Design of real-time electrical conductivity monitoring control system in hydroponic system

A.F.M. Yamin*, H. Yusoff, H. Ghafar, Mohd Jumain Jalil, S. Kasolang

School of Mechanical Engineering, College of Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Kampus Permatang Pauh, 13500 Permatang Pauh, Malaysia

*Corresponding e-mail: aliff.farhan6205@uitm.edu.my

Keywords: Electrical conductivity; hydroponic; arduino

ABSTRACT – Hydroponics is a technique of growing vegetables in a shallow nutrient solution. In current practice, growers need to check the value of the Electrical Conductivity (EC) nutrient solution manually and systematically in the reservoir according to the schedule. This manual process is tedious since it requires the grower to check EC values regularly. Therefore, an automated EC monitoring system is needed to overcome this problem. The system consists of a vegetable growing pipe, a nutrient solution tank, two fertilizer containers, a submersible pump, an Arduino Uno microcontroller, a data logger shield, three solenoid valves, three flow meters, a water level sensor, a temperature probe sensor, an analog EC probe sensor, four relays, an LCD, a keypad, and a 12 V power distribution system. The EC value of the nutrient solution is continuously controlled automatically, based on the feedback provided from the EC sensor by controlling the volume of water, fertilizer A and fertilizer B. The results show that the EC value in the nutrient solution is maintained within the threshold values set in the system. In conclusion, the system can facilitate growers in maintaining the EC value of nutrient solutions for hydroponic systems.

1. INTRODUCTION

The hydroponic system is a technique for planting vegetables in a shallow stream of nutrient solution [1]. This cultivation technique requires the nutrient solution to be pumped from the reservoir, pass through a pipe containing the vegetables, and continuously flow back into the reservoir. In most conventional hydroponic systems, parameters such as EC of nutrient solution are set to the desired value while setting up the system. However, in current practice, water levels and EC values of nutrient solutions in reservoirs are measured and handled manually by the grower on site. Furthermore, according to a pre-allocated schedule, the grower needs to check water levels and EC values periodically or at least once a day. This task is inconvenient for farmers since it needs to be routinely and consistently done every day [2].

Moreover, a low EC value will affect the growth morphology of the vegetables. Therefore, an automated EC monitoring system and control are required to overcome this problem. The research aims to design a monitor EC values system for nutrient solutions in the tank by automatically controlling water and fertilizer without human interference. The proposed system will allow users to monitor and control the EC value of nutrient solutions in the nutrient solution tank.

2. PROTOTYPE DEVELOPMENT

2.1 Hardware development

Figure 1 shows an overall hardware assembly of the monitoring and control system of the EC value in the hydroponic system. The assembly consists of three 3.5" diameter growing pipes, a 79-liters nutrient solution tank, two 5-liters fertilizer containers, a submersible pump, an Arduino Uno microcontroller, a data logger shield, three solenoid valves, three flow meters, a water level sensor, a temperature probe sensor, an analog EC probe sensor, eight relays, an LCD, a keypad, and a 12 V power distribution system. The nutrient solution tank is the main tank in the system that supplies a mixture of water and fertilizer to the vegetables. Two fertilizer tanks were used to store type A and type B fertilizer. Three flowmeters, three solenoid valves, and a water level sensor were used to control water and fertilizer based on the EC input value. Finally, a submersible pump transfers the nutrient solution from the tank and channel it to the growing pipe.

Figure 1 Overall hardware and control system assembly of monitoring and control system of the EC value in the hydroponic system.
2.2 Control system development

The overall system flow chart for the proposed system is illustrated in Figure 2. The system contains three sensors: an analog DFR0300 EC sensor probe, DS18B120 waterproof temperature sensor probe, and water level sensor. An EC analog probe was used to compute nutrients in the nutrient solution. The temperature sensor is needed to measure the nutrient solution's temperature since the nutrient solution's EC value is highly dependent on the temperature. The system will continuously monitor the EC value of the nutrient solution in the tank.

![Figure 2 Flowchart of the EC value monitoring system.](image)

3. RESULTS AND DISCUSSION

In this project, the prototype is tested using a lettuce plant. Ten seedlings of the lettuce will be prepared by planted the seeds at the growing pipes. As shown in Table 1, the EC values were set based on the recommended growing condition for the lettuce plant in the hydroponic system. The real-time EC value of the nutrient solution was recorded through a data logger with an interval of 1 hour until the seven days. Figure 3 shows the EC values of real-time nutrient solutions for seven days. At the beginning of prototype testing, the EC value was approximately 1230 μS/cm. The conductivity of the nutrient solution decreased slowly until the beginning of the second day.

Then, the reduction of EC occurs rapidly until it reaches the minimum threshold value, $EC_{\text{min}}$, at 3.5 days. At this point, the EC value increased sharply to 1240 μS/cm. This is due to the control system has activated the solenoid valves on fertilizer A and B. The control system also ensures that the value of the nutrient solution does not exceed the maximum threshold, $EC_{\text{max}}$ at 1250 μS/cm. At 3.5 days, the EC decreased gradually for the second time until reaching $EC_{\text{min}}$ at 6.5 days. Then, the system again increased the EC level in solution to 1210 μS/cm. As observed, there was a decrease in EC levels in the second cycle. This may be due to the fertilizer level in the stock tank decreasing after the system is active for the first time. As a result, the pressure in the stock tank decreases and causes the amount of incoming stock to decrease. If this process is continued after seven days, it is predicted that the system will undergo the same process until all the fertilizer in the tank is depleted.

![Figure 3 EC evolution of nutrient solution in the tank for seven days.](image)

<table>
<thead>
<tr>
<th>Minimum Threshold EC Value, $EC_{\text{min}}$ (μS/cm)</th>
<th>Target EC Value (μS/cm) $EC_{\text{set}}$ (μS/cm)</th>
<th>Maximum Threshold EC Value, $EC_{\text{max}}$ (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1150</td>
<td>1200</td>
<td>1250</td>
</tr>
</tbody>
</table>

Table 1 Target and threshold EC values for growing lettuce.

4. CONCLUSION

As for the conclusion, the prototype design managed to control the EC value of the nutrient solution in the tank within the threshold values. The system actuated the solenoid valves at fertilizer A and fertilizer B if the EC value was below $EC_{\text{min}}$.

ACKNOWLEDGMENT

This project is funded by Internal Grant Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang.

REFERENCES
