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THE EFFECTS OF DIFFERENT NUTRIENT TYPES ON THE PRODUCTIVITY OF OFF-SEASON WATER SPINACH IN HYDROPONICS

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ABSTRACT

Nowadays, hydroponic models have been widely applied in Vietnamese cultivation. Hydroponics is a very modern method that promises to make a lot of valuable contributions to the agriculture of Vietnam. The experiment was conducted in October – December 2018 at the greenhouse - High-tech agriculture area of Thai Nguyen University of Agriculture and Forestry (TUAF), aimed to acknowledge the influences of different nutrient hydroponic solutions on the survival and the growth of Ipomoea aquatica planted by the hydroponic method. The experimental models are commenced with 3 formulas and three replications for the data of water. (including *pH* and *TDS – Total Dissolved Solids*) as well as the nutrient solutions in order to determine effects on the efficiency of cultivated vegetables (specifically on the speed of breeding leaf, growing root, and the harvesting productivity). Experimental trees are planted on 3 hydroponic frames. Each frame circulates with a corresponding formula of nutrient. The first formula is the orginal sample in order for comparisons with other formulas. Through the analysis below, it is possible to comprehend that the third nutrient formula is the most effective one in height growth, productivity, and the speed of breeding leaf. Specifically, the heights of trees in the 3 harvested classes, which are respectively 30 cm, 32 cm and 31 cm, are all higher than the compared classes of other 2 formulas. Similarly, the weights measured of trees of the 3rd formula are also the highest numbers which are respectively 950 gram, 760 gram, and 970 gram for the 3 harvested classes.

Keyword: *NFT (Nutrient Film Technique), Hydroponics, water spinach, nutrient solutions*

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LOẠI DINH DƯỠNG KHÁC NHAU VÀ NHỮNG ẢNH HƯỞNG TỚI NĂNG SUẤT CỦA CÂY RAU MUỐNG TRÁI VỤ (*IPOMOEAN AQUATICA*) BẰNG PHƯƠNG PHÁP THỦY CANH

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TÓM TẮT

Ngày nay, mô hình thủy canh đã được áp dụng rộng rãi trong canh tác ở Việt Nam. Thủy canh là một phương pháp rất hiện đại hứa hẹn sẽ có nhiều đóng góp quý giá cho nền nông nghiệp Việt Nam. Thí nghiệm được thực hiện vào tháng 10 - 12 năm 2018 tại nhà kính - Khu nông nghiệp công nghệ cao của Đại học Nông lâm Thái Nguyên (TUAF), nhằm mục đích thừa nhận những ảnh hưởng của các giải pháp thủy canh dinh dưỡng khác nhau đối với sự sống và sự phát triển của cây rau muống bằng phương pháp thủy canh. Các mô hình thử nghiệm được bắt đầu với 3 công thức và ba lần lặp lại cho dữ liệu của nước. (bao gồm pH và TDS - Tổng chất rắn hòa tan) cũng như các giải pháp dinh dưỡng để xác định ảnh hưởng đến hiệu quả của rau được trồng (cụ thể là tốc độ của lá giống, rễ phát triển và năng suất thu hoạch). Cây thí nghiệm được trồng trên 3 khung thủy canh. Mỗi khung lưu thông với một công thức dinh dưỡng tương ứng. Công thức đầu tiên được lựa chọn là công thức đối chứng. Thông qua phân tích dưới đây, có thể hiểu rằng công thức dinh dưỡng thứ ba là công thức hiệu quả nhất trong tăng trưởng chiều cao, năng suất và tốc độ của lá giống. Cụ thể, chiều cao của cây trong 3 lớp thu hoạch, tương ứng là 30 cm, 32 cm và 31 cm, đều cao hơn so với các lớp so sánh của 2 công thức khác. Tương tự, trọng lượng đo của cây theo công thức thứ 3 cũng là những con số cao nhất tương ứng là 950 gram, 760 gram và 970 gram cho 3 lần thu hoạch.

