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ENGINEERING FACTORS AFFECTING ON BASIL GROWING

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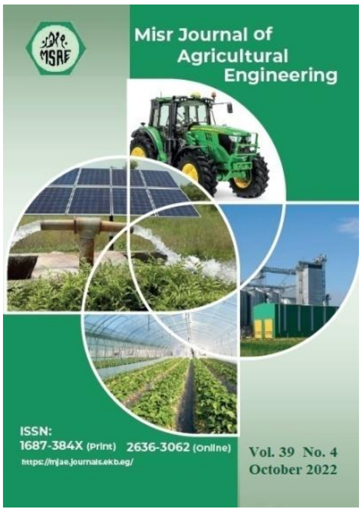


Keywords:
Root zone temperature; Dissolved oxygen; Basil growth; Yield quality; Hydroponics

ABSTRACT

*This study was carried out to measure and manage the operational parameters of the hydroponic system. A series of experiments were conducted to examine various parameters, including the effects of four different levels of operating pressures (0.50, 0.75, 1.00 and 1.25 bar), four different levels of root zone temperatures (16, 22, 28 and 34 °C), and basil seedlings that were two weeks old on oxygen level, herb production, water productivity, and power consumption. The results show, the best production conditions ware , Basil age 45 days, the root zone temperature, 28 °**C** , and operating pressure was 100 kPa (1bar). The results also show that, The maximum dissolved oxygen concentration of 6.8 mg/L, 90.66 leaves, a plant height of 24.20 cm, a stem diameter of 4.68 mm, and a total weight of 17.30 g/plant for the leaves. Basil's longest root length was 64 cm, at 22 °**C** in the root zone and operating pressure was 100 kPa (1bar). The maximum quantity of essential oil was 2.8% and highest Basil's water productivity was 0.3 kg/m3 at the root zone temperature, 28°**C**.*

1. INTRODUCTION

Egypt's population is gradually growing, making it necessary to develop new strategies to close the gap between agricultural output and needs of population. The procedure of growing plants without soil is referred to "hydroponics" and is one of the innovative techniques. Plants are grown in a variety of different medium in hydroponic systems, and the nutrient solution contains all the necessary ingredients for plant growth. This enables better management of nutrient availability and plant growth. In order to enhance one or more aspects of plant production, hydroponics also enables the root environment to be changed. More than 7 billion people live on the planet today, and it's expected that number will increase to 9.7 billion by 2050 and 11 billion by 2100. **(UN, 2019).** In Egypt, there are 28769.58 ha (of medicinal, aromatic, and cutting flower plants that are grown, and they yield $56390*10^3$ kg/year. On 5430.6 ha, green basil is produced, producing $213441*10^3$ kg/year **(Ministry of Agriculture and Land Reclamation, 2018).**

The morphological and chemical diversity of basil creates a wide range of chances for growing different cultivars of this important therapeutic plant. There are numerous basil cultivars and forms, and they vary in terms of the plant's size, habit, colour, shape, and size of its leaves and blossoms, the amount of essential oils they contain, their chemical makeup, and other biologically active substances **(Saran, et al., 2017).**

Due to changes in dissolved oxygen levels in nutrient solution during high-temperature seasons, high nutrient solution temperature stress in the root zone is a significant factor limiting hydroponic crop growth. This indicates that more straightforward and affordable root-zone temperature management may be a useful remedy for the temperature stress that hydroponically grown crops experience **(Muthir, et al., 2019).**

In conventional hydroponics, each plant develops in a container with a nutrient solution flowing through it and an inert material like pumice stone, wood chips, glass wool, or sand. This substance is permeated by the nutritional answer. Plant roots also pierce the material, and it is because of their root system that a plant may stand upright. This system is more efficient at mass nutrient transfer from the fresh entering solution to the expanded root system than a comparable system growing in soil, although convection and diffusion transport are still far from ideal. The fluid surrounding the roots is lacking in essential nutrients, most notably oxygen **(Eridani, et al., 2017)**.

The two main benefits of a drip system are that it conserves more water than conventional systems and can tolerate temporary equipment or power outages. As a result of the solution's timed supply, this technique can be quite effective. Individual plant roots receive an insufficient amount of nutrient solution from the reservoir via the water pump. It is frequently used to grow peppers and tomatoes, producing a very high-quality crop **(George and George, 2016).**

The main objective of the study was to evaluate and control the hydroponic system's operational parameters by analyzing the effect of changing the root zone temperature on the oxygen level and the effect of operating pressure on the growth of basil (Ocimum basilicum L.).

2. MATERIALS AND METHODS

The study was conducted over four months, from September to December 2021, in Damietta, Egypt (31°11'10" N, 31° 35' 59" E). *Ocimum basilicum L.* seedlings that were two weeks were planted in plastic pots with a 1:1:1 mixture of peatmoss medium, perlite, and vermiculite. The weather at Damietta Station in September, the mean air temperature reaches its peak and exceeds 28.71 °C, but the average temperature reaches its lowest point in December, when it reaches 13.43 °C. **According to National Canters for Environmental Information (2021)**, the lowest relative humidity values were recorded in October, while the highest values were recorded in December, Fig. 1. The main tank's irrigation water was filled with nutrient solution, keeping the pH between 5.5 and 6.5 and the EC constant at 1.0 to 1.6 dS/m for the basil.

