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Performance Test of Nutrient Control Equipment for Hydroponic Plants

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Abstract. Automatic control equipment has been made for the nutrient content in irrigation water for hydroponic plants. Automatic control equipment with CCT53200E conductivity controller to nutrient content in irrigation water for hydroponic plants, can be used to control the amount of TDS of nutrient solution in the range of TDS numbers that can be set according to the range of TDS requirements for the growth of hydroponically cultivated crops. This equipment can minimize the work time of hydroponic crop cultivators. The equipment measurement range is set between 1260 ppm up to 1610 ppm for spinach plants. Caisim plants were included in this experiment along with spinach plants with a spinach plants TDS range. The average of TDS device is 1450 ppm, while manual (conventional) is 1610 ppm. Nutrient solution in TDS controller has pH 5,5 and temperature 29,2 ^{o}C, while manual is pH 5,6 and temperature 31,3 ^{o}C. Manually treatment to hydroponic plant crop, yields in an average of 39.6 grams/plant, greater than the yield of spinach plants with TDS control equipment, which is in an average of 24.6 grams / plant. The yield of caisim plants by manual treatment is in an average of 32.3 grams/crop, less than caisim crop yields with TDS control equipment, which is in an average of 49.4 grams/plant.

INTRODUCTION

Background

Automatic control equipment has been made for the nutrient content in irrigation water for hydroponic plants (Figures 1 and 2). The nutrient content in the irrigation water is Total Dissolved Solid (TDS) which contains the dissolved nutrient content required by hydroponically grown crops. Hydroponic plants themselves grow with nutrient intake derived from nutrients dissolved in irrigation water through their roots [1] [5].

In a hydroponic system, plants grow with added nutrients in a certain media or nutrient solution and without soil. Hydroponics uses only water and nutrients fertilizer to cultivate plants. So many advantages could be counted for using of hydroponics to grow plants. Soil is not necessary. It's stability and high yields. No nutrition pollution is released into the environment. Higher nutrient and water use efficiency due to control over nutrient levels. Hydroponic systems are very useful and can range from simple setups to highly sophisticated ones [1][6][7]. Conventional hydroponic cultivation can be seen in Figures 3 and 4.

AIM

Conducting performance test of nutrient control equipment to some hydroponics plants with the comparison of hydroponics cultivation manually/conventionally.

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FIGURE 1. Front view of hydroponics nutrition automatic control equipment

FIGURE 2. Side view of hydroponics nutrition automatic control equipment

FIGURE 3. Conventional hydroponics cultivation

FIGURE 4. Hydroponics plants in Greenhouse

TOOLS AND MATERIALS

The prototype of the hydroponic nutrient control equipment (Figure 5) consists of a conductive controller CCT53200E, 12 VDC solenoid valve, 5 V Relay, timer, tank (bucket) containing a mixture of water and AB Mix fertilizer, mixed nutrients, reservoir tank, measuring cups, stirrers, scales. The hydroponic nutrient used is the nutrient AB mix for vegetable plants (leaves). Hydroponics plants are cultivated on 2 sets of hydroponic planting equipment as in Figure 3. A set of hydroponic plant equipment for the treatment of nutrient control equipment. One other hydroponic growing equipment Set for treatment in the conventional hydroponic cultivation.

The nutrients used in this study were the nutrition of AB mix for the hydroponic plant of leaf vegetable type (pakchoy, spinach, caisim). The selection of leafy vegetable crops is due to more mature planting age than fruit crops (sweet pepper, melon, tomatoe) [8] [9] [10].

