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Evaluating the Efficacy of Misting for Microclimate Regulation in Greenhouse Environments: A Case Study on Packcoy (*Bracissa Rapaa Subsp. Chinensis*)

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ABSTRACT

Plant disasters usually occur due to the incompatibility of the environmental temperature with the temperature limit for plant growth. One example is the pakcoy plant, which requires exposure to direct light with a hot air temperature. Evaporative cooling is one of the methods to reduce temperature and increase the relative humidity of the greenhouse to create optimal climatic conditions for plants. One way of evaporative cooling is using a toolmisting (atomizer). This study aims to determine the effectiveness of misting in microclimate control (temperature and humidity). Greenhouse on the growth of pakcoy plants. This study used the direct observation method carried out during the planting period of pakcoy plants. Based on the results obtained, the lowest average temperature was in the 30 minutes misting of 27–30 °C, at misting 20 minutes 27–31 °C, meanwhile misting for 10 minutes 27–31 °C and without misting ranges from 32–38 °C. Air humidity on misting 30 and 20 minutes was between 81–89%, and treatment misting 10 minutes ranged from 82–89%, while without misting, ranging from 63–77%. Using misting as an effective control of temperature and humidity produces an average air temperature and relative humidity for the growth of pakcoy plants, namely a temperature of 26-31 °C and a humidity of 82-89%. The misting treatment with an interval of 20 minutes produced the highest number of leaves, namely 22 leaves, and the misting therapy with a gap of 10 minutes made the plants with the highest plant height and weight. The use of misting ignition time intervals significantly affects temperature but does not significantly affect humidity.

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1. INTRODUCTION (10 PT)

Climate is a part of the ecosystem that directly or indirectly influences the sustainable growth of food production. The leading indicators of climate change are changes in the pattern and strength of climate parameters: temperature, air humidity, rainfall, and wind speed. Erratic weather causes unstable temperature and humidity, making determining planting and harvesting times difficult. [1] From 2020 to 2050, Indonesia is expected to experience an increase in temperature and changes in rainfall.

Air humidity, temperature, and sunlight intensity affect plant growth and productivity. This is because each type of plant has a minimum and maximum temperature limit for each growth period when the temperature is very high. Growth slows down or stops regardless of water supply, and premature fall of leaves or fruits is possible. Plant disasters usually occur due to the incompatibility of environmental temperatures with plant growth temperature limits. One example is pakcoy plants that require direct light exposure with air temperatures not too hot.

Pakcoy is a kind of vegetable from the mustard family, and since pakcoy contains vitamins and nutrients necessary for the human body, the selling price is also high. Pakcoy can be developed and maintained from an economic and business perspective because of the increasing consumer demand, so the market opportunity is also high. Pakcoy plants can grow well in warm and cold places, so that they can grow in high and lowlands, but best in highlands.

One of the technologies created to control parameters that can affect plant growth is greenhouse technology, or can be called greenhouse. Evaporative cooling is one method to lower the temperature and increase the relative humidity in the greenhouse to condition the optimal climate for plants in the greenhouse. Evaporative cooling conditions the air by using liquid water vapor to directly or indirectly reduce the air temperature. One way of evaporative cooling is using a misting device (fog). The cooling system uses a misting tool to release droplets through a high-pressure nozzle.

2. MATERIALS AND METHODS

2.1 Study Area

This research was conducted in the Greenhouse of Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar. A greenhouse is a building with a structure in the form of a closed house that serves as a place for plant growth and is conditioned based on the environment following plant growth needs [2] In the tropics, greenhouses can protect plants from extreme weather changes such as rain intensity, temperature, and excessive solar heat [3] One of the plants cultivated in the greenhouse is pakcoy. Pakcoy plants require temperatures between 15 °C and 30 °C and air between 19 °C and 21 °C for good growth. A temperature of 13 °C for too long can cause plants to enter the reproductive growth phase too quickly. A humidity of 80–90% is required for pakcoy plant growth. Humidity above 90% inhibits plant growth [4]

2.2 Plant Seeds and Planting Media

Pakcoy seedlings were seeded for 14 days or until they had three true leaves. After seeding, pakcoy seedlings are transferred to planting media as a mixture of manure, soil, and firewood husks and placed into a greenhouse with a drip irrigation system installed as a water source for plant irrigation.