Từ khóa: *Hệ thống NFT, Thủy canh, Rau muống, Dung dịch dinh dưỡng*

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1. Introduction

It is well known that the population of the world is constantly increasing every day. As a result, the increase in requirements for food, including fresh vegetables, occurs respectively [1]. Vegetables are not only one of the essential daily food but also the wealthy resources supplying a huge amount of vitamins, microelements, and macroelements. Additionally, vegetables are the cultivated plant that is highly profitable via both domestic business and exporting activities of many countries. Vegetables are also very diverse in kinds such as fruit vegetables, tuber vegetables, etc [2].

Water spinach originates in tropical Asia, particularly in the Southern and South-eastern Asia, tropical Africa, Middle Asia, South America, and Australia. The root of this vegetable is eyed root, hollow and thick body. Farming water spinach has 2 main breeds including the white water spinach and the red water spinach: The white kind is often planted terrestrially on soil furrows without too much water required. The body of this kind is whitely green, small, and weak against floods; The red kind can be cultivated terrestrially and aquatically. It favors the temperature ranging from 20 – 30^{o}C. This kind has big bodies, red and succulent petiole [3].

Water spinach is most cultivated in Vietnam as it suits the taste as well as the gastronomic culture of Vietnamese people. Hydroponic water spinach is planted within roofed greenhouses, in a circulating hydroponic system (nutrient film technique) which ensures not only the synchronization among vegetables but also the economization of both water and human work. Simultaneously, hydroponic systems are completely automatic, the property that helps significantly in saving time. As a result, this method offers many economic benefits for users. Besides, this technique also provides the ability to cultivate water spinach year-round (even under unseasonable conditions), and to increase the cultivating seasons. However, so far, there hasn't been any research specifying the influences of particular nutrient solutions on the productivity of vegetables. Therefore, it is necessary to conduct research in order to determine the most appropriate nutrient solutions for water spinach, creating the most efficient productivity for vegetables in a circulating hydroponic system [4].

2. Materials and methods

2.1. Materials and study scale

Experiments for the research was implemented with the time from October 2018 to December 2018 at the High-tech agriculture area of Thai Nguyen University of Agriculture and Forestry, particularly at the sector of greenhouses which are equipped with ventilation. The rooftop is active automatically which can open and close pursuant to the butterfly wing form in an isolated system from each other. This is usefully convenient for controlling micro climate within the greenhouses and also for maximumly economizing consumed energy.

2.1.1. Materials

- *Breed*: The highly-yielding water spinach breed, which is manufactured at Dai Dia company, located at District 6, Ho Chi Minh City, Vietnam [5].

- *Water spinach:* Water spinach (scientific name is Ipomoea aquatic) is a semi-aquatic tropical vegetable which desires high temperature ranging from 25 to 30^{o}C. It only grows sustainably under sufficiently watered condition. This vegetable can be planted on various soil types: clay, sandy soil, mixed-sandy soil, humid humus or organically fertilized soil with a *pH* degree ranging from 5.3 – 6.0 [3].

Nutrient Film Technique: This system includes plastic pipes (supplying – draining pipes) with 90 mm diameter, 4 m length

which are set on 60m high iron patterns. Plastic pipes are chiseled with 5 cm diameter holes and 17 cm apart from each other in order to install tree baskets inside. The pipes are set with the distance ranging from 10 -12 cm between 2 pipes which incline toward the recipient tank (1^o inclining compared to the ground equilibrium). At the head of each tube, there are systems supplying nutrient solutions which are modified in doses and speed by a control lock. Nutrient solutions are contained in plastic tanks which are set 0.7m higher than the pipes that lead the fluid. The solutions flow through pipes then go into containing tank. And so as the fluid flows in curculation during the whole growth process of trees.

- *Seedling trays*

Plastic or spongy trays with small holes for seeding before installing seedlings into the hydroponic system.

- *Substrate and plastic t*

- Substrate: Substrate is blended with the ratio of 30% disease-processed ground alluvia + 30% organic fertilizer composted by biological products + 40% coconut fibers. This substrate exists in flour form which is deeply brown and soft.

- Plastic basket: Made of regular plastic, a basket has a cup-shape with 5 *cm* height and 4 *cm* diameter brim. The cup is chiseled with a hole at the bottom for root to root to yield.