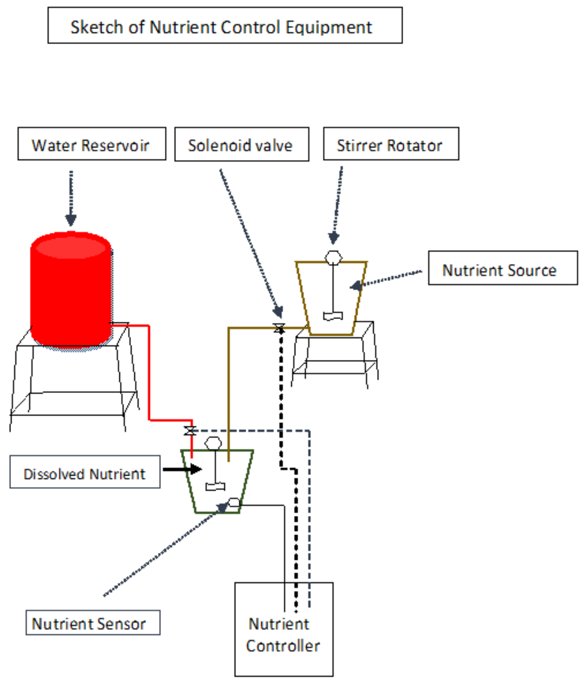

FIGURE 5. Sketch parts of nutrient control equipment

METHODOLOGY

The controlling device of the TDS (Total Dissolved Solid) amount of the nutrient solution in the CCT53200E conductivity controller, is set to the range of minimum up to the maximum number of TDS required by hydroponically grown crops (Figure 1). As controller/comparison, the hydroponic cultivation of the same plant is manually / conventionally conducted (Figure 3).

The recording is made to the magnitude of TDS, pH, temperature and yield, either by treatment with TDS control equipment or by manual treatment, against hydroponically grown crops. Observations and records are made on the growth of plant height, leaf number, width and length of plant leaves during cultivation.

LOCATION

The location of observation and data processing activities carried out at the Field Stationof Center for Appropriate Technology Development - Indonesian Institute of Sciences at K.S. Tubun No.5, Subang, West Java

LITERATURE REVIEW

The composition and concentration of nutrients for plant growth purposes vary considerably, depending on the type of plant, plant growth stage and environmental conditions around the cultivated plant. For example, tomato plants require nutrient content between 1400-3500 ppm, mustard greens 1050-1400 ppm, pakcoy 1050-1400 ppm and spinach 1260-1610 ppm. In general, the plant grows through several stages, namely the stages of seed growth, vegetation stage and generative stage [2] [3].

The concentration of nutrients in the mixing tank of water with nutrients Mix AB, controlled based on the nutritional needs for plant growth. At the bottom of the tank, a TDS sensor is installed in which detects the concentration of the nutrient solution. Sensor detection results are compared with the input reference numbers. When the sensor detection result is smaller than the input reference number, the TDS / nutrient controller will activate the relay that opens the solenoid valve at the tank mixed nutrient A and B mixture output, which is regulated by the timer.

When the sensor detection results are greater than the input reference number, the TDS controller will activate the relay that opens the solenoid valve at the output of the water tank, in the setting time period of the timer. The mixing device at the source tank of the AB Mix nutrient as well as in the water mixing tank with the AB Mix nutrient solution, periodically rotates stirring the liquid in both tanks using a timer. This is done to further homogenize the nutrients in the mixed solution in the tank [4].

The term ppm is quite familiar among hydroponic plant hobbyists. Ppm stands for part per million (one millionth part) which is the unit to measure the concentration of a liquid solution. In the hydroponic system, ppm is used to measure the concentration of the nutrient solution. Measurement of the concentration of the hydroponic nutrient solution is needed to adjust the nutrient requirements according to the plant growth phase. The addition of ppm nutrients adjusted to the age of the plant, the older the plant age is generally higher also ppm nutrients needed.

The level of nutrient concentration required for each plant is different. Fruit vegetables, in general, require a higher amount of ppm of nutrients compared to leafy vegetable crops. In addition to ppm nutrients, which should also be considered in hydroponics is the level of acidity or pH of the nutrient solution [2] [12]. The concentration of hydroponic nutrients is measured by TDS meters with ppm units. The need for ppm and pH of nutrients for some hydroponic plants can be seen in Table 1.