2.3 Sistem Misting Installation

The misting system uses a 12-volt, 100-psi DC water pump connected to a PE hose as a water distributor to the nozzle. The misting hose is installed at a height of 2.5 meters above the plant. After the misting is installed, testing the installation function and measuring the discharge from the misting are carried out. Then, set the misting ignition time for each treatment, namely for 10 minutes, 20 minutes, and 30 minutes, each of which is given a 60-minute break from 8 a.m. to 5 p.m. Next, observe and record microclimate data in the greenhouse in the form of air temperature and humidity, as well as pakcoy plant growth data in the form of plant height (cm) and number of leaves (strands), and record pakcoy plant production results (strands).

2.4 Observations of Parameters

Measurement of air temperature and humidity. Air temperature is measured using a thermometer that will be observed every hour starting from 8 am to 5 pm, which is done every 1 hour. Temperature measurements are carried out from transplanting plants until harvest. The temperature measured is the air temperature in the greenhouse. Air humidity is measured using a hygrometer, which will be observed every hour from 8 a.m. to 5 p.m., done every 1 hour. Temperature measurement is carried out from when the plants start transplanting until harvest. The temperature measured is the air temperature in the greenhouse.

Plant growth was observed by measuring plant height (cm) and number of leaves (strands) at 2-day intervals after transplanting until the pakcoy plants were harvested. When pakcoy plants were harvested, crown wet and dry weights were measured. Wet crown weight is the weight of the plant without roots measured when the plants are harvested. The crown dry weight is the weight of the plant crown when it no longer contains water. The plants were placed in an oven at 70 °C every 2 hours to reduce the water content in the plants until the water content value was constant. The crown's dry weight was weighed after harvest.

2.5 Data Analysis

Data processing is carried out by collecting observation and measurement data during research, then processing it using Microsoft Excel based on descriptive analysis functions, then analyzing statistically using various analyses or Analysis of Variance (ANOVA) and DMRT further tests with a signification rate of 5% using SPSS software.