- System installation and experimental procedures

The study makes use of a soilless cultivation technique (Drip hydroponic system). A schematic diagram of the prototype's key components may be found in Fig. 2. The following diagram illustrates the components of the drip hydroponic system that was employed. The system consists of four frames, each one could support three tanks and was built to be 5 $*10^{-3}$

m thick. The frame's measurements were 1.50 m long,0. 22 m wide, and 0.25 m tall. The main tank is a green polyethylene tank with a capacity of 50 L and dimensions of 0.58 m height, 0.30 m tank diameter, and 0.34 m manhole diameter for collecting the excess nutrient solution that was directed to the other tanks, each one has a capacity of 15 L and dimensions of 0.34 m height, 0.24 m width, and 0.27 m manhole width connected to 16 $*10^{-3}$ m inflow pipe connected to emitters.

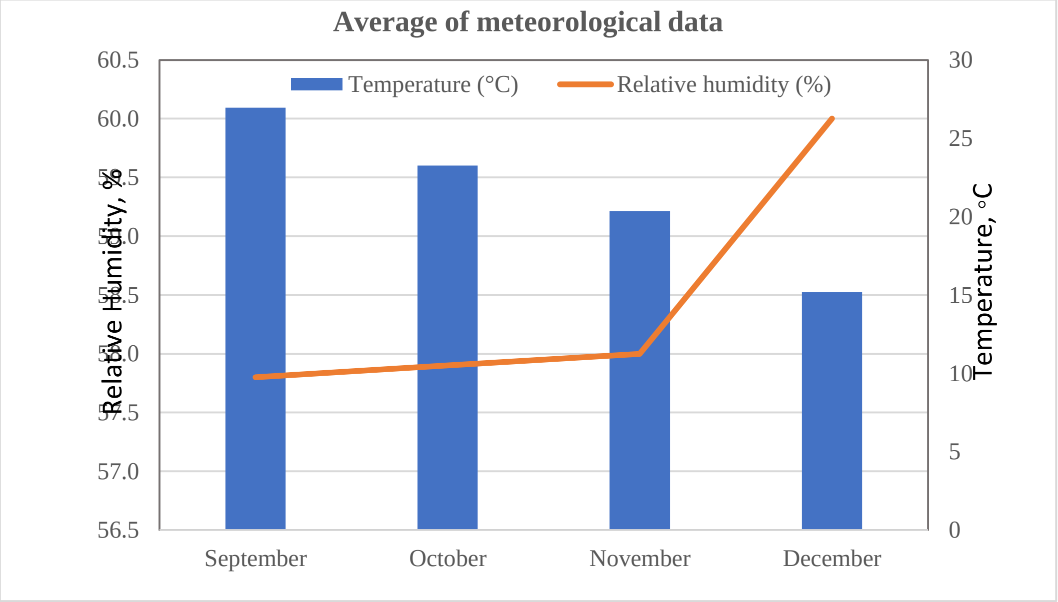
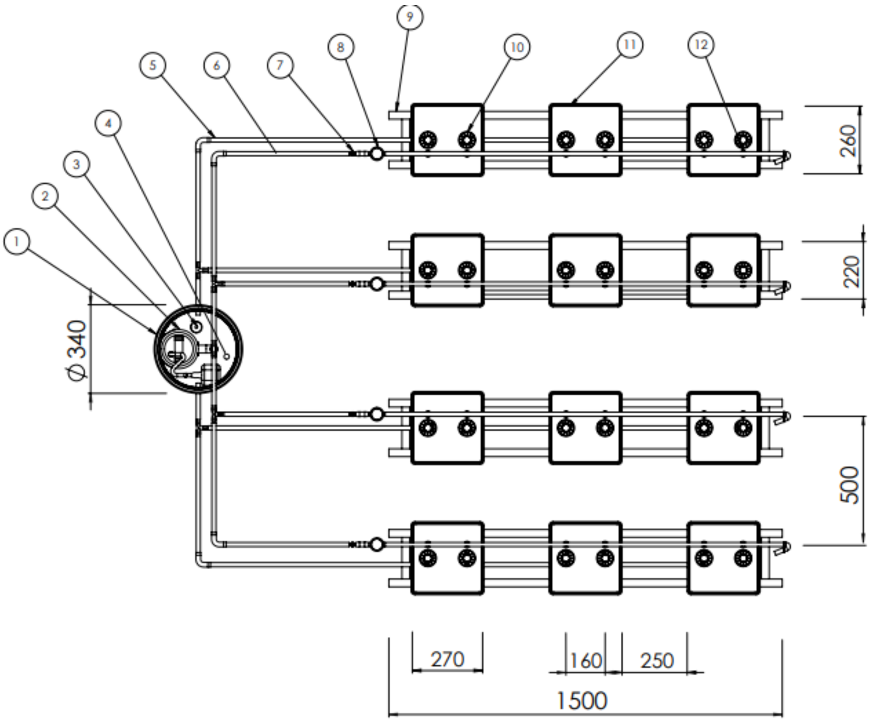


Fig. 1: Average monthly meteorological data of Damietta station

No.	**Part name**
1	Main tank
2	Pump
3	Heater
4	Dissolved oxygen sensor
5	Outflow pipe
6	Inflow pipe
7	Ball valve
8	Preasure gauge
9	Frame
10	Cup
11	Tank
12	Emitter



All dimensions : mm

Scale: 1:10

Fig. 2: Schematic diagram of drip hydroponic system

Each line had six emitters fixed to the inflow pipe; at one bar of operating pressure, the emitter's discharge rate was 4 L/h. The pressure gauge, which was controlled by a ball valve, was used to regulate the pressure of the emitter. Basil was grown in plastic hydroponic cups with a 15 cm space between pots. A tank with fertilizer solution served as the irrigation system. A submersible pump (0.75 kW- one hp) [Model: QDS - CW/DW, Q = 160 L/min., H = 3 bar, V=220, n =2850 rpm] linked to 16 $*10^{-3}$ m tubing to the rest of the system was used to pump the nutrient solution. To irrigate the plant, the nutrient solution was pumped to the emitter. A timer [model: YTS-F, 220v/240v/50Hz, 0-3500 W] was used to change the irrigation intervals]. Throughout the herb development phase, (15 min/h) was activated four times per day, every six hours, for 15 min. The fertilizer solution was returned from additional tanks to the main tank using a 1.6 cm outflow pipe. A submersible stainless-steel heater [Model: RS, P= 500 W, V= 220-240 V, 50 Hz] was used to regulate the temperature. In order to track how temperature affects the amount of dissolved oxygen in the nutritional solution, the heater was installed in the main tank. Sun mesh shade sunscreen for plants (shade mesh), which allows for 70% light transmission, and polythene sheet, which allows for 84% light transmission, were used to cover environmental tests.