TABLE 1. The requirement of ppm and pH of nutrients for some hydroponic plants

Plant name	**ppm**	**pH**	**Harvest period (from seed) (days)**
Pakchoi	1050-1400	7,0	40-60
Mustard green	1050-1400	5,5-6,5	40-60
Caisim	1050-1400	6,5-7	40-60
Kailan	1050-1400	5,5-6,5	40-70
Lettuce	560-840	6,0-7,0	65-90
Kale	1200-1500	6,5-7,0	30-40
Celery	1260-1680	6,5	120-150
Strawberries	1260-1540	6,0	120
Carrot	1120-1400	6,3	90-120
Sawi bitter	840-1680	6,0-6,5	40-60
Sweet corn	840-1680	6,0	70
Potato	1400-1750	5,0-6,0	90-180
Radish	840-1540	6,0-7,0	60-80
eggplant	1750-2450	6,0	70
Broccoli	1960-2450	6,0-6,8	65-70
Watermelon	1260-1680	5,8	60-70
Melon	1400-1750	5,5-6,0	60-65
Kangkung	1050-1400	5,5-6,5	27 bertahap +5
Chili	1260-1540	6,0-6,5	63 bertahap +5
Spinach	1260-1610	6,0-7,0	25 bertahap +5
Tomato	1400-3500	6,0-6,5	63 bertahap +5
Cucumber	1190-1750	5,5	60 bertahap +7

Source:http://www.istemhidroponik.com/kebutuhan-kadar-phppm-nutrisi-pada-masa-panen-sayuran/(May 24, 2017)

RESULTS AND DISCUSSION

In the manual of the conductive controller CCT53200E [11], it is noted that the measurement range can be set from 0.25 ppm to 9.99 ppt (9990 ppm). Because in the test performance of control device TDS nutrition, using spinach crops as hydroponic cultivated plants, then the instrument measurement range is set between 1260 ppm up to 1610 ppm (Table 1). Caisim plants were included in this experiment along with spinach plants with a spinach plants TDS range. This is done to see whether there are differences or similarities plant growth between caisim against spinach with spinach plants TDS ranges.

Normal conditions occur when the reading device CCT53200E is at a value between 1260 ppm - 1610 ppm with water solenoid valve condition and nutrients are closed, so no LEDs are turned on (Figure 6). If the measurement device CCT53200E above 1610 ppm, the system will active relay 1 (RL1) for 18.1 seconds to open the solenoid valve water reservoir. This condition is shown in Figure 6 with a yellow LED lights indicating the solenoid valve open the water reservoir. Meanwhile, if the measurement results below 1260 ppm, the system will activate relay 2 (RL2) during 22.7 seconds to open the solenoid valve container AB mix nutrients. Figure 6 shows a low TDS value with red LED to indicate the solenoid valve opens nutrients AB Mix.

From the treatment of the use of TDS control equipment against manual to spinach and caisim plants, the average TDS device is 1450 ppm, while manually (conventional) is 1610 ppm. Nutrient solution in TDS controller has pH 5,5 and temperature 29,2 ^{o}C, while manual is pH 5,6 and temperature 31,3 ^{o}C. Manually treatment to hydroponic plant crop, yields in an average of 39.6 grams/plant, greater than the yield of spinach plants with TDS control equipment, which is in an average of 24.6 grams / plant (Table 2). This possibility occurs because the amount of TDS in the nutrient solution with manual treatment is greater than that of the TDS control equipment. For the effect of temperature and pH differences, between the treatments of TDS control equipment against manually with a relatively small effect, appear to have not a significant impact.