2.6 Research Flow Chart

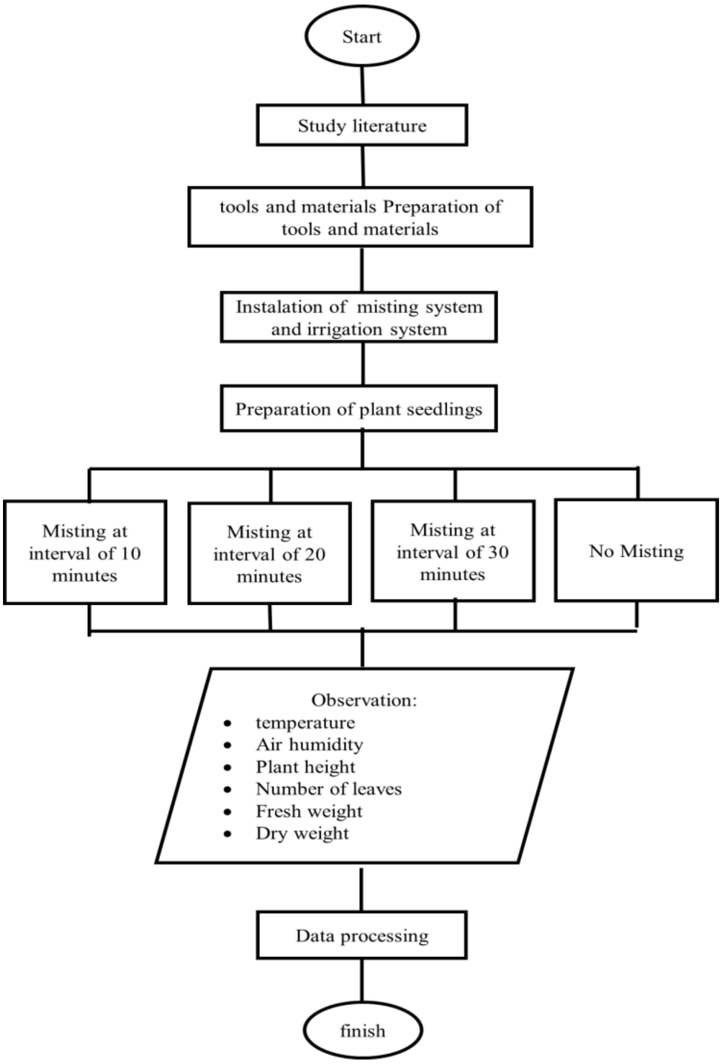

Figure 1. Research flow chart

3. RESULTS AND DISCUSSION (10 PT)

3.1 Air Temperature

The highest air temperature was found in the treatment without misting, while the lowest temperature was obtained by misting the treatment at intervals of 30 minutes. The resulting temperature difference states that misting can effectively reduce the air temperature in the greenhouse. Water mist produced by misting undergoes an evaporation process, and the water mist absorbs heat from inside the greenhouse so that the temperature in the greenhouse becomes lower.

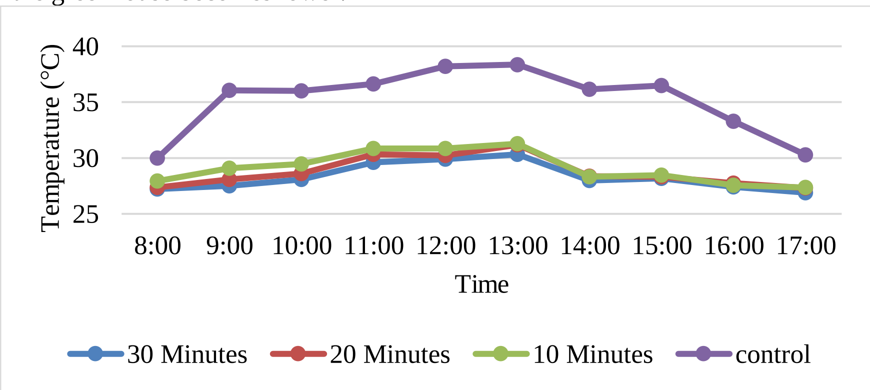

Figure 2. Average hourly air temperature during the planting period.

In Figure 2, you can see a significant difference between the air temperature in misting treatment compared to without misting starting from 8 a.m. to 5 p.m. The temperature during the day between 12 and 13-noon increases because the sun irradiates the temperature inside the greenhouse. The sun's intensity influences the air temperature in the greenhouse, whereas if the intensity of sunlight is more significant and very hot, the resulting air temperature is also higher. As stated by [1], the main factors that cause variations in discharge from application tools along lateral pipes and manifolds are operating pressure differences due to friction, minor losses, and elevation (head) differences.

3.2 Air Humidity

The humidity value was obtained in each treatment based on the relative humidity measurement. Namely, the 30-minute and 20-minute misting treatment ranged from 81-89%, the 10-minute misting treatment ranged from 82-89%, and no misting ranged from 63-83%. Relative humidity is the water vapor content contained in the air.

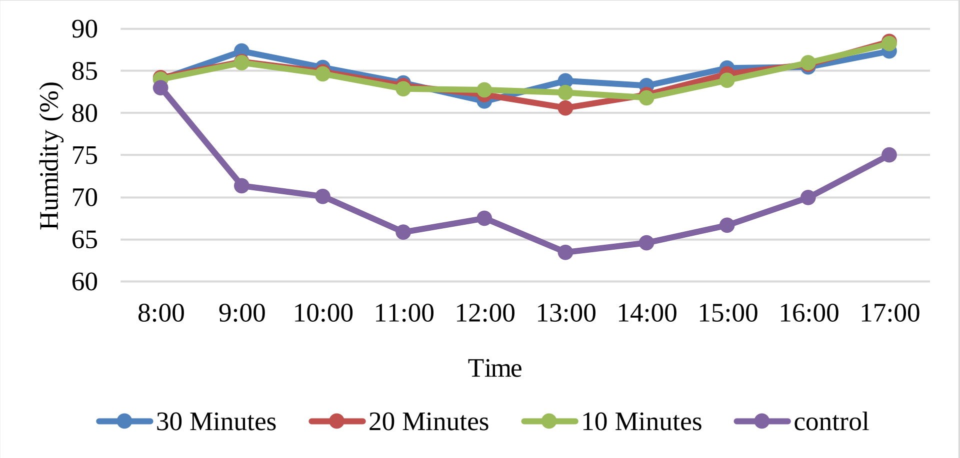

Figure 3. Average hourly air Humidity during the planting period.