- Experimental conditions

The studies were done to find out how the following elements affected basil (*Ocimum basilicum L.*):

1. The root zone can be at four different temperatures (16, 22, 28 and 34 ^{o}C).
2. There are four various operating pressures (0.50, 0.75, 1.00 and 1.25 bar).

Measurements

- Estimation of dissolved oxygen level (DO) in the nutrient solution

As illustrated in Fig. 3, the analogue dissolved oxygen sensor connection diagram. Voltage and dissolved oxygen concentration are inversely correlated at constant temperature. Before reliable data may be acquired, the voltage corresponding to saturated dissolved oxygen must be calibrated by filling the membrane cap with a 0.5 mol/L NaOH solution due to minor variations in probe manufacturing.

Fig. 4 illustrates the data of the change in dissolved oxygen that was captured every hour during the day using the Arduino flowchart, which demonstrates how to measure dissolved oxygen, which changes in reaction to temperature changes.

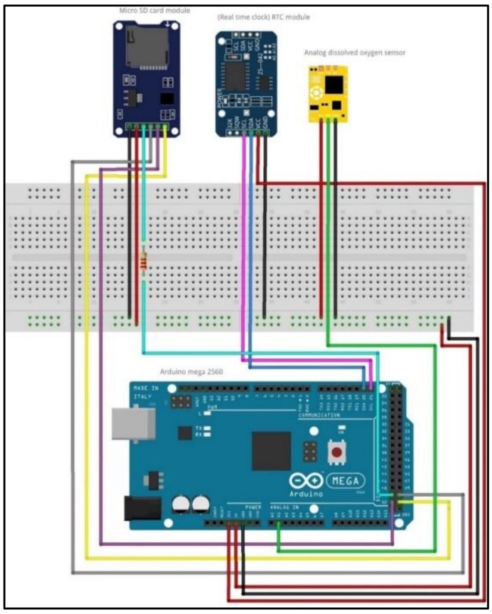


Fig. 3: Analog dissolved oxygen sensor connection diagram

- Estimation of production

A sample of 6 plants from each treatment were taken in order to estimate the amount of essential oil needed for each experiment and gauge the performance of the developing crop.

