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The Contribution of Water and Sunlight to the Lettuce Production

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Abstract

Indonesian lettuce production is still lower than consumption. Lettuce production in Indonesia is still low because hydroponic cultivation needs more concern with the water and sunlight factors. This first study aimed to determine the contribution of water and sunlight to the growth of lettuce. The second study aimed to find out the difference in lettuce production between the difference in water and sunlight conditions. This research used the experimental method. The research was conducted in a field laboratory and hydroponic village at the Faculty of Agriculture, Halu Oleo University. Data collection methods using field observations and measurements. The first objective data analysis techniques described water quality and sunlight measurements. The second objective data analysis used a description of the result of the lettuce variable costing. The results showed that water and sunlight contributed to the production of lettuce. The water adds nutrients, and the sunlight does not direct to lettuce-affected plants, which tend to have broad and healthy leaves. The good water and sunlight conditions contribute to pressing the cost of maintaining plants and raising the profit from lettuce production. These results are important to the attention of the water and sunlight conditions that can raise lettuce production in Indonesia

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INTRODUCTION

Data FAO (2020) shows that 24.9 million tons of lettuce are produced worldwide. Spain and the United States are the two largest lettuce exporters worldwide. Initially, North American and Western European countries ranked highest in lettuce production. China produces around 13.5 million tons in Asia, most of which are used for domestic consumption. Lettuce with green leaves is magnetic for vegetable consumption (Liu et al., 2014).

Since the late 1900s, lettuce plants began to be cultivated on a large scale in other regions with various varieties. The stem lettuce variety is more common in Egypt and China, the butterhead variety is preferred in Northern Europe, and the romaine variety is more prevalent in Mediterranean countries. Currently, the crisphead variety is predominant in northern and western Europe, while in the United States, several varieties of lettuce are grown, with California (71%) and Arizona (29%) accounting for all production. The production of lettuce of various varieties has been developed using a hydroponic system (Lau & Mattson, 2021; Phibunwatthanawong & Riddech, 2019).

Based on data BPS (2020), lettuce production in Indonesia in 2010 was 41.111 tons and decreased in 2015 to 39.289 tons. The growth rate of lettuce production in Indonesia in 2010-2015 was 5.19-6%. Problems arise because lettuce production is still lower than consumption. Efforts were made to import lettuce; data for 2021 amounted to 21.1 tons. The difference between consumption and production is an opportunity to increase production in order to be able to reach national lettuce consumption (Rukmana, 2015).

Lettuce production in Indonesia is still low. The low production is because farmers still use hydroponic cultivation systems that are not quite right (Lakitan, 2018). Hydroponic lettuce cultivation is found to be damaged due to physical factors such as the ongoing hydrological activity of harvested lettuce leaves. Plant products that have been harvested still carry out various processes. It is transpiration, respiration, and

other hydrological activities. This event directly causes weight loss (shrinkage) and reduces the quality of lettuce leaves.

Research Robinson (2015) states that if the water loss is 10% in leaf vegetables, the plant's weight will decrease from its original weight. This leave is due to transpiration, so the lettuce leaves wither, and the quality becomes very low. Temperature is also very influential in the growth of lettuce plants. The ideal temperature for producing high-quality lettuce is 20˚C during the day and 10˚C at night. Furthermore, Al-Degs et al. (2000) stated that the temperatures higher than 30˚C usually inhibit growth, stimulate bolting and cause a bitter taste

The physical environment in the form of sunlight also determines the success of lettuce production. The intensity of sunlight is based on a comparison of the average daily and monthly temperature during the nursery or harvest, carried out in one month. The angle of incidence of sunlight affects lettuce plants (Liu et al., 2014).

Water quality is the primary physical environmental factor needed by hydroponic system lettuce plants. It is because water becomes a growing medium and is used to dissolve nutrients. Water must be of good quality and not polluted by pollution or waste. Water quality can be seen from various indications, such as pH and dissolved mineral levels. The pH and dissolved mineral levels will affect the ability of plant roots to absorb the nutrients provided (Jumin, 2012).