- *Nutrient solution*

* *Solution 1*: The nutrient solution of Thai Nguyen University of Agriculture and Forestry that includes:

- Solution A: KNO_3, $Ca(NO_3)_2$, $MnCl_2$

- Solution B: KH_2PO_4, KNO_3, H_3BO_3, $ZnSO_4$, $CuSO_4$, Fe(EDTA)

* *Solution 2*: 30% organism no.1 + 70% inorganics, which was researched by authors of TUAF, includes:

- Solution A: 30% organism number 1 made of beer residue

- Solution B: $Ca(NO_3)_2$, MnCl2, KH_2PO_4, KNO_3, H_3BO_3, $ZnSO_4$, $CuSO_4$, Fe(EDTA)

* *Solution 3*: 30% organism no.2 + 70% inorganics which was researched by authors of TUAF, includes:

- Solution A: 30% organism made of soy

- Solution B: $Ca(NO_3)_2$, MnCl2, KH_2PO_4, KNO_3, H_3BO_3, $ZnSO_4$, $CuSO_4$, Fe(EDTA)

- Measuring instruments: pH-meter, TDS-meter, ruler, digital scale.

2.1.2. Study scale

The effects of different nutrient solutions on the productivity of water spinach cultivated by hydroponic methods under Nothern climate and unseasonable cultivating conditions.

2.2. Study methods

The average temperature and the light intensity during experimenting was slightly high (the temperature of October was 30.5^oC, November's was 27.6^oC, and December's was 18.8^oC; the humidity of October, November, and December of 2018 is 80.5, 71, and 60.4% respectively). This means that the climate condition of December went lower than the desired condition for the growth of water spinach ($25 – 30^oC$) while the climate condition was relatively suitable in October and November. The light intensity was weaker compared to summer time's intensity. And the humidity which weas high in November and December are assessed to be inappropriate for water spinach to grow compared to Summer.

- Experiment no.2 is arranged randomly with 3 times repeating for 13 monitored trees of each formula. The 3 nutrient formulas include the 1^{st} nutrient solution (CT1), the 2^{nd} nutrient solution (CT2), and the 3^{rd} nutrient solution (CT3).

- The Formula 1 is the sample used to compare with the other 2.

2.2.1. Experimental design

Experimental trees are planted on a garden-frame. Each garden frame has 8 pipes of NFT.

The NFT of each frame circulates with a corresponding formula.

The tank of nutrient solution of is under the corresponding frame.

2.2.2. Data Collection

- 13 trees of each formula will be selected in order to measure and monitored the desired criteria. The repetitions are selected in a completely random way.

- *TDS, pH*: Daily monitored

- *Other criteria*: 5 times per day periodically monitoring height (cm), number of leaves on main body (leaves), mass (*gram*/trees); realistic harvested productivity (ton/1000 m^2), commercial productivity (ton/1000 m^2), dried substance (%), color of body, toughness of vegetable (N/cm)

- Height is measured traditionally by a 50-cm ruler. Weight is measured by a digital scale. Other criteria will be evaluated via supervision and algorithms of the corresponding criteria.

*2.2.3. Method of data analysis***:**

- The data will be collected and typed into Excel in order to process and afterward analyze by the software SPSS 2.0.

3. Results and Discussion

3.1. Different nutrients influence differently on the ability to alter pH within the pipe of water spinach

According to the **table 1**, the fluctuation of *pH* degree among 3 formulas has been demonstrated. Each type of vegetable or tree has a certain range of appropriate pH degree. The *pH* degree of each formula if it is not in the range will affect the ability to absorb necessary factors for the growth of plants. Cultivating vegetables or trees in environments with high acidity migh cause simptoms like: excess of Alluminum (Al), Hydrogene (G), toxical Manganese (Mn). The lack of essential nutrients such as Calcium (Ca) and Magnesium (Mg) migh also occur due to living in acidic environment [6].

On the other hand, in an alkaline environment, the increasing Molybdenum (Mo) *pH*enomenon can likely appear in the nutrient solutions. Meanwhile, the concentrations of *PH*os*pH*orus (P), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), and Cobalt (Co) decrease, which lead to a lot of negative effect on plants [6].

