Electrolysis of Water Using Iron Electrode to Boost the Growth of Hydroponic Plant of Water Spinach

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Abstract: Hydroponics is a method of cultivating plants without using soil. Water spinach plants grown in hydroponic media can be increased by adding iron elements that can be absorbed by plants. The purpose of this study was to determine the effect of electrolysis of water using iron electrodes which produced Fe2+ and Fe3+ ions which flowed water spinach hydroponic plants to the growth of water spinach hydroponic plants. Data analysis using independent t-test and parameters observed were plant height, leaf number, and stem circumference. The results showed that the use of the electrolysis method had an effect in increasing the growth of water spinach hydroponic plants.

1. Introduction
Water spinach is one type of vegetable plant. Based on the place of development, water spinach plants can be planted in water (Ipomoea aquatica Forsk), and soil (Ipomoea reptansPoir). Water spinach growth is influenced by external and internal factors. External factors that affect the growth of water spinach are the nutrient content in the water spinach plant. Macronutrients must be fulfilled by plants and micronutrients to be considered. One of the important micro minerals for plants is iron because it functions in helping the process of photosynthesis [1]. Ipomoea reptansPoir can be planted using a hydroponic system. Hydroponic systems used in plant growth can be advantageous in situations where nutrient media must be well controlled and when intact roots need to be harvested for downstream applications [2].

Iron (Fe) is an important element for living organisms including plants because it has an important role in cellular respiration, intermediate metabolism, transport of oxygen, and DNA stability and repair, and photosynthesis in plants. Fe is one of the abundant elements of the earth, but these elements are not always available for plants grown on soil with a neutral pH to basic pH. About 30% of the land in the whole world consists of alkaline soil which causes less Fe requirements for plant growth. Fe deficiency is a major obstacle to crop yield and quality, which ultimately affects human health, especially for humans who are the main consumption of plant resources [3]. Addition of Fe as much as 6 ppm in Anthurium hookery can increase plant height, stem length, number of leaves and leaf area, because Fe has a role in the formation of chlorophyll so that more Fe is found in plants, photosynthetic activity will increase. photosynthesis produces food and energy sources for plant growth and development. Plant growth can be seen by increasing plant biomass, such as plant height, leaf number, and leaf area. The
leaf surface area of a plant increases the amount of biomass produced and increases plant growth both in the number of leaves, stalk length and plant height [4].

Iron is taken by plants in the form of ferric (Fe$^{3+}$) or Ferro (Fe$^{2+}$) ions. Iron plays a role in the synthesis of chlorophyll and enzymes that function in electron transfer systems[5]. Lack of Fe$^{2+}$ causes inhibition of chlorophyll formation and finally the preparation of proteins also become imperfect. In addition, the lack of Fe can reduce levels of pigment and protein. Fe deficiency symptoms start from young leaves, then develop on leaf bone sheets and eventually all leaves become yellow. Availability of Fe$^{3+}$ and Fe$^{2+}$ in the soil is lacking because it is influenced by soil reactions, interactions with other elements, and the activity of microorganisms in the soil. Iron is taken by plants basically in the form of Fe$^{2+}$ from nature, but iron in nature is available in the form of Fe$^{3+}$. Therefore Fe$^{3+}$ ions must undergo a reduction process to Fe$^{2+}$ so that it can be absorbed by plants [6].

Fe$^{2+}$ ions are obtained from the electrolysis method. The first results of iron electrolysis are Fe$^{2+}$. Electrolysis is the event of decomposition of an electrolyte by an electric current producing chemical energy. The following chemical reaction formed Fe$^{2+}$:

$$\text{Fe} \rightarrow \text{Fe}^{2+}(aq) + 2e^-$$

Water is a very weak electrolyte, which can ionize into H$^+$ and OH$^-$ ions. It is very possible to electrolyze into H$_2$ and O$_2$ gases. Modification of electrolysis of water can be a modification of the electrode used. If the electrode used is reactive, the anode will oxidize the electrodes so that it dissolves in solution (Moreno et al., 2007). Hydroponics is suitable as a place for applying electrolysis methods to produce Fe$^{3+}$ ions which are ready to be absorbed by plants. Hydroponics is a method of farming or cultivating plants without using soil, but by using media other than soil as a substitute for soil media (Bachri, 2017). This hydroponic cultivation has advantages compared to conventional planting. Some of the advantages of hydroponics include not needing to do soil treatment, not depending on the season, cleanliness can be maintained and more efficient in water use[5]. Based on these considerations, it is necessary to know the influence of the use of iron electrolysis method on the growth of water spinach in a hydroponic manner.