Research on lettuce was carried out by Liu et al. (2014) examining the effect of nitrogen fertilizer on growth and the nitrate content of lettuce. Nitrogen 200 kg per hectare makes lettuce leaves longer and wider, lowering nitrate concentrations. Research Lau & Mattson (2021) shows that organic fertilization affects lettuce hydrogen peroxide. Research Phibunwatthanawong & Riddech (2019) looked at the effect of liquid organic fertilizer on the growth of vegetables using the hydroponic method was green cos lettuce. Previous research has mainly focused on the effect of fertilizer on lettuce growth. This study is different from previous studies by looking at the effect of water and sunlight on lettuce production that not be done before. The first objective was to determine the contribution of water and sunlight on the growth of lettuce. The second objective is to find out the difference of lettuce production between locations with different water and sunlight conditions.

RESEARCH METHODS

This study used an experimental method by looking at the contribution of water and sunlight to lettuce production. This research was conducted at two locations in the Faculty of Agriculture, Halu Oleo University. One location in the field laboratory is the first, and one in the hydroponic village is the second. The location was chosen because it has the same environment. The difference in contribution to the treatment in the experiment could be seen.

The time for conducting the research is one month, May-June 2022. The subjects of this research trial were lettuce plants that were ten days old. The lettuce age was chosen at ten days because harvesting can be done 40 days after sowing. The test subjects were at each location of nine hydroponic pipes. The locations and test subjects were deliberately chosen because experimental research requires proper control (HL et al., 2022).

This research data collection method is by observation and field measurements. The data analysis technique for the first objective is a description of the results of water quality measurements (pH and PPM), the angle of incidence of sunlight, the irradiation intensity in the room (measured by a Lux Meter), and the irradiation intensity of the water (measured by a Water Thermometer). The intensity of monthly sunlight is calculated using the formula for the average monthly temperature received by hydroponic plants based on research Kim et al., (2011) and Ryu et al. (2011) carried out for 30 days from seeding to harvest, every 12:00 PM using the formula below.

Monthly Temperature= Daily Temperature/30

The description of the formula above regarding monthly temperature is the result of daily temperature data collected for one month and divided by 30 days. The daily temperature is obtained by recording temperature measurements every day at 12.00 PM. The number 30 is used as a comparison because it is the number of days in a month.

Data analysis for the second objective is to describe the calculation of production results using variable costing by calculating the average number of production results per month using formula two below.

Production Results = Total Production – Cost

Cost = Raw Materials + Labor + Plant Care + Transportation

Information from the formula above related to production results is the total income obtained minus all production expenditures. Production expenditures are all costs incurred in the framework of lettuce production activities. Production expenses include the cost of raw materials, labour costs, plant maintenance costs, and transportation costs.

RESULTS AND DISCUSSION

Water and Sunlight Contribution

The degree of acidity and the number of dissolved particles on the water factor is seen in relation to the lettuce. First, the acidity in the first location, there are differences in the degree of acidity of the water caused by the provision of nutrients. The pH level of the water before being given nutrition was 6.6 or included in the neutral pH category. The pH level after being given additional nutrients increased from 1.0 to 6.7. This result can be interpreted that the pH level of the water depends on the provision of nutrients. The pH category is no longer neutral, but to the pH the water should be.

At the second location, the pH level tends to be neutral and quite good, which is in the range of 7.0. This result means that the presence or absence of nutrients does not affect the pH level of the water. These results align with research Phibunwatthanawong & Riddech (2019) which states that hydroponic lettuce plants require water with an optimal pH value of 4.5 – 7.8. Two research locations have optimal pH; namely, the first location is in the pH range of 6.0, while the second location is in the pH range of 7.0. The second location has a higher level of acidity, which is not affected by nutrition, while the first location has an acidity level that contributes 10% addition of nutrients. Table 1 shows the results of calculating the pH of the water at the study site.