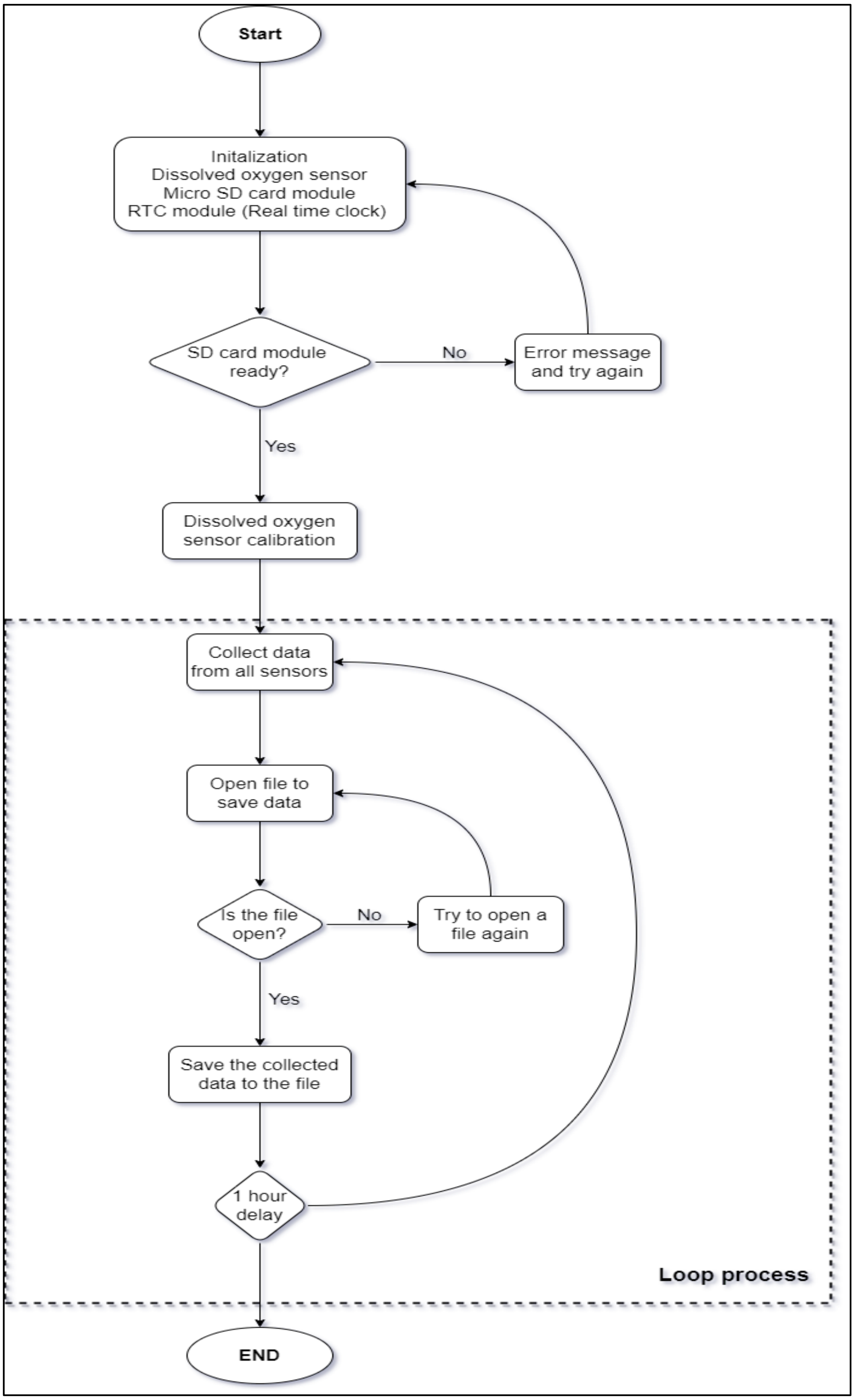


Fig. 4: Arduino flowchart of dissolved oxygen sensor

a. Growing parameters

1. Plant height and root length

Electronic digital caliper with accuracy ± 0.02 mm was used to measure both of the height plant every six days during experiment and the root length of plant after harvesting.

2. Number of leaves per plant

Numbers of leaves per plant were counted every six days during experiment.

3. Stem diameter(mm)

Stem diameter was measured after harvesting by electronic digital caliper with accuracy ± 0.02 mm.

4. Total fresh weight of leaves (g/plant)

Fresh weight of leaves was measured after harvesting by accuracy of ±0.01 gm.

b. Estimation of essential oil quantity

The essential oils are obtained by steam distillation of leaves. The samples were analyzed in the central laboratory, Faculty of Agriculture, Ain Shams University.

Estimation of water productivity

The water productivity (kg/m^3) was computed using the following formula given by **Bhushan, 2007**.

$$\text{Water productivity (kg/m}^3\text{)} = \frac{Yeild(\frac{kg}{ha})}{Crop\ water\ use\ (\mathrm{m^3/ha})} \qquad [1]$$

3. RESULTS AND DISCUSSION

By installing a soilless culture system hydroponics (Drip hydroponic system), it will be possible to change the root zone temperature and study the impact of operating pressure on the oxygen level, herb output, water productivity.

1. Estimation of "DO" level in the nutrient solution for basil

a. At age 20 days

From the data illustrated in Fig. 5, increasing the dissolved oxygen to 6.54 mg/L at root zone temperature of 28 ºC and at root zone temperature of 16 ºC can be showed and tends to decrease dissolved oxygen to 0.92 mg/L 24 hours later.

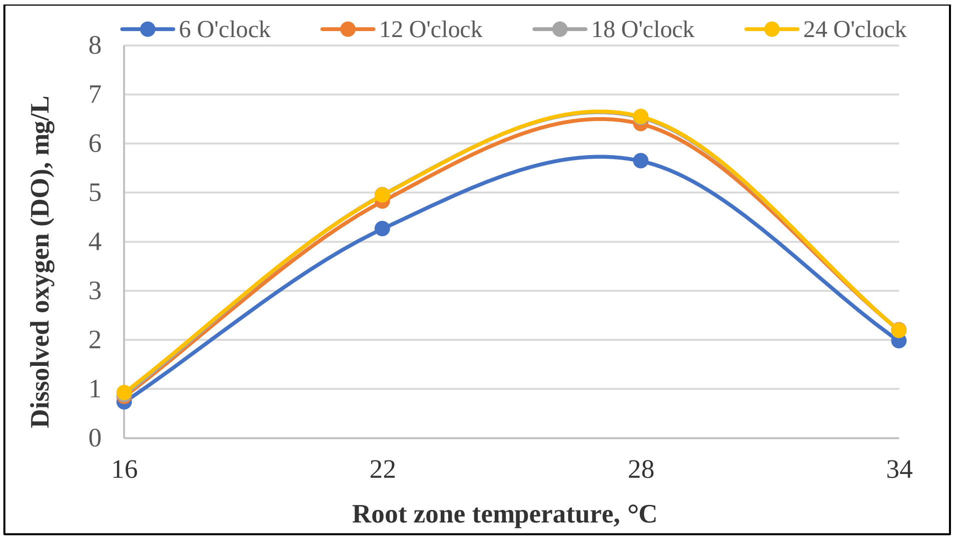


Fig. 5: Effect of root zone temperatures on dissolved oxygen for basil at age 20 days

b. At age 26 days

According to the findings shown in Fig. 6, when the dissolved oxygen is raised to 6.57 mg/L at a root zone temperature of 28 $^{\mathrm{o}}$C and at a root zone temperature of 16 $^{\mathrm{o}}$C, the dissolved oxygen tends to drop to 1.2 mg/L 24 hours later.