2. Method

The materials used in the study were superior varieties of water spinach seeds (Bangkok), NPK (pearls), and iron metal. The tools used are hydroponic installation, nutrient storage bucket, water pump, hose, and adapter. The method used in this study is the experimental method with the addition of the water electrolysis method using iron electrodes in the hydroponic growing media on the growth of water spinach. The experiment consisted of 2 treatments namely hydroponics using iron electrolysis and hydroponics without using iron electrolysis. Water spinach plant samples consisted of 10 plants for electrolysis treatment and 10 plants without electrolysis treatment. Several stages of research from the nursery to the harvest are nutrition, nursery, planting, maintenance of plants in the form of nutrition, and harvesting. The data collection stage was carried out from the time the water spinach began to be planted on the planting media after seeding. A long period of seeding of water spinach seeds for 6-7 days. Measurements are made every 2 days after planting until harvest time is 20 days. The variables observed included plant height, leaf number, and stem circumference. Data analysis using independent t-test with SPSS 25.

3. Results and Discussion

The use of iron electrolysis method in a hydroponic plant of water spinach is done by adding an electrolysis method of water to produce decomposition into O$_2$ at the anode and H$_2$ at the cathode by electric current passing through the water. Two electrodes can use iron Fe. In this study, the type of electrode used was iron (Fe). The reduction reaction that takes place at the cathode:
and the oxidation reaction takes place at the anode:

\[ 2 \text{H}_2\text{O}(l) \rightarrow \text{O}_2(g) + 4 \text{H}^+(aq) + 4e^- \]

Figure 1 Comparison of the growth rates of the average water spinach

Based on Figure 1 shows that the height of water spinach in the electrolysis treatment has an average value of 38.35 cm high and plant height without electrolysis 28.38 cm. Increasing plant height affects stem enlargement. The stem extension is caused by two processes, namely cell division, and cell enlargement, the cell enlarges and reaches the maximum size followed by cell division. The difference in stem diameter in electrolysis and without electrolysis has a significant difference which shows the difference in number, which is 0.18 cm. The results of the growth in the number of leaves are significantly different from the 3 leaf difference numbers. Macronutrient growth in the number of leaves in both treatments can be fulfilled by giving the same NPK fertilizer, but there are differences in micronutrients that cause water spinach plants in the electrolysis treatment to have more leaves than water spinach without electrolysis treatment.

Data obtained in the form of plant height, number of leaves, leaf length, leaf color, and stem diameter. The results of data analysis from the measurement results have norm distribution with Shapiro-wilk and homogeneous. The data analysis test was continued by the independent t-test presented in table 1.

Table 1 The results of the analysis of the growth of hydroponic water spinach in electrolysis and without electrolysis

| Observation Parameters | Results of t-test | Sig. (2-tailed) | Remarks        |
|------------------------|-------------------|----------------|----------------|
| Height                 | 13.623            | 0.00           | significantly different |
| Many leaves            | 3.595             | 0.01           | significantly different |
| stem circumference     | 15.811            | 0.00           | significantly different |

Based on table 1, all observational parameters show significantly different results with information on the value of Sig (2 tailed) or p-value <0.05. This is because the concentration of nutrients dissolved in nutrients greatly influences the metabolism of plants, namely the speed of plant photosynthesis, enzyme activity and the potential for ion absorption by roots, which affects nutrient absorption. Electrolysis produces micronutrients from an anode, namely iron in the form of ions which are ready to be absorbed by plants in the form of Fe$^{2+}$. One of the functions of Fe is as an executor of transferring electrons in the metabolic process. Lack of Fe will result in reduced activity of the cytochrome, catalase, dipeptidase, peroxidase enzymes, and so on that have an important role as a catalyst for reduction-oxidation [5]. The differences in each parameter in detail can be seen in the following figure. This difference has something to do with the element of Fe absorbed by plants. The function of Fe is as a
constituent of chlorophyll, proteins, enzymes, and plays a role in the development of chloroplasts. Lack of Fe causes inhibition of chlorophyll formation and protein preparation becomes imperfect[7]. From the results of the study, the electrolysis of water using iron electrodes can increase the growth and production of water spinach plants.

4. Conclusion
Electrolysis of water using iron electrodes applied to the water spinach hydroponic plants can be concluded that observations of growth on plant height, leaf length, many leaves, leaf color, and stem circumference showed significant differences. The results of water spinach plant growth showed that water spinach hydroponic plants with electrolyzed water treatment using iron electrodes were better than without electrolysis treatment.

5. Suggestion
It is better to do further studies related to knowing the percentage of Fe content in water spinach plants.

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