Table 1. The Result of the Water pH

Treatment	pH	
	First Location	Second Location
Before give nutrition	6.6	7.0
After given nutrition	6.7	7.0

Source: Research results (2022)

The second water factor is the number of dissolved particles per million (ppm) before and after being given nutrients. There was a difference in the number of dissolved particles in the two study locations before being given nutrients of 168 ppm. The dissolved particles were 175 ppm at the first location, and the second location was 343 ppm. The difference in the number of dissolved particles in the two study sites after being given nutrients was 97 ppm. At the first location, the dissolved particles were 673 ppm,

while at the second location were 770 ppm. This result can be interpreted as the second location having higher dissolved particles than the first location. Dissolved substances between the first and second locations with the addition of nutrients from fertilizer N, P, K as much as 30%. These results are in line with research from Kim et al. (2011), the solvent particles needed by lettuce plants are 200-400 ppm.

The standard solvent particles followed Singh et al. (2012) of 800-1500 ppm for plants transferred to a hydroponic installation. This result shows that the second location has more dissolved particles of 168 ppm than the first. Although both locations have the same addition of plant nutrition, the second location has excellent solvents and is suitable for plant growth. Table 2 shows the results of calculating water-dissolved particles at the study site.

Table 2. The Result of Calculating water-dissolved particles

Treatment	Dissolved particles (ppm)	
	First Location	Second Location
Before give nutrition	175	343
After given nutrition	673	770

Source: Research Result (2022)

The sun exposure factor consists of the angle of incidence of sunlight and temperature. Observations of the angle of incidence of sunlight, along with measurements of room temperature and water temperature, were carried out when the angle of incidence was 90º. The direction of sunlight at first location receives direct sunlight throughout the day. The second location only receives sunlight in the morning and evening. The placement of the plant table in the first location takes a horizontal direction from east to west. This result means that for 12 hours, the plants are exposed to direct sunlight because they are in the direction of the sun's rising and setting. The position of the plant table in the second vertical location faces north and south, so the plants only receive indirect sunlight because they are in the rising and setting position of the sun.

The sun exposure factor is based on the direction of light. The second location is better than the first location because it does not face the rising and setting sun. Based on research conducted by Schneider et al. (2018), lettuce requires a light intensity of around 7-8 hours per day. The result also aligns with (Saadu et al., 2021) that sunlight is necessary for plants as a nutrient for development and photosynthetic activity in leaves.

The results showed that the highest room temperature at the first location was 38.5˚C, and the lowest room temperature was 23.3˚C. The highest water temperature in the first location is 31.9˚C, and the lowest is 20.3˚C. This result shows the growth temperature of lettuce plants in the first location, including medium for minimum and high for maximum. The second location has the highest room temperature of 37.5˚C and the lowest temperature of 22.1˚C. The highest water temperature is 28.9˚C, and the lowest is 19.1˚C. This result shows that the growth temperature of lettuce plants at the second location was almost high and very good at the minimum. Good lettuce plant growth has an optimum temperature of 15˚C and a maximum temperature of 28˚C (Garrett, Owen & Lopez, 2015; Kim et al., 2011). Table 3 shows the results of room temperature and water temperature measurements at the study site.