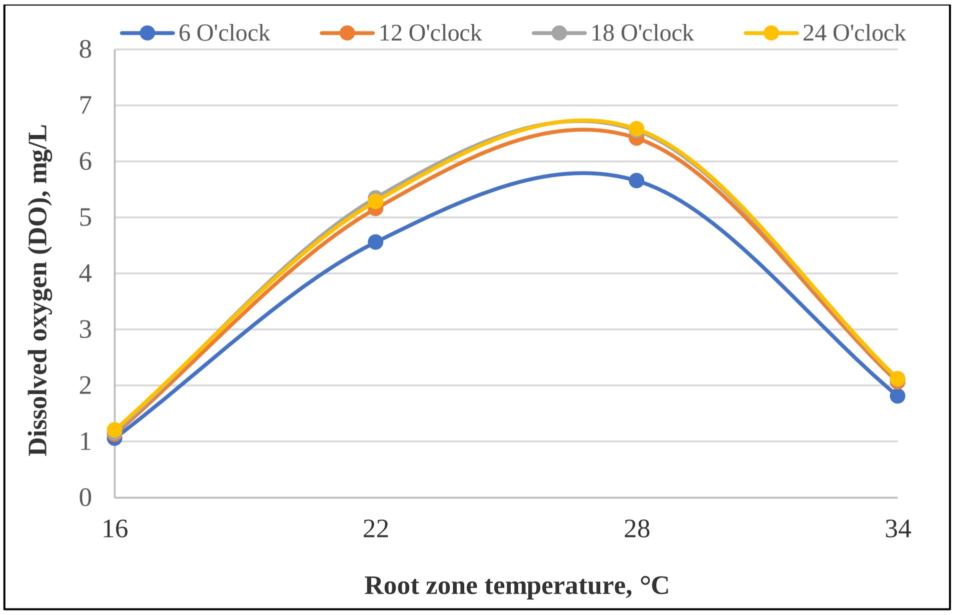


Fig. 6: Effect of root zone temperatures on dissolved oxygen for basil at age 26 days

c. At age 32 days

According to the data shown in Fig. 7, increasing the dissolved oxygen to 6.72 mg/L at root zone temperatures of 28 °C and 16 °C tends to cause the dissolved oxygen to drop to 1.49 mg/L 24 hours later.

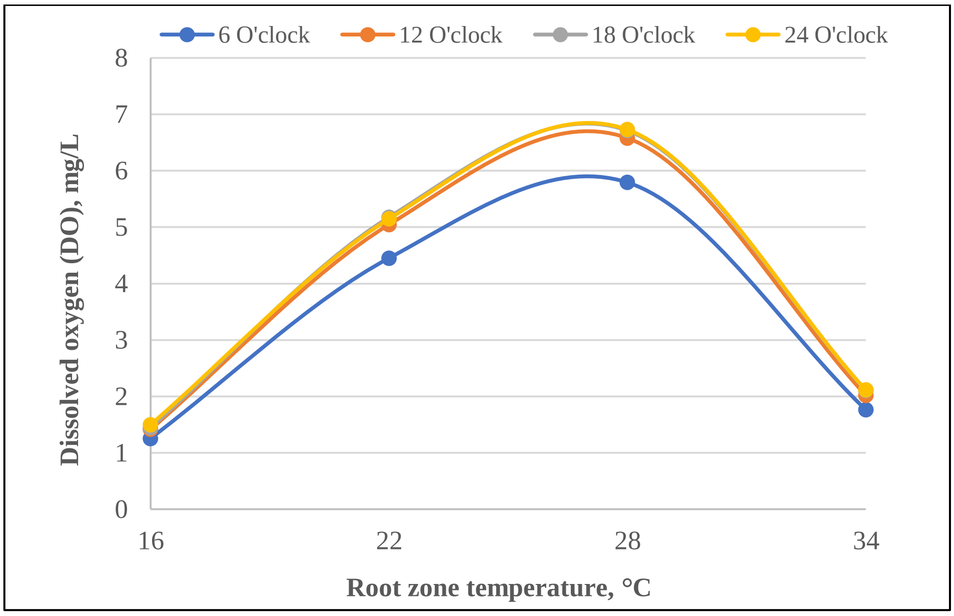


Fig. 7: Effect of root zone temperatures on dissolved oxygen for basil at age 32 days

d. At age 38 days

The tendency is for the dissolved oxygen to decline to 1.49 mg/L 24 hours after increasing it to 6.72 mg/L at root zone temperatures of 28 °C and 16 °C, respectively as illustrated in Fig. 8.

e. At age 45 days

According to the data shown in Fig. 9, raising the dissolved oxygen to 6.8 mg/L at root zone temperatures of 28 °C and 16 °C tends to lower the dissolved oxygen to 1.49 mg/L at 18 O'clock.

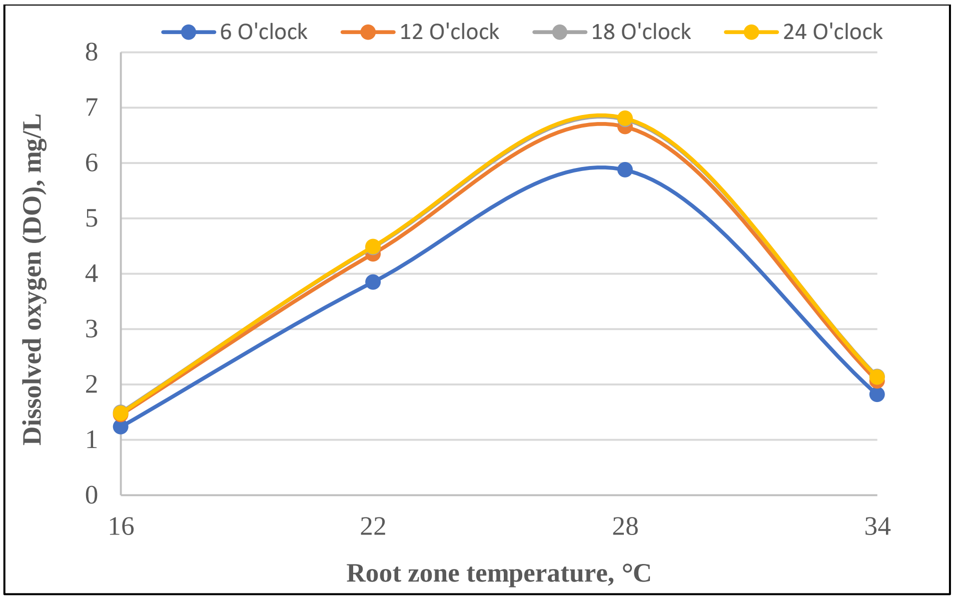


Fig. 8: Effect of root zone temperatures on dissolved oxygen for basil at age 38 days

