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Intelligent mushroom cultivation house with fired clay balls to air humidification

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Abstract

The objective of this research is to study the effects of oyster mushroom cultivation in a smart mushroom cultivation facility with the fired clay balls that help retain moisture. The study compares the opening of mushroom caps in three systems: system 1, where caps are opened in a greenhouse with regular watering; system 2, where caps are opened in a greenhouse with soil pellets aiding moisture retention; and system 3, which involves caps opening in a greenhouse with soil pellets aiding moisture retention and automated watering controlled by a time-based system. The results of the study indicate that the use of fired clay balls can help reduce the average temperature by 0.87°C. Incorporating an automatic system further decreases the average temperature by 3.69°C. Adding the fired clay balls also increases the average humidity by 16.15%RH, and when combined with the automatic system, it results in a 19.76%RH increase. The use of the fired clay balls has no significant impact on water consumption and electricity usage. However, when combined with the automated control system, there is a significant reduction compared to manual watering. The system employing the fired clay balls shows an approximately 11.94% increase in yield, and when combined with the automated system, the yield increases by 22.41%. If farmers cultivate mushrooms with a quantity of at least 2,500 capsules, they can expect a daily profit of approximately 450 Baht, and the payback period is estimated to be 3.54 months.

Keywords: Fired clay balls, Oyster mushrooms, Greenhouse humidity control system

1. Introduction

Mushroom cultivation is a career that can create sustainable income for farmers. Mushrooms are living things that belong to the bacterial group (Fungi) that do not have young leaves, roots, or yellow leaves. They have a structure called hyphae. That allows the mushroom to absorb nutrients from the environment. Mushrooms come in a wide variety of shapes, colors, and sizes. Some types of mushrooms are highly nutritious and contain extracts that are beneficial to health. There are several types of mushrooms that are commonly grown and consumed, including button mushrooms or chae mushrooms. Button Mushroom: The most popular and widely available mushroom in the world. It's a winter mushroom. Originated in France. It has a mild flavor and is popular for use in various dishes. Shimeji mushrooms are dark-colored mushrooms and have a strong flavor. Often used in Japanese and Thai cuisine. Termite mushrooms: Mushrooms that have long strings, few roots, and a sweet taste. Oyster Mushroom: Oyster mushrooms, also known as Pleurotus ostreatus, are commonly grown mushrooms found in temperate forests. and subtropical regions around the world. It is grown commercially in many countries and is popular in Chinese, Japanese, and Korean cuisine. It has a delicate texture and a mild spicy flavor. It has a wide, thin, oyster- or fan-shaped cover that is white, gray, or tan, with gill lining beneath the cover. It has curly edges and is found in bushes or separately. Portobello Mushrooms are large mushrooms with a strong flavor. It is often made into noodles and grilled or fried. And there are many other types that are not mentioned here. Growing and consuming mushrooms is popular all over the world. But there are some regions where they are grown and eaten in abundance. For example, Europe is the birthplace of straw mushrooms and shimeji mushrooms. Asia tends to consume shimeji mushrooms and stem mushrooms. America tends to eat stem mushrooms. and button mushrooms Africa often eats shimeji mushrooms. And button mushrooms are popular in local cuisine. From the above, it can be seen that growing and consuming mushrooms has both nutritional benefits and a variety of uses in food.