Table 3. The Result Temperature Measurement of Room and Water

Week	Day	First Location				Second Location			
		Room		Water		Room		Water	
		max	min	max	min	max	min	max	min
Week 1	1	36.4˚C	33.3˚C	29.8˚C	28.9˚C	35.9˚C	32.8˚C	28.9˚C	27.8˚C
	2	37.3˚C	35.3˚C	30.6˚C	29.6˚C	36.4˚C	34.8˚C	29.3˚C	28.3˚C
	3	35.3˚C	32.5˚C	28.6˚C	27.6˚C	34.8˚C	31.3˚C	27.5˚C	26.6˚C
	4	38.5˚C	36.5˚C	31.9˚C	30.3˚C	37.5˚C	35.5˚C	30.6˚C	29.3˚C
	5	33.5˚C	31.7˚C	26.9˚C	24.8˚C	32.6˚C	30.6˚C	25.5˚C	23.8˚C
	6	32.6˚C	29.8˚C	25.3˚C	21.6˚C	31.3˚C	28.4˚C	24.9˚C	20.6˚C
	7	37.5˚C	35.5˚C	30.9˚C	25.3˚C	36.5˚C	33.8˚C	29.9˚C	24.8˚C
Week 2	1	24.4˚C	23.8˚C	22.8˚C	22.4˚C	23.9˚C	22.6˚C	22.3˚C	21.9˚C
	2	24.9˚C	23.3˚C	22.3˚C	22.1˚C	23,6˚C	22.3˚C	22.1˚C	21.6˚C
	3	24.6˚C	23.7˚C	22.7˚C	22.5˚C	23.8˚C	22.4˚C	22.2˚C	21.4˚C
	4	24.5˚C	23.3˚C	22.3˚C	22.1˚C	23.9˚C	22.1˚C	21.9˚C	21.3˚C
	5	24.7˚C	23.4˚C	22.4˚C	22.2˚C	23.6˚C	22.2˚C	22.1˚C	21.4˚C
	6	24.2˚C	23.4˚C	22.4˚C	22.2˚C	23.4˚C	22.2˚C	22.1˚C	21.2˚C
	7	24.5˚C	23.7˚C	22.7˚C	22.4˚C	23.7˚C	22.4˚C	22.2˚C	21.4˚C
Week 3	1	28.6˚C	27.9˚C	27.9˚C	26.6˚C	27.4˚C	26.9˚C	26.4˚C	25.8˚C
	2	28.3˚C	27.3˚C	27.6˚C	26.3˚C	27.9˚C	26.6˚C	26.1˚C	25.3˚C
	3	28.4˚C	27.5˚C	27.6˚C	26.4˚C	27.6˚C	26.6˚C	26.5˚C	25.7˚C
	4	28.1˚C	27.6˚C	27.3˚C	26.1˚C	27.5˚C	26.3˚C	26.1˚C	25.3˚C
	5	28.2˚C	27.5˚C	27.8˚C	26.2˚C	27.7˚C	26.8˚C	26.3˚C	25.4˚C
	6	28.2˚C	27.9˚C	27.6˚C	26.2˚C	27.2˚C	26.6˚C	26.2˚C	25.4˚C
	7	28.4˚C	27.9˚C	27.3˚C	26.4˚C	27.5˚C	26.3˚C	26.4˚C	25.7˚C
Week 4	1	29.9˚C	28.3˚C	23.9˚C	22.9˚C	28.4˚C	27.8˚C	22.8˚C	21.6˚C
	2	29.6˚C	28.3˚C	23.6˚C	22.6˚C	28.9˚C	27.8˚C	22.3˚C	21.3˚C
	3	30.8˚C	29.5˚C	21.8˚C	20.4˚C	29.6˚C	28.3˚C	20.7˚C	19.4˚C
	4	30.9˚C	29.5˚C	21.9˚C	20.3˚C	29.5˚C	28.5˚C	20.3˚C	19.1˚C
	5	30.6˚C	29.7˚C	21.6˚C	20.4˚C	29.7˚C	28.6˚C	20.4˚C	19.2˚C
	6	30.4˚C	29.8˚C	22.4˚C	20.2˚C	29.2˚C	28.4˚C	21.4˚C	20.2˚C
	7	28.7˚C	27.5˚C	22.7˚C	20.4˚C	27.5˚C	26.8˚C	21.7˚C	20.4˚C

Source: Research Result (2022)

The results shown that monthly temperature calculations at the first location are 26.8˚C, and the second location is 23.8˚C. Based on the results of these measurements, the monthly average temperature for the first location was 3˚C higher than the second location. High air temperatures can make lettuce plants curly. The solar radiation intensity factor means that the second location has a sufficient intensity for the growth of lettuce plants, while the first location is 1˚C hotter. This result is in accordance with Schneider et al. (2018) stated the temperature referred to is 15-2˚C from the monthly average temperature from the beginning of planting and seeding until the end of the harvest. In addition Zhang et al., (2022) stated the lettuce growth condition can setting by experimental procedures.

