THE EFFECTS OF DIFFERENT NUTRIENT SOLUTIONS ON THE GROWTH OF BASIL (*Ocimum basilicum* L.) CULTIVATED UNDER THE CONDITIONS OF GREEN HOUSES

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SUMMARY

Hydroponics cultivation has been more and more dominant as the modernization tendency nowadays. However, this method strictly requires precise preparations in making nutrient solutions, which are suitable for corresponding type of plants. Apprehending the fact that Basil is a kind of herb that is capable of creating many benefits for food and medical field, the study team has conducted this project in order to determine the most suitable nutrient solutions for the growth of Basil cultivated in hydroponics. The project is designed with 3 platforms representing 3 nutrient formulas (CT1, CT2, CT3). TDS (Total Dissolved Solutes) and pH are monitored and maintained daily over 3 nutrient types. Simultaneously, criteria, which are harvesting times, heights, weights, and lengths of root, are also recorded and analyzed. About the results of the research, formula CT3 is concluded as the most suitable nutrient type for Basil. This conclusion was demonstrated via that the harvesting times of CT3 are all shorter than the times of the other 2 formulas harvests with the time of each harvest ranging from 10 – 15 days. The average height of CT3's plants reaches the highest, 40 cm. Whereas, the average height of CT2's is 39 cm and CT1's is 34 cm. Likewise, the weights of CT3's harvests reach more than 1000 gram in 4 out of 8 harvests. Not a single time of harvests of CT1 and CT2 reaches 1000 gram. Similarly, the lengths of roots of CT3's plants are greater than the other two formulas' lengths in 8 monitored times.

Keywords: Hydroponic, NFT, nutrient film technique, nutrient solution, *Ocimum basilicum* L..

1. INTRODUCTION

Hydroponics is the cultivation in aqueous solutions without using soils. In this cultivation method, the nutrition for plants of this technique is provided via nutrient solutions (Lee et al., 2010). Effect of silicon on growth and salinity stress of soybean plant grown under hydroponic system. This is a new technique that offers a desirable efficiency and is recently proved to be suitable for urban areas. It not only solves the issue of lacking greenfield land but also contributes to satisfying the demand for food which is gradually increasing. Moreover, hydroponic cultivation is implemented on automatic systems that have no requirement of pesticides (Savvas, 2003). That is why hydroponic is capable to offer a considerable effectiveness in terms of conserving natural resources, labor forces, and time for utilizers. Simultaneously, it still can provide vegetables with good qualities and hygienic standards that surpass the recent evaluation. Besides, with this modern technique, it is possible for farmers to cultivate consistently all year round (even under unseasonable circumstances) and to increase the number of cultivating periods (Savvas, 2003). However, phytoextraction of cadmium by Ipomoea Aquatica (water spinach) in hydroponic solution: effects of cadmium speciation with each type of vegetable comes a distinct demand for nutrition (Wang et al., 2008). This fact leads to the necessities of studies on nutrient solutions for clarification and classification.

The importance of fresh vegetables is undeniable. Nevertheless, this study aims only for the growth of Water Basil (*Ocimum basilicum* L.). Water Basil is a type of herb that can be cultivated perennially, which plays an important role in terms of commercials. (Roosta, 2014). Comparison of the vegetative growth, eco-physiological characteristics, and mineral nutrient content of basil plants in different irrigation ratios of hydroponic. Uptake and partitioning of selenium in basil (*Ocimum basilicum* L.) plants grown in hydroponics Both fresh leaves and dried leaves are used for culinary purposes (Chalchat and Ozcan, 2008). Water Basil is considered an herb owing to its diuretic capabilities. This type of vegetable is cultivated commonly in Vietnam because it fits the general taste and food cultures in the country. The reasons above with the fact that greenfield land areas are reducing assert that applying Water Basil in hydroponics is needed for the future paths of Water Basil cultivation. However, there haven't been any specific studies on the effects of various nutrient solutions on the efficiency of Water Basil. That is the reason why the research group is executing this study to determine the nutrient type that best fits the growth and maturation of Water Basil cultivated in circulating hydroponic systems.

2. RESEARCH METHODOLOGY

2.1. Materials and the studying scale

Experiments of Water Basil (*Ocimum basilicum* L.) cultivation are implemented under the conditions of a net house located at the high-tech agricultural greenhouse site, Thai Nguyen University of Agriculture and Forestry (TUAF – coordinate: 21°35'37"N; 105°48'32"E). The studying period lasted 6 months from January to June 2019. Water Basil breeds are collected from a local seed store and sowed in the net house at the TUAF. The growth, productivity, plant qualities, and supplied nutrients are recorded frequently.