Besides, *pH* of nutrient solutions is also dependent on the substrate of vegetables. Processing substrates properly in order to chemically improve the inertness is necessary before utilizing. Consequently, the longer substrates are used, the more organic factors remaining will there be. That also means more modifications will be required in order to apprehend desired *pH* degrees.

Those above were the reason causing the fluctuation of *pH* in the experiments. As demonstrated in the **table 1**, the average value of each experiment is the suitable one for water spinach planted by hydroponic method. Respectively, they are 4.6 ± 0.819, 4.79 ± 0.994, 4.73 ± 1.043. The highest value, which is 7 ± 1.043 is of the 3rd formula, and the lowest value, which is 4 ± 0.819, is of the 1st formula. The conducted experiments resulted in the declaration of appropriate *pH* range for water spinach, which is from 4.5 – 5.5. Within this range, roots will be able to well grow without catching undesired phenomena like lack of microelements. The height growth will be positively stable and the result will be efficient. Whereas, if the *pH* degree is higher than 6.5, the growth of water spinach will be depleted with yellowing phenomenon occurring due to the inability to absorb microelements [7].

Table 1. *Statistics of pH value of formulas (p < 0.05)*

No.	Formula name	Monitored number	Maximum value	Minimum value	Average value
1	CT1	62	7 ± 0.819	4 ± 0.819	4.60 ± 0.819
2	CT2	62	7 ± 0.994	4 ± 0.994	4.79 ± 0.994
3	CT3	62	7 ± 1.043	4 ± 1.043	4.73 ± 1.043
4	CV %	62	2.856	2.856	2.856

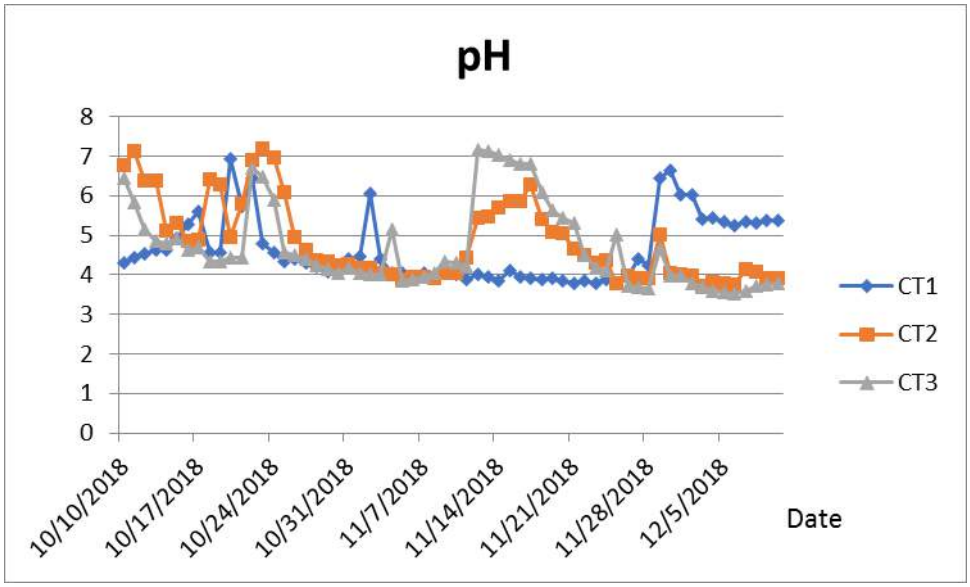

Figure 1. *Graphs that indicate the fluctuation of pH degree among the 3 formulas*

The **figure 1** shows that although the research didn't take longer than 60 days, the *pH* degree of all 3 formulas was most maintained within the range from 4 – 4.9, particularly in 37 days; the next range is from 5 – 5.9 and the least used range is from 6 – 7. According to the results of experiments, the growth would be depleted because of the yellowing phenomenon if the *pH* degree exceeded 6.5, which led to the inability to absorb microelements [6] [7].

