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An NFT (*Nutrient Film Technique*) Hydroponic Irrigation System design Using Various Gutter Slopes On Pakcoy Plants (*Brassica rapa* L.)

An NFT *(Nutrient Film Technique)* Hydroponic Irrigation System design Using Various Gutter Slopes On Pakcoy Plants *(Brassica rapa L.)*

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Abstract. This research aims to design irrigation systems an NFT hydroponic with various gutters slope on pakcoy plants (*Brassica rapa* L.). This research was conducted in October 2020 to March 2021 at greenhouse of Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Sriwijaya University. This research method used observation method. The observed paramaters were plant water need, the uniformity of irrigation water, the uniformity of electrical conductivity, and the uniformity of water flow the thickness and the production of pakcoy plants at NFT using slope of gutters 4%, 6%, and 8%. The results shown that the highest average value of irrigation water uniformity at a gutter slope of 8% was 93.44%. The highest average value of electrical conductivity uniformity of gutters at 8% slope was 99.45%. The highest average value of water thickness uniformity in the three guttering treatment at 8% gutter slope was 89.91%. The weight of crop production at a slope 8% was 3,184 g roots and 2,189 g of plants without roots. Plant water needs in the initial period of growth was 2.43 mm/day, the middle period of growth was 3.42 mm/day, and the final period of growth was 4.95 mm/day.

1. Introduction

Nowadays, food crops production activities in Indonesia have been increasingly developed, which prove by numerous cultivation technologies that have been successfully adopted from developed countries, including the urban farming system which currently being implemented is the hydroponic cultivation system. Hydroponic cultivation produce clean plants, efficient use of nutrients as it is customized to plant needs, weeds free plants and are rarely attacked by pests, produce high quality and quantity of plant as it has high selling value, and able to cultivate in limited land.

One of the most widely used hydroponic techniques to produce food crops is the Nutrient Film Technique (NFT). In this system, the plant roots are placed in a shallow nutrient layer. The nutrient solution is circulated for 24 hours continuously and contains nutrients that is needed for plants. Roots are able to growth in the nutrient solution. The application of this system needs to consider the possibility of excess water, which will reduce the amount of oxygen. Therefore, the nutrient layer in the NFT system is arranged specifically, with maximum solution height is 3 mm, in order to fulfill the need for nutrient water and oxygen [1].

There are many factors that must be considered in hydroponic farming such as water quality, nutrient solution, EC (Electrical Conductivity) value, nutrient solution pH, water flow rate, gutter slope, media, and others. The most important aspect that needs to be considered in hydroponic

technology is the management of nutrient solutions related to the value of EC (Electrical Conductivity) and pH [2].The distribution of nutrient solution in NFT hydroponics is influenced by the slope of the gutter, since it affects the flow speed of nutrients which eventually impact to absorption rate of nutrients by the roots [3].

Therefore, this study used modified gutters such as special NFT hydroponic gutters, because the bottom surface is flat like a special NFT hydroponic gutter. The flat bottom surface causes the roots free to spread and maximized absorption of nutrients. So, this study aims to design an NFT hydroponic irrigation system with various gutter slopes on pakcoy plants (*Brassica rapa* L.) to obtain optimal and uniform crop yields.

2. Research Methodology

This research was carried out from October 2020 to March 2021 at Greenhouse, Department of Agricultural Technology, Faculty of Agriculture, Sriwijaya University.The materials used in this research were: 1) Water source, 2) Pakcoy plant seeds, 3) AB Mix fertilizer, 4) Box PVC gutters, 5) PVC pipe, and 6) 7 mm Fertigation Hose. Equipment used in this research were: 1) Drill, 2) Nutrient measuring cup, 3) pH meter, 4) EC meter, 5) TDS meter, 6) Nutrient solution tub, 7) Stationery, 8) Camera digita, 9) Calculator, 10) Aquarium Pump, 11) Ruler, 12) Meter, 13) Thermohygrometer, 14) Mild Steel, and 15) Netpot.

This study used field observation method. This study analyzed data quantitatively on water needs, uniformity of irrigation water, uniformity of electrical conductivity and uniformity of water flow thickness and weight of crop production at 4%, 6% and 8% gutter slopes.