2.1.1. Materials

- A circulating hydroponic system (based on Nutrient Film Technique – NFT):

This system includes plastic pipes (supplying – draining pipes) with a diameter of 90 mm and a length of 4 m. The pipes are arranged on an iron frame that is 60 cm high. The pipes are chiseled with 5 cm diameter holes that are 17 cm apart from each other for placing tree baskets. On the frame, pipes are arranged with 10 – 12 cm spacing between every 2 pipes. The frame is designed with a 1^0 slope compared to the ground. At the heads of the pipes, there is a system pumping nutrient that is controlled in respect of doses and speed by an adjustable lock. Nutrient solutions are contained within a plastic tank that is placed 0.7 m higher than the nutrient driving pipe. This design allows a consistent closed circulation for the hydroponics system. (Pattillo, 2017).

***- Substrate and plastic basket*:**

Substrate: A substrate is blended following a ratio containing 30% alluvial soil that is processed for anti-pathogens before being ground added 30% manure composted by biological products and 40% coconut fiber. Substrates exist in a floury form that is deeply brownish and porous.

Plastic basket: A plastic basket is made of regular plastic. It is cup-shaped and 5 cm high. Its head is wider than its bottom with a diameter of 5 cm. Whereas, its bottom has a 4 cm diameter and is chiseled with a hole for the roots to pierce outward.

- Nutrient solution:

The experiment applied 2 nutrient solutions including one from Thai Nguyen University of Agriculture and Forestry (TUAF) and another from the Gia Vien Hydroponics solution company.

The nutrient solution of TUAF (Solution 1) includes:

+ Solution A: Potassium Nitrate (KNO_3), Calcium Nitrate $Ca(NO_3)_2$, Manganese (II) Chloride ($MnCl_2$).

+ Solution B: Mono-potassium phosphate (KH_2PO_4), Potassium Nitrate (KNO_3), Boric Acid H_3BO_3, Zinc Sulfate ($ZnSO_4$), Copper Sulfate ($CuSO_4$), Ferric EDTA (Fe EDTA).

The nutrient solution of Gia Vien Company (Solution 2) includes:

Solution A: Nitro Nitrate (NO_3- N), Calcium (Ca), Zinc Oxide (ZnO_2), Ferric EDTA (Fe EDTA).

Solution B: Phosphorus Pentoxide (P_2O_5), Zinc Oxide (ZnO_2), Nitro Nitrate (NO_3- N), Sulfur (S), Magnesium (Mg), Manganese (Mn), Boron (B), Copper (Cu), Zinc (Zn), Molybdenum (Mo).

3 formulas were applied for the experiment. The compositions of those formulas are:

* Formula CT1: 100% Solution 1;

* Formula CT2: 30% Solution 1 + 70% Solution 2;

* Formula CT3: 30% Solution 2 + 70% Solution 1.

The formulas have been conducted in order to justify the hydroponic solutions of Hoagland that we have applied for off-season water spinach (Quang N., 2019).

2.1.2. Studying scale

The study focuses on the effects of 3 different nutrient formulas on the growth and maturation of Water Basil cultivated under the climate condition of northern Vietnam.

2.2. Methodology

2.2.1. Study method

Seedlings germinate in seeding trays. After the sprouting of 2 – 3 leaves, the plants are inserted in a circulating hydroponics system with a density of 5 Water Basil plants/506.25 cm^2 (100 plants/m^2).

A 2-factor experiment is arranged in a completely random design with 3 replications for 3 used formulas: Formula CT1; Formula CT2; and Formula CT3. Cultivation parameters are set and monitored daily or regularly following a schedule. Result comparisons are carried out after synthesizing data and statistics via graphs for conclusions.

2.2.2. Monitored parameters

- TDS (Total Dissolved Solids);
- pH: Daily monitored;
- Some growth characteristics as height (cm), weight (g/plant), and root length which were recorded every 5 days.

2.2.3. Data analysis method

- Data is collected and typed on Excel to be processed and afterward analyzed by the SPSS 2.0 software (Wahyono, 2012).