3.2. Different nutrients influence the ability to change TDS within solution tanks

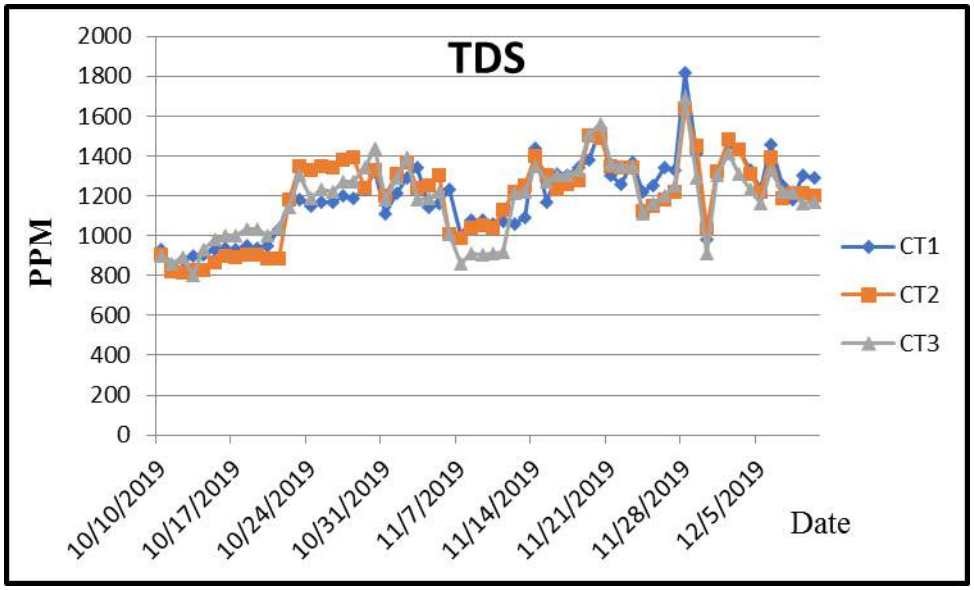

Figure 2. *The diagram of nutrient concentrations of each formula*

Via the analysis of **figure 2**, it is indicated that the nutrient concentration of all experiments were maintained most within 1000 – 1400 ppm. The reason is that in Winter, due to the coldness, the absorbtion as well as the relsease of substances of trees and vegetable are weaker than they are in Summer. More specifically, low temperature makes water cold, which reduces the speed of molecules within fluid. Consequently, it is harder for nutrients and substances to circulate in or

out of trees or vegetables [8]. Therefore, *TDS* should be maintained at high content but still in the reasonable range allowed by the requirements of water spinach in order to facilitate the absorbtion of vegetables. Additionally, as *pH* and *TDS* are dependent on the content of water, the decrease of water amount within containing tanks through time and the absorbtion of trees will also lead to the increase of these 2 criteria.

Table 2. *Summarized table indicating the values of nutrient content (p < 0.05)*

No.	Formula name	Monitored number	Maximum value (*ppm*)	Minimum value (*ppm*)	Average value (*ppm*)
1	CT1	62	851 ± 0.875	1820 ± 0.924	1190 ± 0.213
2	CT2	62	813 ± 0.785	1640 ± 0.796	1192 ± 0.176
3	CT3	62	801 ± 0.404	1690 ± 0.524	1178 ± 0.394
4	CV %	62	1.67	0.89	1.35

This table summarizes the data of the 3 previous grapH in order to indicate more clearly the that the nutrient contents are respectively 1190 ppm, 1192 ppm, 1178 ppm which were maintained during the whole experimental process. The lowest level of TDS of the 3 formula were respectively 851 ppm, 813 ppm, 801 ppm and the highest one are respectively 1820 ppm, 1640 ppm, and 1690 ppm for all 62 monitored samples. From that, it is perceptible that the TDS level of the 3 formulas are unconsiderably different during experimenting. Explaining for this, it is in order to maintain the nutrients of the 3 formulas in the most similar content for conveniences and accuracy in comparisons by statistic softwares.