Figure 3 shows that during the day, humidity decreases from 8 a.m. to 1 p.m., and increases in humidity occur from 1 p.m. to 5 p.m. This is because during the day, the temperature increases. Relative air humidity is inversely proportional to air temperature. The higher the temperature, the lower the air humidity. As the temperature increases, the air can hold more water, which causes the moisture to decrease.

Conversely, if the temperature falls, the air cannot resist the water melt, increasing humidity. According to [5], the air humidity will be smaller during the day because the sun's intensity influences the water content stored in the air. The higher the power of the sun, the smaller the air humidity.

3.3 Discharge of Misting

The use of misting as a temperature control utilizes droplets of water particles to increase the water vapor content in the air. Regulation of water discharge in misting is carried out to determine water needs that can result in optimal temperature and humidity control and efficient use of total water volume.

Table 1. Nozzle discharge based on misting ignition duration

Handling (minute)	**Duration of misting (minute/day)**	**Volume of water needed (ml/day)**	**The volume of water required by the planting period (l)**
30	180	11,952	537.84
20	140	9,352	420.84
10	80	5,904	265.68

In Table 1, it is shown that the duration of misting ignition affects the amount of water volume added per day. The 30-minute Misting discharge difference with the highest water discharge produces the lowest temperature. It shows that the greater the misting discharge, the greater the heat that can be absorbed by the fog grains so that the air temperature decreases. However, humidity can be high if the water discharge is too much. The decrease in temperature causes moisture to increase, which occurs due to the large number of mist droplets that water does not evaporate, and the amount of water vapor that the air can accommodate decreases so that it falls to the surface of the greenhouse. This is according to the statement of [6] that when the air temperature rises, the air can hold more water molecules, causing air humidity to decrease. Otherwise, if the temperature drops, the air cannot have water molecules, causing humidity to increase.

3.4 Plant Height

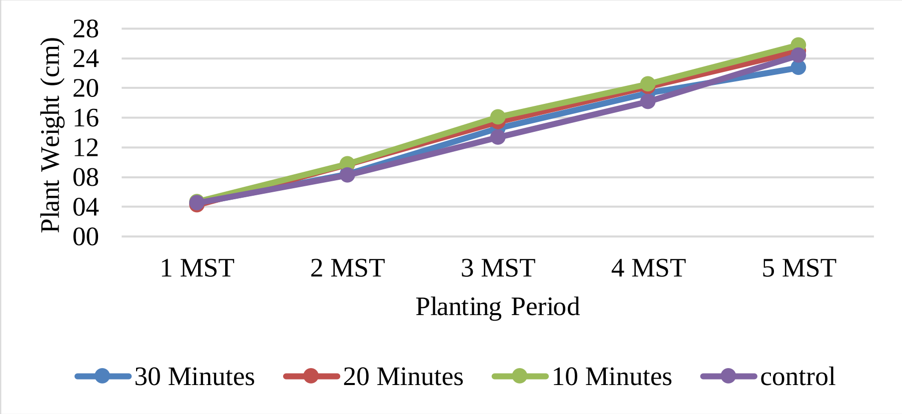

Figure 4. Plant Height Growth.

The average value of the largest plant height was found in the 10-minute misting treatment, which was 25.0 cm. This stated that the 10-minute misting treatment produced plants with the most optimal height compared to other treatments. The 10-minute misting treatment is the treatment that produces the most optimal average plant height. This is due to optimal environmental conditions following the growth of pakcoy plants. Misting it can increase humidity to create moisture following pakcoy plants' growth. According to [1], the humidity needed for developing pakcoy plants ranges from 80–90%. If > 90%, it will affect plant growth.