3. RESULTS

3.1. The effect of different nutrient solutions on the adjustment ability of pH and TDS

3.1.1. Alterations of pH values of the 3 nutrient formulas

Table 1. Statistics of oscillation frequencies of pH degrees in 180 experimental days (Frequency dimension: day)

No.	pH value	CT1 (day)	CT2 (day)	CT3 (day)
1	4	60	10	23
2	5	43	70	75
3	6	30	79	52
4	7	47	21	30

Table 1 demonstrates oscillation frequencies of pH degrees of each formula. Each type of cultivated plant has a corresponding prioritized pH range. If the pH value of a solution does not lie in the optimal limit of plants, the productivity of those plants will be degraded significantly (James, 1946). An acidic environment may cause serious symptoms to trees such as an excess of Aluminum (Al), hydrogen (H), and hazardous Manganese (Mn), while a shortage of essential nutrients like Calcium (Ca) and Magnesium (Mg) occurs. On the contrary, in an alkaline environment, nutrient solutions may encounter a phenomenon of Molybdenum (Mo) increasing. Whereas, the contents of Phosphorus (P), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), and Cobalt (Co) reduce, leading to negative influences on the growth of cultivated plants (C.Dakshinamurti, 1964).

Substrates also play a vital role in pH evaluation. The usage of natural substrates that are not yet processed to create the chemical inertia leads to the retaining of organic factors. These factors cause instability in maintaining optimal pH levels. As a result, regular inspections and adjustments are required (Rubiat Islam, 2017).

According to Table 1, CT2 and CT3 have pH values oscillating the most in the range from 5.0 – 6.9. This range is considered as an appropriate level for the optimized growth of plants. In CT1, pH values focus on 4 and 7, which are the exorbitant level of acidity and alkalinity for the growth of Water Basil. Consequently, the productivity results of CT1 are lower than the results obtained from the two other formulas.

3.1.2. The alteration of TDS values of the 3 nutrient formulas

Table 2. Statistics of oscillation frequencies of TDS values in 180 experimental days (Frequency dimension: day)

No.	TDS values	CT1 (day)	CT2 (day)	CT3 (day)
1	600	15	7	10
2	700	15	30	35
3	800	21	20	45
4	900	22	35	50
5	1000	10	40	20
6	1100	40	30	10
7	1200	27	7	5
8	1300	30	11	5

Like pH, TDS (Total Dissolved Solids) is a parameter that needs to be set at an allowed level for plants to grow. Simultaneously, it needs to be maintained within an optimal limit so that plants will provide the highest productivity. If TDS values are excessive (>1200 ppm), it will be difficult for plants to absorb microelements, which leads to an excess or a lack in terms of nutrition (Rubiat Islam, 2017). However, TDS adjustment processes occasionally require flexibility depending on cultivation times, particularly in the winter. The reason is indicated that during the winter, cold weather results in the degradation of nutrient absorption and water excretion of trees compared to the summer. Especially, the effects of coldness are amplified while hydroponics cultivated trees on only water. As a result, TDS values need to be set on a high level but still in the allowance of trees to facilitate the absorption of nutrients. Additionally, there is one more reason explaining the dependence of TDS and pH on the average amount of water of a solution. The solution contained in a drained tank because of the plants absorbing water would encounter the phenomenon of pH and TDS increasing inherent in the decrease of water.

Table 2 shows the oscillation amplitudes of TDS values of CT2 and CT3, which focus the most on the range of 700 – 1100 ppm. It can explain why plants of these 2 formulas grow better than the trees of CT1 do as the TDS value of CT1 is virtually maintained within the range from 1100 – 1300 ppm.

3.2. Time of each growing period of Water Basil

Table 3. Time of each growing period of *Ocimum basilicum* L. of the 3 nutrient solutions

Formula	Root sprouting	Time counted from seeding (days)								
		Installment	Harvest time							
		on the hydroponic system	First harvest	Second harvest	Third harvest	Forth harvest	Fifth harvest	Sixth harvest	Seventh harvest	Eighth harvest
CT1	5	15	30	20	20	15	20	15	20	20
CT2	5	15	30	15	10	15	10	15	15	15
CT3	5	15	30	10	15	10	10	15	15	10

From the achieved results, it is clear that in the 3 different solutions, the time for root sprouting was identical (5 days) and on the 15th day, all plants is mature enough to be installed on a circulating hydroponic system in a net house. Since the installment, plants of all formulas will be harvested after every 10, 15, or 20 days. Table 3 shows that Water Basil individuals exhibit different speeds as well as distinct periods of growth in each different formula. It can show the results in some early harvest times of CT3. In general, CT3 is the formula that provides the best growth periods because the time gaps among harvests are short (10 – 15 days). The formula that provides the most stable and equal growth periods of Water Basil is CT2 with 5 harvests every 15 days. CT1 is the most fluctuating formula with reported growth periods prolonged within 15 – 20 days.