Production Results of Lettuce

The result shown that the net production results between the first and second locations experience a 30% difference from the production day (in a price of IDR 360,000). Differences arise due to the amount of production and other plant care. There is a 10% difference in plant maintenance costs (IDR 100,000) due to the difference in the number of pests that attack. Labor costs at the first location are IDR 160,000/person, while the second location does not require labor because the place results from a jointly owned business. The similarities between the two locations in the cost of raw materials and transportation (the buyer bears transportation). The result used the costing variable and in line with (Hasan, 2015), which the calculation of net production results through the costing variable, namely net income minus revenue

Differences in production yields are also due to plant care and fertility differences. Net income with the advantage of going to a second location. The second location is a bit in the cost of caring for the plant. The results of the plants in the second location are fresher, wider, and more abundant. The second location does not incur labor costs. These results are in accordance with Purbaningsih et al. (2022) and Rasti et al., (2020) which the components of all financing and production values are essential for knowing the productivity and income of a commodity

The first location benefits and yields tend to be small. The lettuce plants in the first location had small leaves, and 2% of the profits went to pay for the labor. The contribution of the water factor and sunlight can cause differences in the yield of lettuce production at the study site. The difference lies in the quality of the plants due to the levels of pH, dissolved substances, angle of incidence of light, and better temperatures,

thereby saving on plant maintenance costs. These results align with research Hariyanto et al. (2022) that each type of plant can produce well depending on the physical conditions of the area. In addition Fuentes-Castañeda et al., 2016, Maarif (2018) and Schneider et al., (2018) stated the quality of horticultural plants, aquaponics, and hydroponics, could be better. It will cause a lack of water in the stems and reduce the weight of the vegetables in kg. Furthermore, Lau & Mattson (2021) stated that upland plants such as lettuce that do not receive sufficient or excessive sunlight can cause plants to experience a deficiency of N and K nutrients which causes the leaves to turn yellow and brown.

A comparison of plant length, leaf length, and leaf width at the study sites can be seen in table 4 below.

Table 4. The Result Plant Length, Leaf Length, and Leaf Width

Location	Plant Length	Lear Length	Leaf With
First	23 cm	11 cm	7 cm
Second	30 cm	14 cm	9 cm

Source: Research Result (2022)

Based on the data above, it can be seen that plants in locations that are not exposed to direct sunlight have plant lengths of 7 cm and leaf lengths that are 3 cm longer and a width of 2 cm compared to locations that receive direct sunlight. The second location has the ideal size of green lettuce. These results are in line with Fuentes-Castañeda et al. (2016) that the plant length for mature lettuce is 25-30 cm, and the leaf length is about 14-15 cm with a width of 9-10 cm.

CONCLUSION

This study concluded that water and sunlight contribute to the production of lettuce. Production results are affected by water quality and the effect of water caused by adding nutrients. Locations exposed to the sun and high temperatures directly produce stunted plants. Locations that do not receive direct sunlight and have a suitable temperature for the plants produce plants with broad, healthy leaves. Differences in water and sunlight contribute significantly to crop production, especially in plant maintenance costs and the profits from lettuce production. Production differs based on the level of net production and crop fertility.

RECOMMENDATION

Future researchers are expected to be able to measure not only daily temperature but the temperature every hour of the day so they can see the level of temperature difference at certain hours for more accurate results in calculating temperature. Then the production results can be further studied, especially the problem of plant maintenance, and pay more attention to how the production results of the first trial location and the second location can be balanced.

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