3.5 Number of leaves

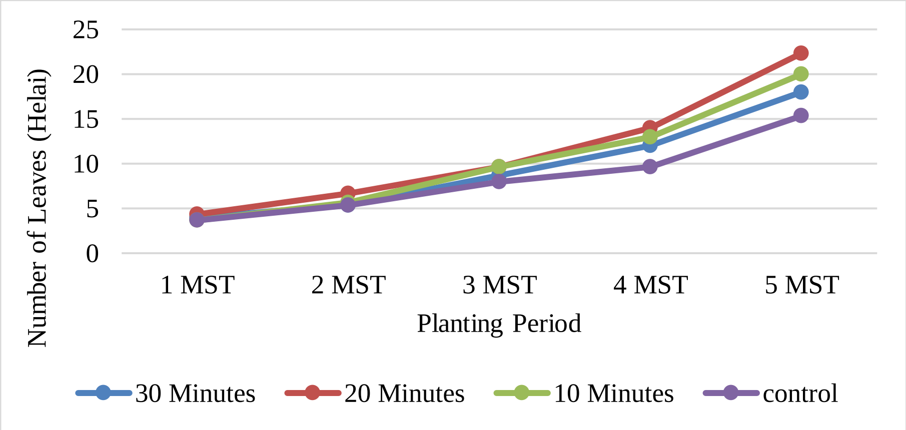

Figure 5. Growth in The Number of Leaves.

In the 20-minute misting treatment, the air temperature and relative humidity needed by pakcoy plants are sufficient so that their growth is better than other treatments. The least number of leaves is found without misting, which is 15 strands. The number of leaves produced without misting is the lowest due to the environment that is not optimal for the growth of pakcoy plants. Inappropriate air humidity causes the mouth of the stomata to close, which affects the photosynthesis process and does not run properly, so the leaf growth process decreases. According to [1], to achieve high yields and high quality, mustard pakcoy must be grown in an environment suitable for its growing conditions. The optimum growing environment can cause plant growth and development to be optimal. Plant growth is strongly influenced by genetic factors and the environment in which it grows

3.6 Biomass

Plant weights are examined by calculating the wet and dry weights of plants observed after harvest. The wet weight of the crown is calculated by weighing the rootless pakcoy plant by the time the plant has been harvested. The dry weight of the crown is calculated by reducing the plant's moisture content in the oven for 16 hours at 70 °C until the weight is constant.

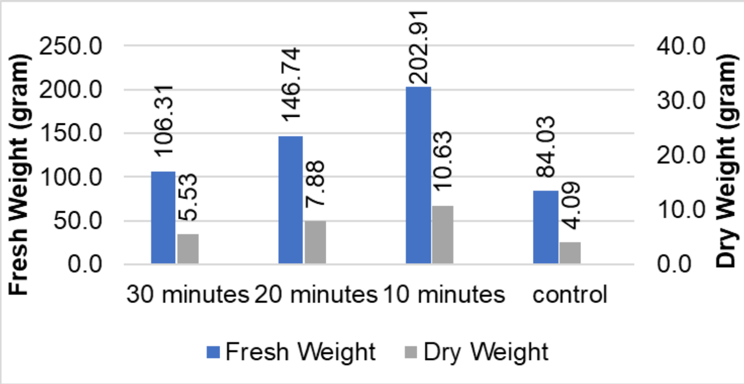

Figure 6. Biomass Chart.

Figure 6 shows that the 10-minute misting treatment has higher plant productivity than other treatments, while the lowest productivity is found without misting. The highest average dry weight found in the 10-minute misting treatment showed that the environment created was optimal for plant growth, and the absorption of nutrients occurred optimally. Without misting, it produces the lowest crop production because it has the least number of leaves. The number of leaves and plant height influence plant production or wet weight. The more the number of leaves, the higher the wet weight or crop production. According to [7], wet weights consist of all parts of pakcoy plants. The higher the plant, the wet weight will increase. In addition to plant height, the number and width of leaves also affect the increase in plant wet weight.

4. CONCLUSION (10 PT)

Based on the results of the research that has been done, it can be concluded.

1. Using misting to control air temperature and humidity effectively produces an average air temperature and relative humidity for pakcoy plant growth, namely temperatures of 26-31 °C and humidity of 82-89%.
2. Misting treatment with an interval of 20 minutes produces the highest number of leaves, 22 strands, and misting treatment with 10 minutes produces plants with the highest plant height and weight.
3. The use of misting ignition time intervals has a noticeable effect on temperature but no real effect on humidity.

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