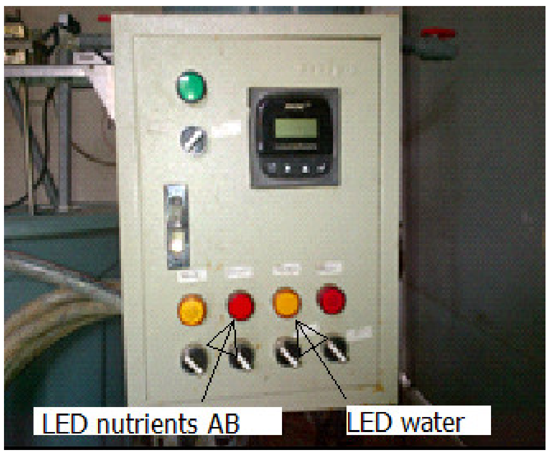

FIGURE. 6. Light Emitting Diode (LED) of the hydroponic nutrients control

In contrary, caisim crop yields by manual treatment, is in an average of 32.3 grams/crop, less than caisim crop yields with TDS control equipment, which is in an average of 49.4 grams/plant. This possibility occurs, because of the amount of TDS in the nutrient solution in manual treatment, greater than the maximum TDS range listed in Table 1 (1400 ppm) for the caisim plant.

TABLE 2. Average yield of TDS, pH, temperature and yield of TDS control equipment and manual treatment against spinach and caisim plants

Plant	Spinach		Caisim	
Treatment	**Automatic equipment**	**Manual**	**Automatic equipment**	**Manual**
TDS (ppm)	1450	1610	1450	1610
pH	5,5	5,6	5,5	5,6
Temperature (°C)	29,2	31,3	29,2	31,3
Yields (gram/plant)	24,6	39,6	49,4	32,3

To support data crop yields of spinach and caisim cultivated by hydroponic techniques, either with the help of equipment TDS control or manually (conventional), the high growth data of spinach plants, the number, width and length of plant leaves, during January 2017 can be seen on Table 3 and Figures 7 up to 10. As for caisim plants can be seen in Table 4 and Figures 11 up to 14.

TABLE 3. Growth of spinach plant height, number, width and length of the leaves of plants, during January 2017

Treatment	Automatic equipment				Manual			
Growth period	**Jan-08**	**Jan -13**	**Jan-18**	**Jan-23**	**Jan-08**	**Jan -13**	**Jan-18**	**Jan-23**
Plant height (cm)	1,27	3,08	6,61	13,58	1,62	3,77	8,37	16,12
Number of leaves	4,9	7,1	9,2	12,3	5,1	7,5	9,8	13,6
Leaf width (cm)	0,90	1,08	1,18	1,24	0,95	1,26	1,36	1,45
Leaf length (cm)	1,09	1,29	1,43	1,47	1,22	1,59	1,73	1,82