3.3. The effect of different nutrient solutions on Water Basil

3.3.1. Heights of plants

Table 4. Average height (cm) of basil samples before harvesting in each formula

Formula	Average height (cm)							
	Harvest time							
	First harvest	Second harvest	Third harvest	Forth harvest	Fifth harvest	Sixth harvest	Seventh harvest	Eighth harvest
CT1	24	25	27	30	34	35	34	34
CT2	23	25	29	33	37	40	37	39
CT3	23	26	28	34	37,5	41	42	40

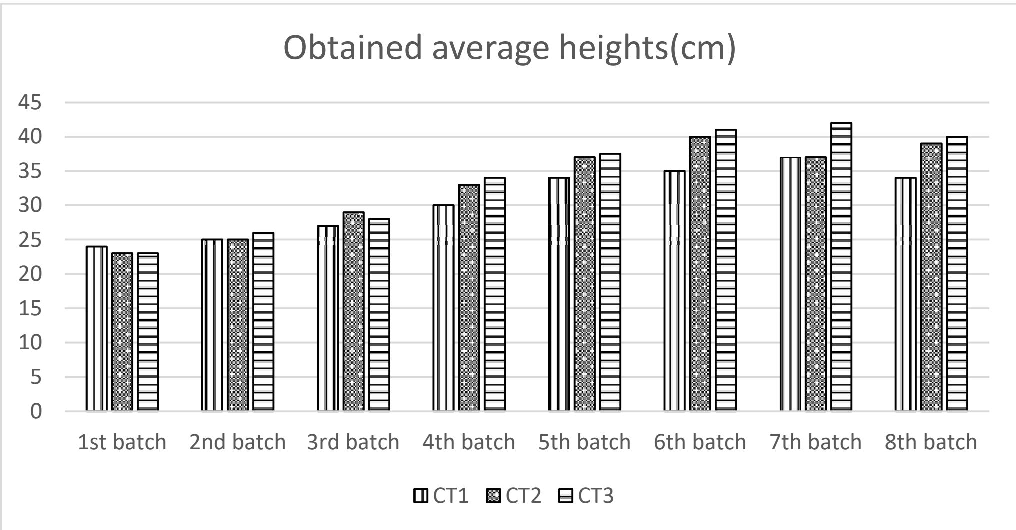

Figure 5. Average heights of *Ocimum basilicum* L. before harvesting in 3 testified nutrient solutions

The 3 different nutrient solutions caused the influences corresponding to each type to have certain statistic meanings to the heights of Water Basil. From table 4, the heights of Water Basil of CT1 are the lowest among the achieved data of the 3 formulas, even though at first, the heights of CT1 individuals are higher than the other formulas' plants. For CT2 and CT3, the highest plants are 40 cm and 42 cm respectively. This is also a special statistic meaning while the highest plant of CT1 is also 35 cm. In the 7th harvest, plants of CT1 and CT3 appeared to decrease in terms of height. However, the odds among heights of CT3 are insignificant compared to the initial heights (< 2 cm). Whereas, the disparity of CT1 reaches 3 cm, which corresponds to 80% of the height of the tallest plant of CT1. CT3 also possessed ideal heights of plants, which means that the productivity is higher and the harvest speed is shorter. Through 8 harvests, the average height of CT3 is 40 cm, CT2 is 39 cm, while CT1 only has an average height of 34 cm.

3.3.2. Root lengths

Table 6. Average root lengths of *Ocimum basilicum* L. before each harvest time of the 3 nutrient solutions

Formula	Average root length (cm)							
	Harvest time							
	First harvest	Sevond harvest	Third harvest	Forth harvest	Fifth harvest	Sixth harvest	Seventth harvest	Eight harvest
CT1	4	5	6	10	12	15	18	19
CT2	4	6	8	12	15	17	21	22
CT3	6	7	9	12	16	19	23	25

	CT1	*CT2*	*CT3*
Mean	11.125	13.125	14.625
Standard Error	2.07396704	2.39372319	2.57000208
Median	11	13.5	14
Standard Deviation	5.86606463	6.7704716	7.26906361
Sample Variance	34.4107143	45.8392857	52.8392857
Confidence Level (95.0%)	4.90415276	5.66025591	6.07708926
Range	15	18	19

