant^{-1}) was found with a treatment T4. These results agreed with those obtained by **Shahak *et***

***al.*, (2008) and Milenković *et al.*, (2012)** who found that the intermittent irrigation and soil heating increased the total fresh yield which was associated with both higher productivity (number of fruits produced per plant).

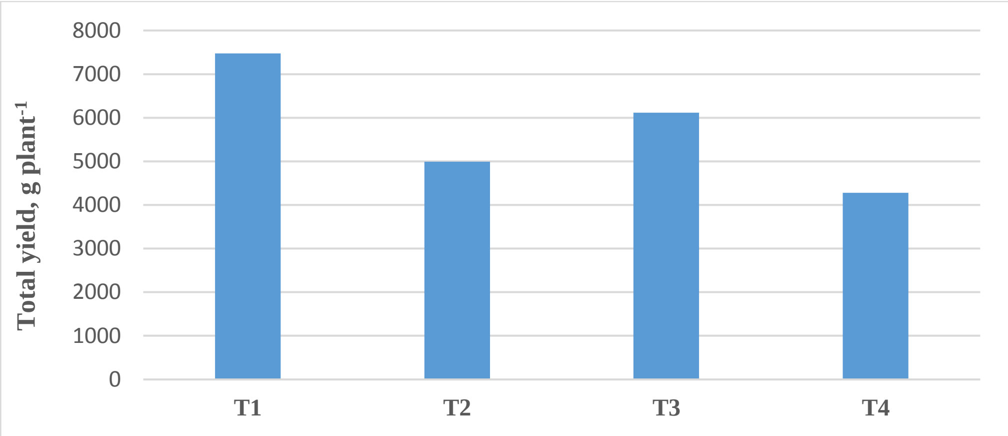

Figure (3.11): Total yield of cucumber plant during the growth period plant.

The statistical analysis showed that there is a significant difference between the average fresh yield of cucumber for all treatments, the results indicate that the average fresh yield was 8969.13, 5988.47, 7336.73 and 5131.79 g plant-1 for T1 to T4, respectively.

4. CONCLUSION

The experiment was carried out to study the effect of root zone temperature on nutrient uptake in soilless cultivation systems and to obtain the best reused rate for nutrients after treatment and fertigation management in closed soilless culture systems and fertilizer calculator for each element's at long time of plant, the obtained results can be summarized as follows:

- Air temperatures recorded outside and inside. The results indicate that the daylight air temperature for all treatments (T1 to T4) during the growing period were 27.905 to 33.431°C,and outside were 16.796 to 42.983°C, while the nightly air temperature results for all treatments (T1 to T4) during the growing period were 9.015 to 22.417°C, and outside were 5.565 to 21.485°C.
- Air relative humidity recorded outside and inside. The results indicate that the daylight air relative humidity for all treatments (T1 to T4) during the growing period were 78.917 to 89.518 %, and outside were 39.029 to 93.029 %, while the nightly air relative humidity results for all treatments (T1 to T4) during the growing period were 23.778 81.170 %, and outside were 18.279 to 52.791%.
- soil temperatures recorded during the full season was 26.94°C for all treatments and the nightly soil temperatures during the full season was 15.055°C for treatments (T2 and T4), and 23.407°C for treatments (T1 and T3) was higher by 35.68% than the (T2 and T4) treatment. The average daily soil temperature for T1 and T3 treatments during the growing period ranged from 23.407 to 26.94 °C, while, the average daily soil temperature for (T2) and (T4) ranged from 15.055 to 26.94 °C.
- The average nitrogen consumption rate was increased in T1 (58.50 ppm) treatment over those of all treatment T2, T3 and T4, 52.00, 55.75 and 46.00 ppm, respectively.

- The average Phosphorus consumption rate was increased in T1 (56.38 ppm) treatment over those of all treatment T2, T3 and T4 for 51.63, 54.38 and 43.50 ppm, respectively.
- The average Potassium consumption rate was increased in T1 (82.88 ppm) treatment over those of all treatment T2, T3 and T4 for 76.25, 80.25 and 70.88 ppm, respectively.
- The average Calcium consumption rate was increased in T1 (97.75 ppm) treatment over those of all treatment T2, T3 and T4 for 92.63, 96.00 and 87.75 ppm, respectively.
- The average Magnesium consumption rate was increased in T1 (13.75 ppm) treatment over those of all treatment T2, T3 and T4 for 9.75, 12.38 and 7.50 ppm, respectively.
- The average PH number was decreased in T1 (6.76) treatment over those of all treatment T2, T3 and T4 for 6.57, 6.69 and 6.5, respectively.
- The average EC was decreased in T1 514.875 ppm treatment over those of all treatment T2, T3 and T4 for 682.625, 555.75 and 736.625 ppm respectively.
- Total fresh yield values of cucumber crop ranged from 7474.278 to 4276.49 g plant^{-1} for different treatments. The highest value of total fresh yield (7474.28 g plant-1) was achieved with a treatment T1.

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تأثير درجة حرارة منطقة الجذر على امتصاص المغذيات في نظم الزراعة بدون تربة

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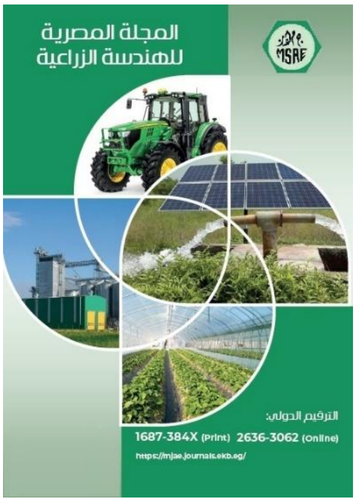

الكلمات المفتاحية:
المغذيات، الزراعة بدون تربة، التسميد، الري، منطقة الجذور.

الملخص العربي

الهدف الرئيسي من هذا البحث هو تقييم تأثير درجة حرارة منطقة الجذر على امتصاص المغذيات في نظم الزراعة بدون تربة والحصول على أفضل معدل لإعادة استخدام المغذيات بعد المعالجة وإدارة التسميد في أنظمة الزراعة بدون تربة مغلقة وحاسب كل عنصر من الاسمدة يحتاجها النبات طول فترة النمو. أجريت التجربة في صوبة زراعية متعددة إسبانيا مغطاة بغشاء البولي إيثيلين وجوانب مغطاة بالفيبرجلاس. يوجد نظام تبريد للتبخر (وسادة ومروحة) ونظام تدفئة جذور وتحكم في عملية الري والتسميد. تتكون التربة الزراعية من البتموس والبيرلايت والفيرميكوليت. أشارت النتائج المتحصل عليها إلى أن نظام الزراعة بدون تربة مع الري المتقطع وتسخين منطقة الجذر (T1) هي الأفضل من جميع الانظمة الاخرى، التي هي حيث هى نظام الزراعة بدون تربة مع الري المتقطع (T2) ، ونظام الزراعة بدون تربة مع الري مرة واحدة وتسخين منطقة الجذر (T3) ونظام الزراعة بدون تربة مع الري مرة واحدة (T4) من حيث امتصاص العناصر الغذائية (النيتروجين (N) والفوسفور (P) والبوتاسيوم (K) والكالسيوم (Ca) والمغنيسيوم (Mg) وأفضل امتصاص كانت المياه هي معاملة نظام الزراعة بدون تربة مع الري المتقطع وتسخين منطقة الجذر وأفضل معايير النمو للنبات التي تشمل طول السيقان ، وقطر الساق ، وعدد الأوراق ، ومساحة الورقة ، وكتلة الثمار والانتاجية.