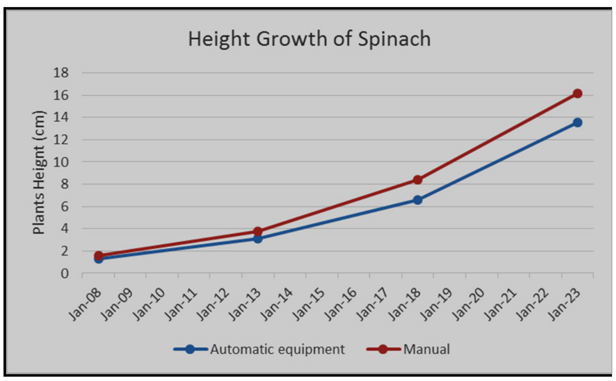

FIGURE 7. Height Growth of Spinach

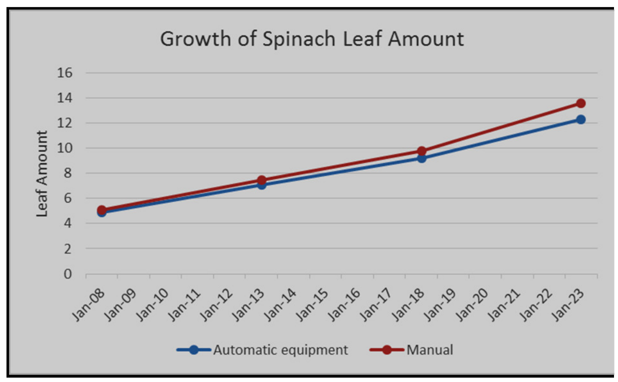

FIGURE 8. Growth of Spinach Leaf Amount

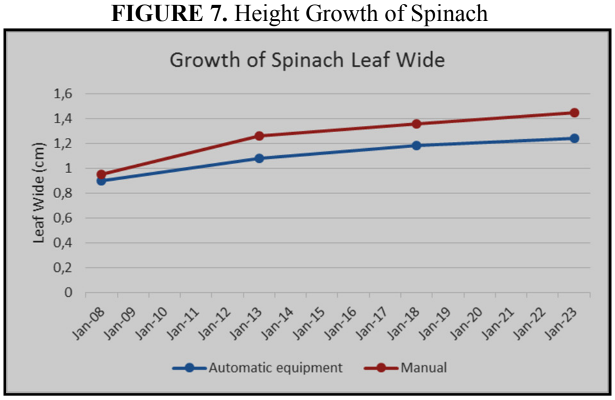

FIGURE 9. Growth of Spinach Leaf Wide

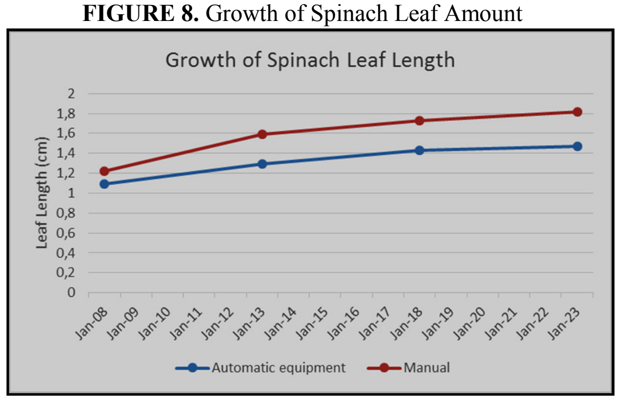

FIGURE 10. Growth of Spinach Leaf Length

TABLE 4. Growth of caisim plant height, number, width and length of the leaves of plants, during January 2017

Treatment	Automatic equipment					Manual				
Growth period	Ja-09	Ja-13	Ja-18	Ja-23	Ja-28	Ja-09	Ja-13	Ja-18	Ja-23	Ja-28
Plant height (cm)	2,04	2,83	3,46	4,04	4,45	2,53	3,34	3,83	4,09	4,38
Number of leaves	-	4,7	6,2	8,2	10,5	-	4,6	6,1	7,7	10,0
Leaf width (cm)	1,29	1,72	1,86	2,21	2,27	1,25	1,58	1,72	1,79	1,88
Leaf length (cm)	2,08	2,79	3,04	3,10	3,16	2,04	2,56	2,88	2,89	3,01