3. Result and Discussion

Based on observation, The average daily temperature is 30.98°C. The percentage of daylight hours in the South Latitude in February and March is 27.65% The plant coefficient values (Kc) in pakcoy plants were 0.54 for the initial growth period, 0.76 for the middle growth period and 1.1 for the late growth period [4], and the ETo is 4.5 mm/day, the value of plant evapotranspiration was 2.43 mm/day at the inital of growth, 3.42 mm/day in the middle period of growth, and 4.95 mm/day at the end of the growth period.

3.1. *Uniformity of irrigation water (CU)*

Irrigation uniformity value is the percentage obtained from measuring the outlet discharge of each gutter at each week of plant age.. Figure 1 show that the uniformity value of outlet discharge irrigation (CU) for these three treatments of gutter slope had the uniformity standard, which was greater than 80%. The uniformity value is in accordance with the statement of [5] which states that the irrigation uniformity value (outlet discharge) must be greater than 80%. The uniformity value shows that the irrigation network in NFT (Nutrient Film Technique) hydroponics is able to provide an even distribution of nutrients for each of the three treatments of gutter slope. Uniformity of irrigation water is presented in figure 1

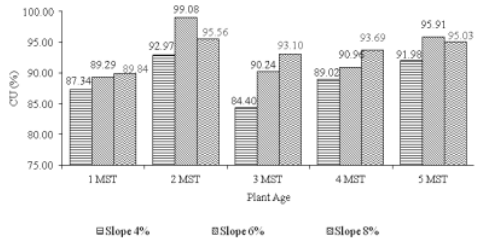

Figure 1. Graph of irrigation water uniformity (CU) at each plant periode in week

In Figure 1. shown that the slope of 8% has a higher uniformity value compared to the slope of 4% and 6%. From the data obtained, the nutrient solution discharge in the three treatments of the slope of the gutters tends to decrease every week of plant age. This is in accordance with [6] which stated that if there are more plant roots, the speed of nutrient water flow will decrease. so that the rate of nutrient flow will affect the thickness of the water. In addition, the flow of nutrients is affected because there is clogged dirt in the inlet pipe, it is necessary to check periodically.

The largest outlet discharge was found in the first week (1 MST) and the lowest was in the last week (5 MST) for each slope. The factors that affect the discharge of the first week and the last week of discharge are different apart from being caused by the slope of each gutter, namely the roots in the first week are still small and root absorption is still slow. In contrast to the last week, the outlet discharge became smaller which was influenced by the slope of the gutters, the increasing number of roots and the presence of moss growing on the gutters which inhibited the rate of nutrient solution. The rate of nutrient flow affects the circulation of the solution. Flow velocity that is too fast can make it difficult for roots to absorb nutrients because circulation is too fast, while flow velocity that is too slow causes nutrient deposition [7].

The solution discharge affects plant growth because the flow of water that is too heavy will inhibit plant growth which causes plant roots to become increasingly difficult to absorb the nutrients contained in the water. Then the slope factor becomes one of the considerations in the process of establish the gutter slope of the NFT hydroponic which suitable for plants, therefore the absorption of nutrients in plants goes well so that they can grow normally.

3.2. Uniformity of Electrical conductivity

The uniformity value of electrical conductivity is the percentage obtained from the measurement of electrical conductivity at each slope of the gutter every week of plant age.The uniformity of electrical conductivity value in each week of plant age is presented in Figure 2.

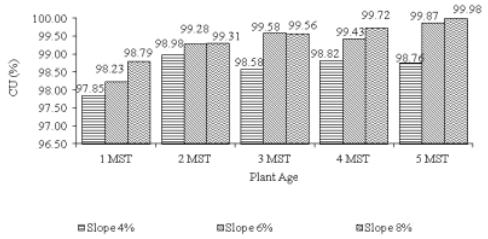

Figure 2. Electrical conductivity uniformity graph.

The difference in electrical conductivity uniformity is not much different between the three slopes, namely 98.76% for a slope of 4%; 99.25 for a slope of 6%; and 99.45% for a slope of 8%. The value of the electrical conductivity uniformity was influenced by the measured electrical conductivity value. In Figure 2 shown that the slope of 8% has a relatively higher uniformity value compared to the slope of 4% and 6%. This is because the 8% slope has a thinner nutrient solution layer than the 4% and 6% slope, so this increases the dissolved oxygen in the nutrient solution. According [4] if the gutter slope is greater, the oxygen content in the nutrient solution will increase, which will indirectly affect the value of electrical conductivity in nutrient solution.