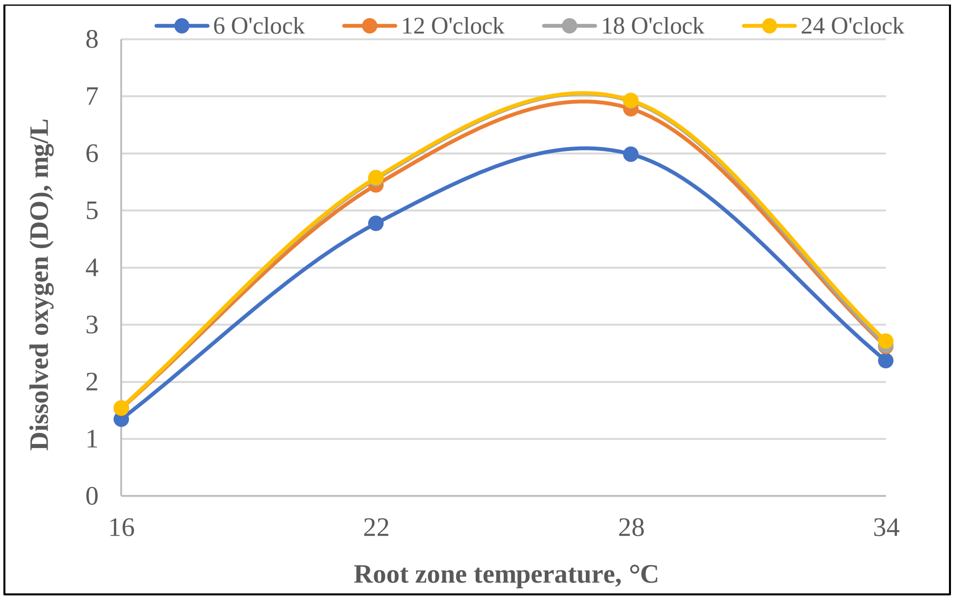


Fig. 9: Effect of root zone temperatures on dissolved oxygen for basil at age 45 days

2. Estimation of basil growth performance

a. Number of leaves

Data presented in Fig. 10, shows the effect of the interaction between root zone temperature and operating pressure on a number of leaves of basil during the growing stages of the study. The highest value of a number of leaves was recorded when operating pressure was one bar and root zone temperature 28 ºC while the lowest value of a number of leaves was recorded when operating pressure was 0.5 bar and root zone temperature 16 ºC.

b. Plant height

Fig. 11 showed that the root zone temperature and operating pressure interact to affect basil plant height during the study's developing stages. When operating pressure was one bar and root zone temperature was 28 ^{o}C, a plant's height was measured at its highest value; when operating pressure was 0.5 bar and root zone temperature was measured at its lowest value.

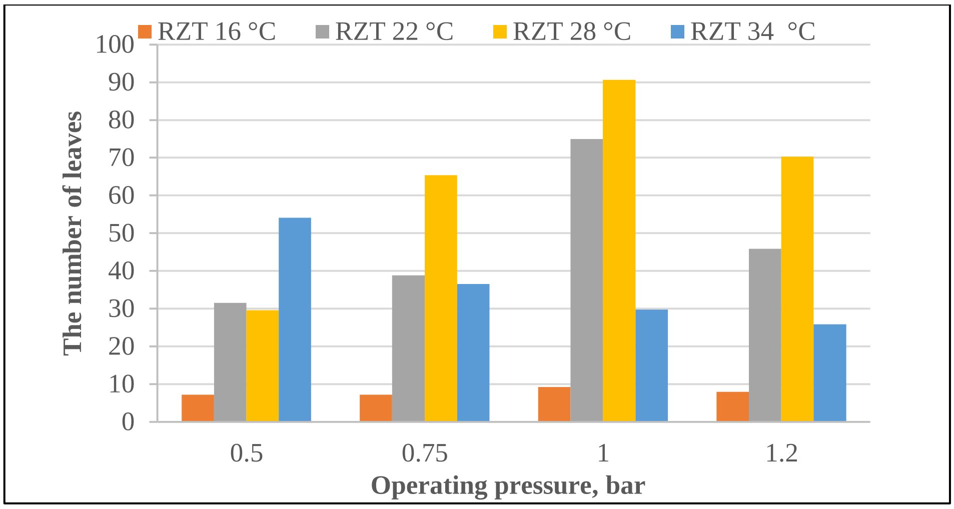


Fig. 10: Effect of root zone temperature and operating pressure on number of leaves of basil