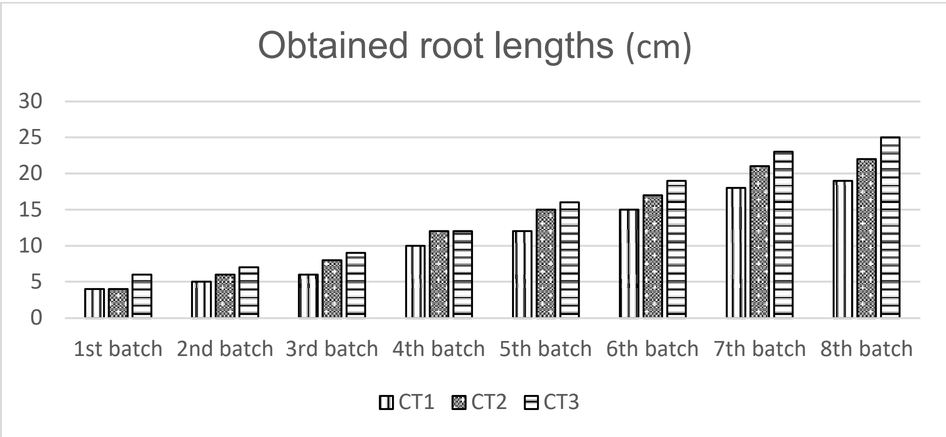

Figure 7. Average root lengths of *Ocimum basilicum* L. before each harvest of the 3 nutrient solutions

Root length is one of the expressions representing the absorption capacity of water and minerals of plants. The longer and firmer the root is, the better the plant grows. Table 6. indicated that the roots of CT3's plants are longer than the roots of CT2's and CT1's. In 180 days of experiments, plants of CT3 had roots that increased 15 – 20 cm. The growth periods of CT3's roots are also different. It was recorded that CT3 obtained the fastest speed of root sprouting. It proves that CT3 reported the highest vitality rate which has roots qualified for the most vigorous growth of Water Basil.

3.3.3. Productivity of Ocimum basilicum L. in the 3 different formulas

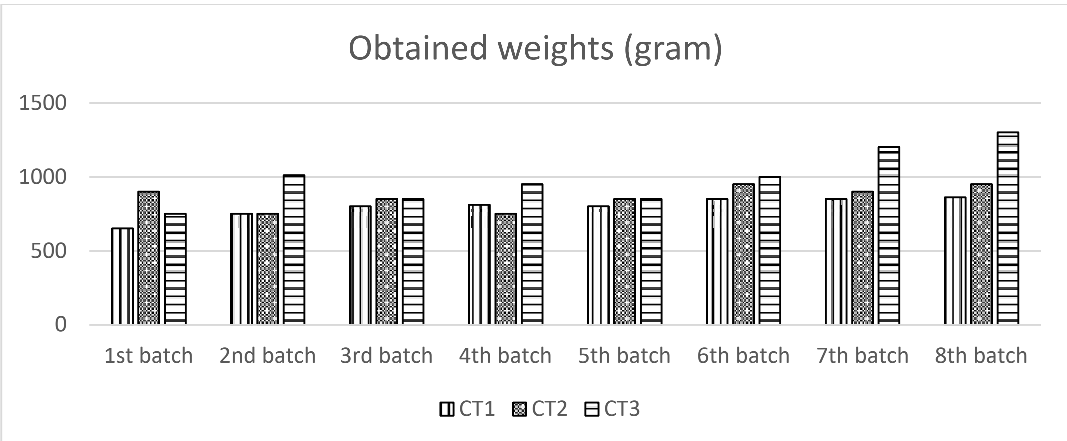

Figure 8. Weights of *Ocimum basilicum* L. plants of the 3 nutrient solutions through 8 harvests

Table 3, 4, and 6 show the harvest time, heights of plants, root lengths serializing from the lowest to the highest with an order of CT1, CT2, and CT3. Therefore, it is possible to conclude that the seedling and spouting time would be in the same order. The monitored productivity results of Figure 8 show that: Formula CT3 provides the highest productivity of experimental Water Basil with the most productive class reaching over 1300 grams during harvesting. This number is a huge statistic meaning and it is higher than the other 2 formulas' numbers. It is perceptible that the frequency of productivity exceeding 1000 grams of CT3 is very high with 4 over 8 times of harvesting. Whereas, the weights harvested of the 2 other formulas rarely reached over 1000 grams.

Unlike heights and root lengths, the productivity weights of CT1 and CT2's plants are not distinct from each other even though the initial disparity in terms of harvested weights of the two formulas was remarkable.