The provision of nutrients with different concentrations of EC (Electrical Conductivity) can increase the growth of pakcoy plants at EC concentrations of 1.5 and 2.0 [8]. In this study, pakcoy plants were given nutrients with an EC concentration of 0.5-1.8 from the time of transplanting until harvest, in order to avoid excess nutrients that might inhibit plant growth. Crop damage due to too

high EC plant growth will stagnate. If the EC is higher, it will cause toxicity or poisoning and the cells will undergo plasmolysis [9].

3.3. Uniformity of water flow thickness

The uniformity value of water thickness in each week of plant age is presented in Table 1. and Table 2.

Table 1. The uniformity value of water flow thickness at the inlet

Period Plant Age	CU thickness of water flow (%)		
	Slope 4%	Slope 6%	Slope 8%
1 MST	92,99	90,61	91,76
2 MST	90,35	90,86	89,56
3 MST	89,79	86,85	89,91
4 MST	91,54	91,53	93,34
5 MST	88,74	85,69	91,94
Average	90,74	89,21	91,22

Table 2. The uniformity value of water flow thickness at the outlet

Period Plant Age	CU thickness of water flow (%)		
	Slope 4%	Slope 6%	Slope 8%
1 MST	87,98	90,97	90,94
2 MST	91,84	79,26	91,80
3 MST	91,52	87,55	88,83
4 MST	89,35	88,54	90,58
5 MST	88,47	85,69	86,98
Average	89,87	86,42	89,91

On Table 1 and Table 2. shown that the uniformity of water flow thickness in the treatment of the gutter slope which was greater than 80%. This means that the uniformity value of the water flow thickness has met the uniformity standard. The figure above shows that the 8% slope had a relatively higher uniformity value compared to the 4% and 6% slope, but it was not much different. This is because the 8% slope had a thinner nutrient solution layer and a larger slope than the 4% and 6% slope. At a slope of 8% also has a thickness of water flow between 1.5-3 mm, which is in accordance with the statement of [10] that the principle of NFT hydroponics is avoid to use a water thickness that exceeds 3 mm. Thus, the slope factor was one of the considerations in the process of build an appropriate slope for NFT hydroponic gutters to get a good water thickness to ensure the plants grow optimally.

3.4. Production of pakcoy

The production level of pakcoy was measured directly, by weighing the post-harvest plants without dried it. The weight of pakcoy that resulted from the three treatments of gutters slopes is presented in Figure 4 for the weight of plants with roots; and Figure 5 for weight of rootless plant.

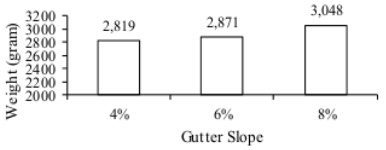

Figure 3. Weight of plants with roots weight

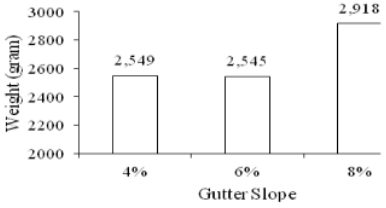

Figure 4. Weight of rootless plants

In Figure 3.3. and Figure 3.4 shown that different plant weights caused by different levels of gutter slope. Based on the characteristics of pakcoy that were ready to be harvested, the most suitable one is found on the slope of the 8% gutter because it has an average weight of 104.93 grams. This was in accordance with the research of [6], which mentioned that the steeper NFT gutter had higher plant productivity, as it will produce a thinner nutrient layer. Respiration in the roots will produce energy to absorb water and nutrients more smoothly to help plants grow faster. The production level of pakcoy plants can be measured directly in the field, namely by weighing the post-harvest plants without prior dried it.

4. Conclusions

The following conclusions can be drown from this study:

1. The highest average value of irrigation water uniformity (outlet discharge) in the three gutter slope treatment at a gutter slope of 8% was 93.44%.
2. The highest average value of electrical conductivity uniformity in the three slope treatment of gutters at 8% slope was 99.45%.
3. The highest average value of water thickness uniformity in the three guttering treatment at 8% gutter slope was 89.91%.
4. The weight of crop production in the three slope treatment gutters that have the highest weight at a slope 8% was 3,184 g with roots and 2,189 g of plants without roots.

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