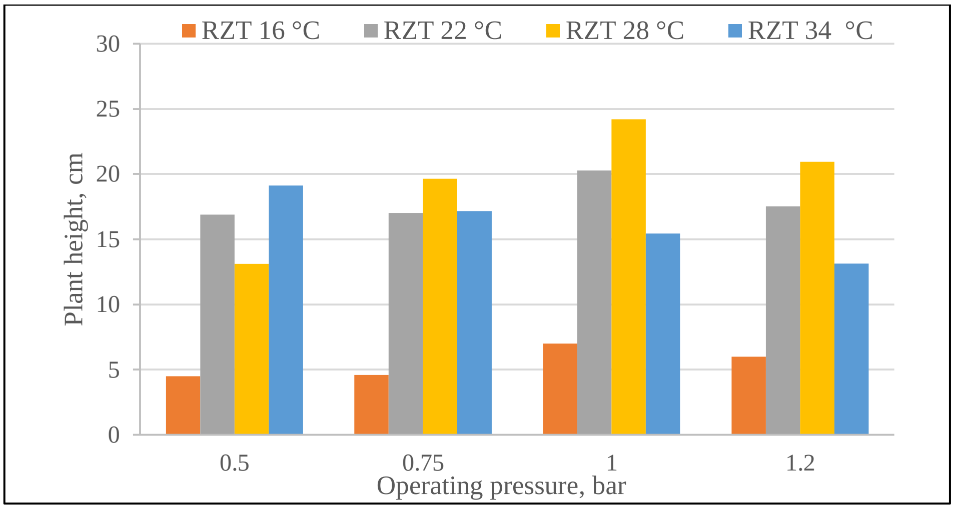


Fig. 11: Effect of root zone temperature and operating pressure on plant height of basil

c. Root length

Data presented in Figs. 12 and 13 shows the effect of the interaction between root zone temperature and operating pressure on a root length of basil at the end of the growing stages of the study. The highest value of a root length was recorded when operating pressure was one bar and root zone temperature 22 ºC while the lowest value of a root length was recorded when operating pressure was 0.5 bar and root zone temperature 16 ºC.

d. Stem diameter

Fig. 13 illustrated that the connection between root zone temperature and operating pressure's impact on basil stem diameter at the conclusion of the study's developing stages. When working pressure was one bar and root zone temperature was 22 ^{o}C, a stem's diameter was measured at its highest value; when operating pressure was 0.5 bar and root zone temperature was 16 ^{o}C, it was measured at its lowest value.

e. Total leaves weight

The data presented in Fig. 14 showed that the relationship between root zone temperature and operating pressure affected the total weight of basil leaves at the conclusion of the study's development stages. The operating pressure of one bar and a root zone temperature of 28 ^{o}C produced the highest value of a total leaves weight, while 0.5 bar and a root zone temperature of 16 ^{o}C produced the lowest value of a total leaves weight.

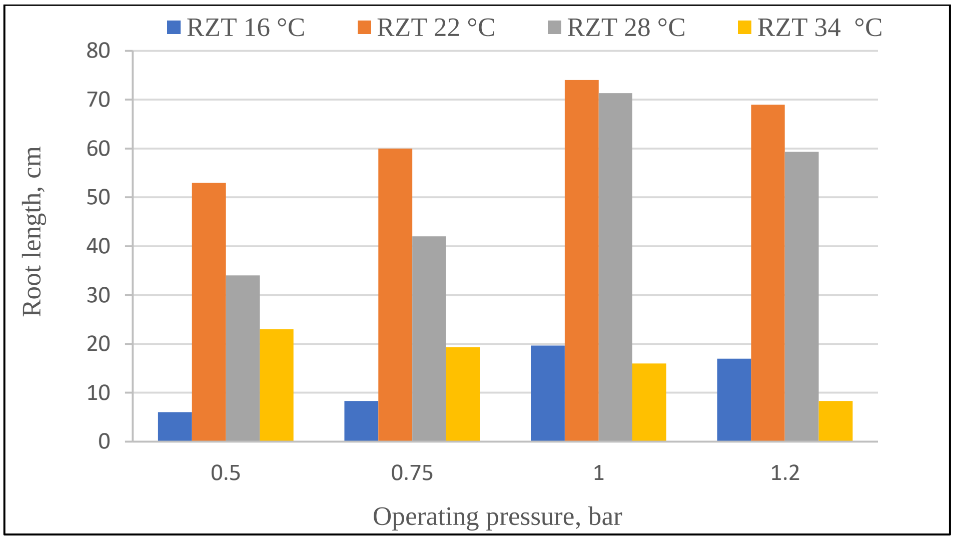


Fig. 12: Effect of root zone temperature and operating pressure on root length of basil

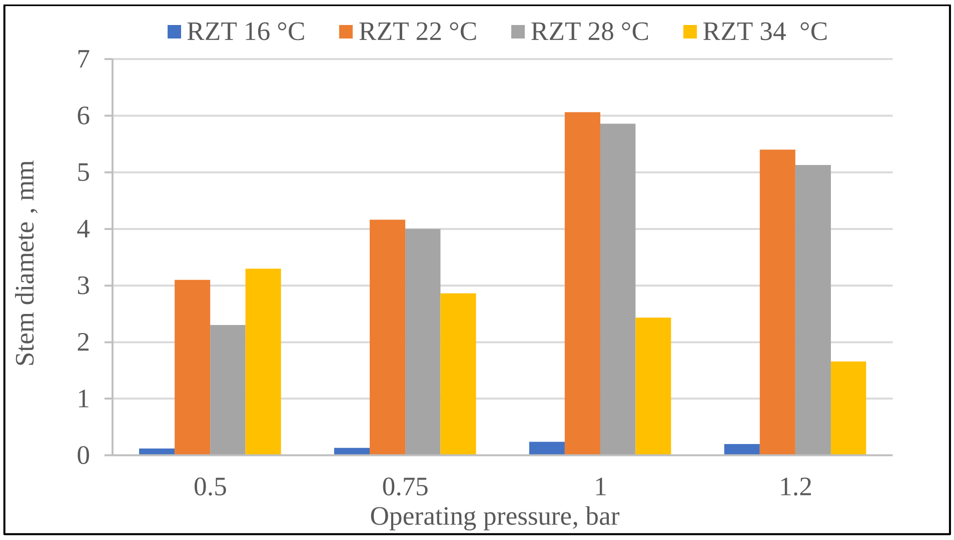


Fig. 13: Effect of root zone temperature and operating pressure on stem diameter of basil