Commercial mushroom cultivation in Asia contributes significantly to world mushroom production. This is because Asia is one of the three largest mushroom producing regions along with the European Union. Great Britain and the United States [1]. Large commercial mushroom cultivation areas in Asia include China and India, where various edible mushroom species are grown commercially [2]. In India, various types of mushrooms are commonly grown, including white button mushrooms (Agaricus bisporus), oyster mushrooms (Pleurotus spp.), straw mushrooms (Volvariella volvacea), snow mushrooms (Calocybe indica). In the northern region, they are called Chan mushrooms. In the northeastern region, they are called rhinoceros foot mushrooms (due to their size). In the central region, so-called white turtle mushrooms and shiitake mushrooms (Lentinula edodes) are grown commercially [2]. These mushrooms account for an important part of the total mushroom production in India [3]. Mushroom cultivation in Asia provides an opportunity to produce nutritious food in a sustainable manner, contributing to maintaining food security and fighting hunger among citizens [4]. An environment where Suitable for growing oyster mushrooms in a greenhouse, including temperature, humidity, and oxygen levels. and CO_2 levels, the optimum temperature range for mushroom growth is between 18°C and 25°C [5]. Relative humidity should be maintained between 80% and 95% [6] (Golub et al., 2023). To meet these conditions, many researchers have studied innovative automatic control systems that can be used in agricultural greenhouses. These systems help control temperature and humidity, creating an optimum environment for cultivation. mushroom in addition, using a proper ventilation system will help promote the growth of mushrooms. For example, carbon dioxide (CO_2) is an important gas for mushroom cultivation. CO_2 gas is used in the photosynthesis of mushrooms. During the growth period of the mushroom mycelium (Mycelium growth), the mushrooms will absorb CO_2 to use in building cells and tissues of the mushroom mycelium during the curing period. This will cause the mushroom mycelium to grow well and be strong [7]. However, CO_2 gas also has an effect on the mushrooms during the fruiting stage. If the mushroom cultivation house has the amount of CO_2 gas is too high and will cause the mushrooms to have abnormal characteristics, such as small mushrooms. Mushrooms do not fully expand. Mushroom flowers are pale in color. Or the mushroom has an unusual shape [8]. The amount of CO_2 gas is suitable for growing oyster mushrooms during the growth period of the mushrooms. If the amount of CO_2 gas is low, it will cause the mushrooms to grow more slowly. The amount of CO_2 gas is high, it will cause the mushrooms to have an abnormal appearance. Therefore, the amount of CO_2 gas in the greenhouse should be controlled appropriately. You may use the method of opening the ventilation in the greenhouse. or use an exhaust fan in order to reduce the amount of CO_2 gas in the greenhouse to an appropriate level, farmers should also measure the amount of CO_2 gas in the greenhouse regularly. To ensure that the amount of CO_2 gas is at the appropriate level. This will help increase the yield and quality of the mushrooms produced.

Maintaining the humidity level in a greenhouse is important for growing plants. Too high humidity can lead to disease and deterioration of plants, while maintaining proper humidity levels increases yield [9]. Various dehumidification technologies They exist in the agricultural industry to control humidity in greenhouses, including ventilation. high temperature treatment Condensation on cold surfaces and absorption by moisture-absorbing materials [10]. Ventilation is the most common method for reducing humidity. But it can cause additional heat, especially in climates where the outside air is hotter than the air inside the system [11].

2. Materials and methods

Preparation of mushroom inoculum [12], preparation of adhesive materials, sterilization, inoculation of mushroom lumps, curing [13], flower opening, and harvesting. product This is the general process of opening mushrooms all over the world [14]. Then wait to enter the system of opening flowers in greenhouses by comparing 3 systems of opening mushrooms (Table 1), namely System 1, the opening system. Flowers in a greenhouse with regular watering. System 2 is a system for opening flowers in a greenhouse with soil pellets to help retain moisture. System 3 is a system for opening flowers in a greenhouse with soil pellets to help preserve moisture and control irrigation. water with an automatic control system that uses time conditions Air temperature and humidity for irrigation, which is in the month of November 2023, a total of 30 days, in each model there will be 400 mushrooms grown in each greenhouse.

Table 1 Groups of the test

System	Symbol
1. Flower opening system in a greenhouse with regular irrigation	NS
2. A system for opening flowers in a greenhouse with soil pellets to help retain moisture.	HS
3. A system for opening flowers in a greenhouse with soil pellets to help retain moisture and control watering with an automatic control system.	AHS

Within the greenhouse where clods were added, 2,000 clods of clay were added. The clay lump is a clay lump with a density of clay used in the study equal to 1.98 ± 0.213 kg/m^3. The mixing technique is mixed with clay. Rice husks and agricultural materials are added before firing at a temperature of 1,200°C to create porous clay lumps inside. Can hold water well.