3.3. Time of each growth period of each water spinach breed, planted by circulating hydroponic technique

Table 3. *Time of each growth period of each water spinach breed planted unseasonably by circulating hydroponic technique*

No.	Formula name	Time counted from planting to: … (days)				
		Growing roots	Bringing into hydroponic system	Harvesting the first class	Harvesting the second class	Harvesting the third class
1	CT1	3	9	20	15	20
2	CT2	3	9	20	15	20
3	CT3	3	9	20	15	20

The experimental results of table 3 indicate that: in different nutrient formulas, the first class is harvestable after 20 days since bringing into hydroponic system. Each following class can be harvested after 15 – 20 days. The growing speed in 3 formulas are almost identical

3.4. The heigh of unseasonable water spinach planted by circulating hydroponic technique

Table 4. *Influences of each nutrient type on the heigh of unseasonable water spinach planted in hydroponic system (cm)*

Formula name	After bringing into the hydroponic solution										
	5 days (1st class) (*cm*)	10 days (1st class) (*cm*)	15 days (1st class) (*cm*)	20 days (1st class) (*cm*)	5 days (2nd class) (*cm*)	10 days (2nd class) (*cm*)	15 days (2nd class) (*cm*)	5 days (3rd class) (*cm*)	10 days (3rd class) (*cm*)	15 days (3rd class) (*cm*)	20 days (3rd class) (*cm*)
CT1	4	14.5	21	27	3.7	14.5	29	12.5	18	20.5	28.7
CT2	5	20.2	25.5	27.5	3.8	20.2	29.7	10.5	18.7	20.5	29
CT3	7	18.2	23	30	3.8	18.2	32	15.3	21.8	23	31

(Notes: the height of experimental water spinach is measured at each 5 days after bringing into the hydroponic system until the havest day of each class)

Planting water spinach in 3 different types of nutrient solutions also leads to distinct influences which are meaningful in measuring the height and the number of leaves of a water spinach. Water spinach samples of formula 3 and formula 2 achieved the greatest height with 30 cm and

27.5 cm respectively. The height of formula one was recorded with only 27 cm. About the number of leaves, the average leaves on a water spinach sample of the 3rd formula is 4.6 leaves/sample. The difference has statistic meaning at level 1% compared to other experiments of the first harvested class.

3.5. The productivity of water spinach of different formulas which was planted unseasonably by the circulating hydroponic technique.

Table 5. *Realistic harvested productivity of water spinach which was planted unseasonably by the circulating hydroponic technique*

Formula name	1st Class (gram)	2nd Class (gram)	3rd Class (gram)
CT1 (13 plants)	870	550	700
CT2 (13 plants)	880	710	930
CT3 (13 plants)	950	760	970

Monitored results on productivity over figure 3.5 indicate that: the spinach seeds planted in the 3rd nutrient solutions produce most efficiently: The first class obtained 950 gr/13 trees, the third class achieve the highest productivity with 970 gr/13 trees, only the second class has the lowest productivity when being harvested; The second formula made a slightly high productivity while the third class achieved 930 gram/13 trees in unseasonable condition, and the productivity of the first class was lowest with 710 gram/13 trees.

The 1st formular was the least efficient nutrient solution. This formular is component from 100% inorganic solution which gave the lowest productivity on the second class with 550 gram/13 plants. The third class had 700 gram/13 plants and the first one achieved 870 gram/13 plants, which was also the most productive class of this formula.

4. Conclusion

Nutrient concentrations affect not only the growth of plants but also the quality as well as the productivity of vegetables, especially of water spinach, during the whole growing process. Based on the previous researches and the results of this research, it has been indicated that using organic nutrient made of beer residue in a low concentration combined with inorganic salted solution will create the most appropriate nutrient solution which facilitates the growth of water spinach. This has also been examined in the third nutrient formula. The average heights of each harvested class obtained the highest numbers which are respectively 30 cm, 32 cm and 31 cm. The weights measured of the third formula in the 3 classes, which are respectively 950 gram, 760 gram, and 970 gram, are all higher than the other 2 formulas. Nevertheless, further researches studying on other kinds of vegetable are necessary in order to obtain more pieces of evidence for this theoretic basic.

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