4. DISCUSSION

Hoagland's hydroponic solution is well-known for the vegetable cultivation especially leafy, however, the result of this study also showed the strong growth of roots thanks to the nutrient supply. It is highly recommended to further studies about the impacts of Hoagland's solution on the tubers. Due to the limited of technical properties, the research group has not studied the optimal concentration of the solution. Therefore, it is nescessary to research the influence of the solution concentration to avoid scarcity of nutrient and surplus supply.

5. CONCLUSION

Water Basil is a type of herb that can considerably apply to hydroponic cultivations. Along with previous studies, the results and data obtained from this study indicate that hydroponic Water Basil requires certain components of nutrition in order to create and maintain the most appropriate conditions for cultivation (exhibited via pH and TDS measurements). Particularly, the most suitable pH level is in the range from 5.0 – 6.9. The proper TDS level ranges from 700 – 1100 ppm. With regards to nutrient solutions, it is clear that nutrient formula CT3 was the best fitting for the growth of Water Basil in the conditions of hydroponic cultivation. Throw out the performance of asserted harvest batches, CT3's plants were always harvested earlier than the harvests of the other two formulas with 10 – 15 days apart between every 2 classes. The growing period of basil in CT3 was considerably more rapid than the harvest times of the other two formulas. Besides, other contributors like heights, weights, and root lengths of CT3 were achieved as the highest numbers. More specifically, the average height through 8 harvests of CT3's Water Basil reached 40 cm higher 1 to 6 cm than CT2 and CT1, respectively. The average weight of CT3's was also superior with 4 over 8 harvesting times exceeding 1000 grams of Water Basil. 8 harvests of the other two formulas rarely recorded 1000 grams. The root lengths of CT3's plants were also higher than CT1 and CT2's in all 8 harvests (exceptionally, the 4th harvest observed a root length of CT3 that was equal to CT2's).

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LOẠI DUNG DỊCH DINH DƯỠNG KHÁC NHAU ẢNH HƯỞNG TỚI SINH TRƯỞNG, PHÁT TRIỂN CỦA CÂY RAU HÚNG QUẾ (*Ocimum basilicum* L.) BẰNG PHƯƠNG PHÁP THỦY CANH TRONG ĐIỀU KIỆN NHÀ MÀNG

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TÓM TẮT

Phương pháp canh tác thủy canh đang ngày càng có ưu thế dựa trên xu hướng hiện đại thời nay. Tuy nhiên, phương pháp này đòi hỏi khâu chuẩn bị dung dịch dinh dưỡng sao cho phù hợp với từng loại cây trồng. Nắm bắt được đặc tính của cây Húng quế đang là một loại rau thơm nhiều lợi ích trong ngành thực phẩm và y dược, nhóm nghiên cứu đã thực hiện dự án này nhằm xác định loại dung dịch dinh dưỡng phù hợp nhất cho sinh trưởng của loại cây này trong canh tác thủy canh. Dự án có các thí nghiệm được thiết kế thành 3 giàn trồng cây tương ứng với 3 công thức dinh dưỡng khác nhau (CT1, CT2, CT3) trên mỗi công thức bố trí 3 lần lặp lại. TDS (Tổng lượng chất tan) và pH sẽ được theo dõi và duy trì hàng ngày trên 3 loại dung dịch. Đồng thời, các chỉ tiêu như thời gian thu hoạch, chiều cao cây, khối lượng cây, và chiều dài rễ sẽ được ghi lại và thống kê. Về kết quả của nghiên cứu, công thức dinh dưỡng CT3 (70% Solution A + 30% Solution B, *Nutrient solutions, Materials*) được kết luận là công thức tốt nhất dành cho cây Húng quế. Điều này được chứng minh khi thời gian thu hoạch của CT 3 ngắn hơn 2 công thức còn lại với chỉ khoảng 10 – 15 ngày một lần thu. Chiều cao trung bình của cây trồng trên CT 3 đạt giá trị cao nhất với 40 cm, khi mà CT2 đạt 39 cm và CT1 chỉ thu được 34 cm. 4 lần trên tổng 8 lần thu Húng quế của CT3 đạt sản lượng lớn hơn 1000 gram trong khi 2 công thức còn lại chưa từng thu được một lần lớn hơn 1000 gram. Tương tự, chiều dài rễ cây của các cây CT3 đều lớn hơn 2 công thức còn lại trong 8 lần theo dõi.

Từ khóa: Dung dịch dinh dưỡng, hệ thống tuần hoàn, Húng quế, thủy canh.

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