2.1 Control and monitoring system within the greenhouse

Inside the greenhouse, sensors are installed that monitor the temperature and humidity of the air. Send information through the internet network system. The frequency of recording data from the sensors is every 1 minute and then calculating the average in each data set. Outside the greenhouse, sensors are installed to monitor the temperature and humidity behavior of the air occurring in the environment. Inside the greenhouse, sensors will be installed in 3 locations to collect data on the temperature and humidity of the air inside the greenhouse at each level to see how they differ. The control system has two parts: Controls the fan to exhaust air that is hotter than the surrounding environment. The conditions for control are set: When the temperature inside the house is higher than outside by more than 3°C, use a fan to pull air from outside into the house. Another device that is controlled within this house is the water pump. The water pump is controlled by time. and controlled by the temperature and humidity of the air, as shown in Figure 1.

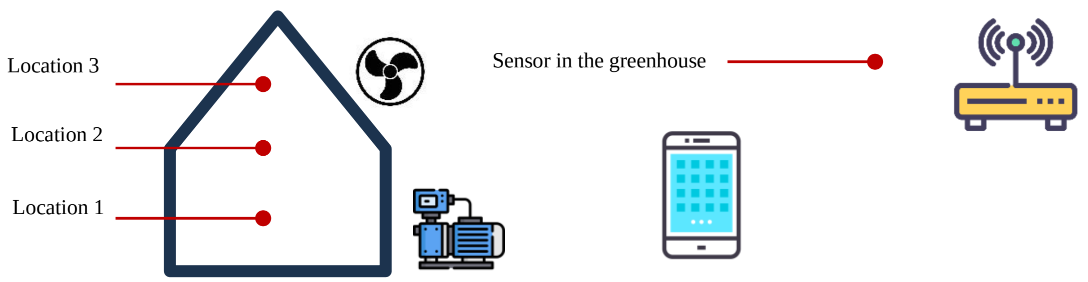

Figure 1 Control and monitoring system within the greenhouse.

2.2 Mushroom opening system in the greenhouse

System of flower opening in greenhouses by comparing 3 systems of flower opening, namely System 1, system of flower opening in greenhouses with normal irrigation (NS), System 2, system of flower opening in greenhouses with Soil pellets help preserve moisture (HS) and the third system is a system for opening flowers in a greenhouse that has soil pellets to help preserve moisture and control watering with an automatic control system that uses time conditions. Temperature and humidity of air in irrigation (AHS) as shown in Figure 2.