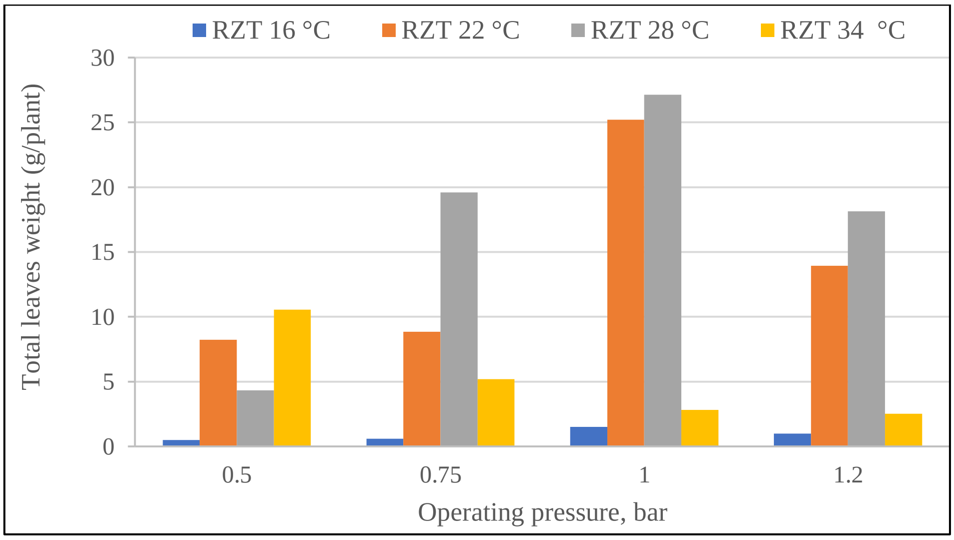


Fig. 14: Effect of root zone temperature and operating pressure on total leaves weight of basil

4. CONCLUSION

The drip hydroponic system has good performance statistics in basil growth. The root zone temperature and operating pressure for the drip hydroponic system should be 28 ^{o}C and one bar, respectively. At these concentrations, there is a maximum dissolved oxygen concentration of 6.8 mg/L, 90.66 leaves, a plant height of 24.20 cm, a stem diameter of 4.68 mm, and 17.30 g of total leaves/plant. Basil's longest root length to date was 64 cm, measured at 22 ^{o}C in the root zone and one bar of operating pressure. When the root zone temperature was 28 ^{o}C, the essential oil quantity reached its maximum value of 2.8%. Basil's water productivity peaked at 0.3 kg/m^3 when the root zone temperature reached 28 ^{o} C.

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العوامل الهندسية المؤثرة على نمو الريحان

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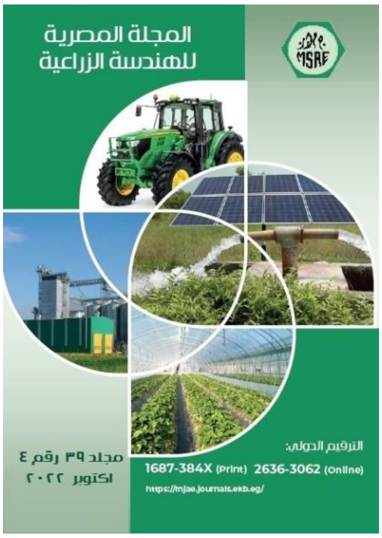
الملخص العربي

لدراسة تأثير درجة حرارة منطقة الجذر على مستوى الأكسجين وكذلك تأثير ضغط التشغيل على نمو الأعشاب ، أجريت هذه الدراسة لقياس وإدارة المعاملات التشغيلية لنظام الزراعة المائية. تم إجراء سلسلة من التجارب لفحص معايير مختلفة ، بما في ذلك تأثيرات أربعة مستويات مختلفة من ضغوط التشغيل (٠,٥٠ و ٠,٧٥ و ١,٠٠ و ١,٢٥ بار) ، وأربعة مستويات مختلفة من درجات حرارة المحلول المغذي في منطقة الجذر (١٦ ، ٢٢ ، ٢٨ و٣٤ درجة مئوية) ، وشتلات الريحان التي كان عمرها أسبوعين على مستوى الأكسجين وإنتاج الأعشاب وإنتاجية المياه. كان عمر الريحان ٤٥ يومًا ، وكانت منطقة الجذر ٢٨ درجة مئوية ، وكان ضغط التشغيل بارًا واحدًا عند تحقيق أفضل النتائج. وفقًا للمعايير المذكورة سابقًا ، كان هناك حد أقصى لتركيز الأكسجين المذاب ٦,٨ مجم / لتر ، و ٩٠,٦٦ ورقة ، وارتفاع النبات ٢٤,٢٠ سم ، وقطر الساق ٤,٦٨ مم ، ووزن إجمالي ١٧,٣٠ جم / نبات للأوراق. كان اكبر طول لجذر الريحان حتى الآن ٦٤ سم ، وذلك عند ٢٢ درجة مئوية في منطقة الجذر و ضغط تشغيل واحد بار. عندما كانت درجة حرارة منطقة الجذر ٢٨ درجة مئوية ، وصلت كمية الزيت العطري إلى أقصى قيمة لها وهي ٢,٨٪. بلغت إنتاجية الريحان ذروتها عند ٠,٣ كجم / م ٣ عندما كانت درجة حرارة منطقة الجذر ٢٨ درجة مئوية.



الكلمات المفتاحية:
درجة الحرارة؛ منطقة الجذور؛ الأكسجين المذاب؛ جودة المحصول؛ الزراعة المائية؛ نمو الرَيحان