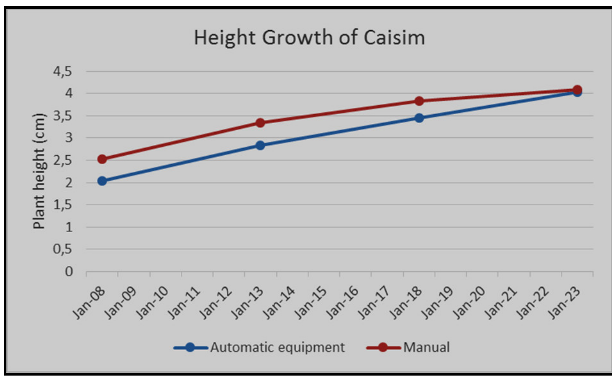

FIGURE 11. Height Growth of Caisim

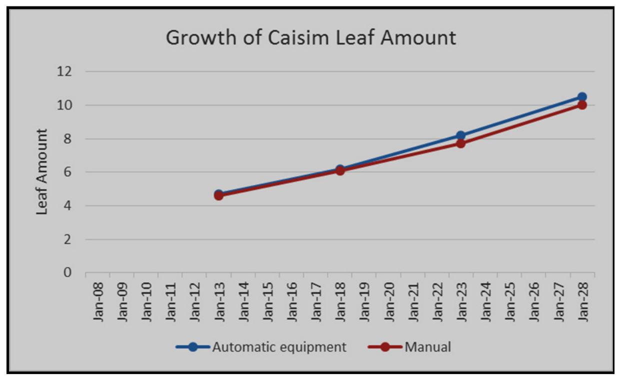

FIGURE 12. Growth of Caisim Leaf Amount

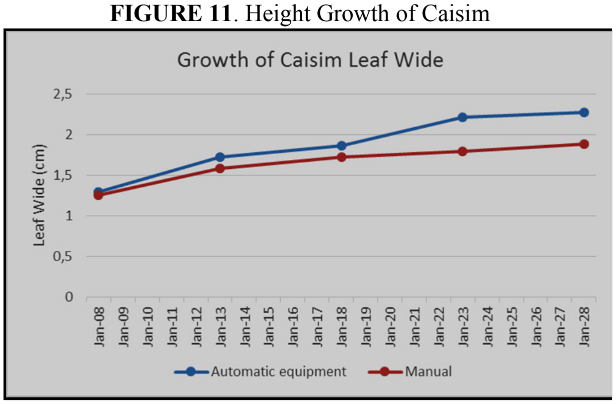

FIGURE 13. Growth of Caisim Leaf Wide

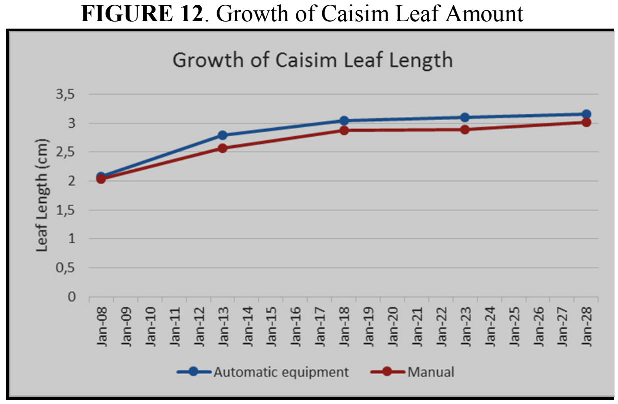

FIGURE 14. Growth of Caisim Leaf Length

CONCLUSION AND SUGGESTION

Automatic control equipment with a CCT53200E conductive controller, for nutrient content in irrigation water for hydroponics plants, can be used to control the amount of TDS of nutrient solution. The TDS ranges that can be set, according to the range TDS requirement for the growth of hydroponic cultivated crops. This equipment can minimize the work time of hydroponic crop cultivators.

The equipment measurement range is set between 1260 ppm up to 1610 ppm for spinach plants. Caisim plants were included in this experiment along with spinach plants with a spinach plants TDS range. The average of TDS device is 1450 ppm, while manual (conventional) is 1610 ppm. Nutrient solution in TDS controller has pH 5,5 and temperature 29,2 ^oC, while manual is pH 5,6 and temperature 31,3 ^oC. Manually treatment to hydroponic plant crop, yields in an average of 39.6 grams/plant, greater than the yield of spinach plants with TDS control equipment, which is in an average of 24.6 grams / plant. This possibility occurs because the amount of TDS in the nutrient solution with manual treatment is greater than that of the TDS control equipment.

The yield of caisim plants by manual treatment is in an average of 32.3 grams/crop, less than caisim crop yields with TDS control equipment, which is in an average of 49.4 grams/plant. This possibility occurs, because of the amount of TDS in the nutrient solution in manual treatment, greater than the maximum TDS range listed in Table 1 (1400 ppm) for the caisim plants. For the effect of temperature and pH differences, between the treatments of TDS control equipment against manually with a relatively small effect, appear to have not a significant impact.

It is recommended to complete the device in addition to not only controlling the magnitude of the TDS of the nutrient solution, but also controlling the pH of the solution, so as to further improve the quantity and quality of the harvest. To determine the amount of irrigation water for the cultivation of hydroponic crops, should also calculate the amount of evapotranspiration hydroponically cultivated plants.

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