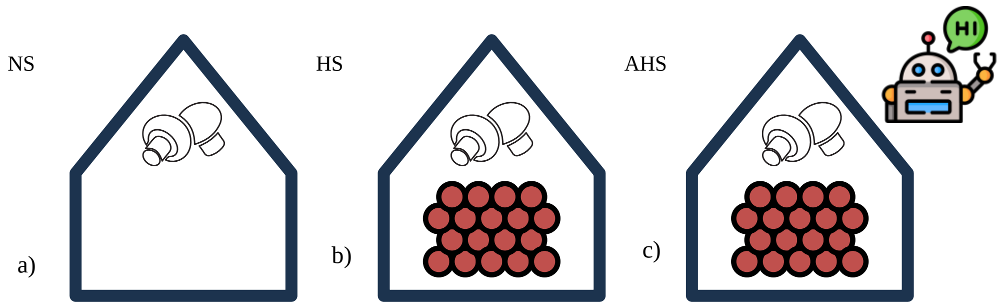

Figure 1 Compare all 3 systems a) NS b) HS and c) AHS

3. Results and discussion

After the monitoring evaluation test, it can be seen that the air temperature during the study was high during the daytime. The average temperature was 26.76 ± 5.11ºC. The average temperature of the greenhouses used in the study was System 1, the flower opening system in a greenhouse with normal irrigation (NS), System 2, the flower opening system in a greenhouse with pellets. Soil helps preserve moisture (HS) and the third system is a system for opening flowers in a greenhouse with soil pellets that help preserve moisture and control watering with an automatic control system that uses time conditions. The temperature and humidity of the air for irrigation (AHS) were 26.34 ± 6.25, 25.88 ± 5.26, and 23.06 ± 5.12ºC, respectively, which had a temperature difference within the environment of 0.41ºC, 0.88ºC, and 3.70ºC. Respectively, the highest internal temperatures were 42.86, 38.70, and 31.48ºC, respectively. It can be seen that inside all 3 types of greenhouses, the average internal temperature was lower than the environmental temperature with the highest differences being 1.44, 2, and 5.96ºC, respectively. That shows that putting clay blocks into the house results in a significantly lower temperature inside the house than outside the house at a confidence level of 95%. An example of the temperature data used in the calculation can be shown as shown in Figure 3.

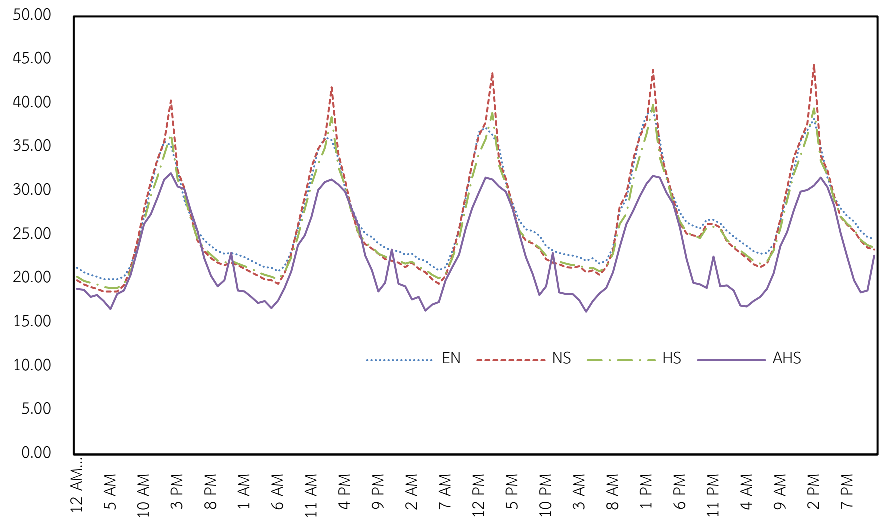

Figure 2 Air temperature data example

Humidity data for the air inside and outside the greenhouse is more visible than temperature. This is because there is a larger difference in numbers than in temperature. The outside humidity has an average value of 73.08 ± 15.52%RH, while inside the 3 types of greenhouses, namely NS, HS and AHS, the average value is 87.56 ± 17.39, 89.23 ± 15.75 and 92.84 ± 10.06 %RH, respectively. It shows that the addition of terracotta clay helped to increase the average temperature inside the house as well. The lowest humidity values that occurred in each pattern were equal to 46.04, 50.12 and 73.02%RH respectively, with the difference between the air humidity in the surrounding area. Inside the greenhouses, all 3 types were equal to 14.48, 16.15 and 19.76%RH respectively, showing that the soil pellets resulted in an even greater increase in the average humidity value. and adding an automatic control system with time conditions the temperature and humidity of the air will give entrepreneurs more income. When such data is created into a graph, an example of data for all 5 days can be shown as shown in Figure 4.

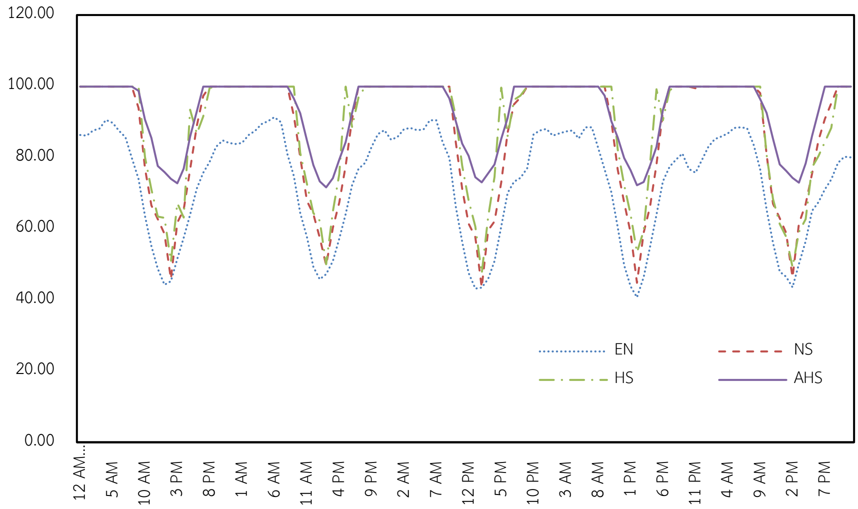

Figure 3 Air relative humidity data example

The yield per unit obtained from daily mushroom cultivation has an average of all 3 levels: NS, HS, and AHS, which are equal to 1.38 ± 0.58, 1.54 ± 0.62, and 1.69 ± 0.63 g/block respectively, according to the sequence shows the average yield per unit of crop. It can be seen that when the yield from the NS greenhouse is compared with the HS greenhouse, the yield of the HS greenhouse has a significantly higher average than the NS greenhouse and when comparing the production from greenhouses that use automatic control systems and those with control systems, it can be seen that the average yield is significantly higher than the normal type, as shown in Figure 5.

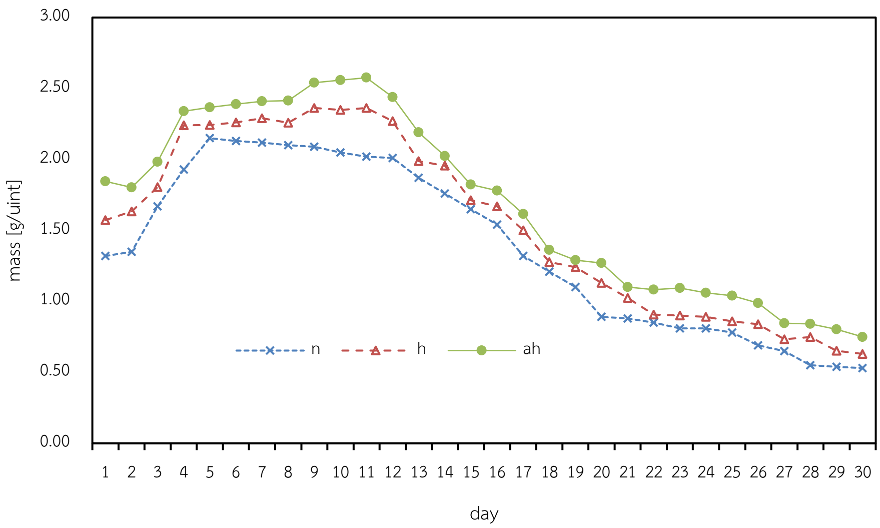

Figure 4 average mass per unit

From collecting data on water use at all 3 irrigation levels, namely NS, HS, and AHS, the value is equal to 18.74, 18.95, and 20.07 L/day, respectively, indicating that the addition of soil pellets significantly increased the humidity and decreased the temperature. But this does not result in the need for additional water in any way. Considering energy use, it can be seen that the average energy use is 0.17 ± 0.025, 0.16 ± 0.024, and 0.21 ± 0.026 kW, respectively. When comparing energy use with statistical values, it can be seen whether using or not using clay clods to increase humidity and reduce temperature do not have a significant effect on energy consumption. But when the automatic system is used, it will have a significantly greater effect on energy consumption than the previous system.

When the cost of using materials and equipment is taken into account to calculate fixed costs and variable costs and then used to calculate the selling price of 80 baht/kg, it can be seen that if farmers want to have a daily profit of approximately 450 baht/day, then farmers need to invest. To build a greenhouse that can open about 2,500 mushrooms in order to rotate the produce and sell it every day and when the payback period is calculated, farmers who invest will have a payback period of 3.54 months.

4. Conclusions

Studying the results of opening mushrooms in a smart mushroom greenhouse with soil pellets to help preserve moisture by comparing mushroom opening in 3 systems: System 1, system of opening flowers in a greenhouse with normal irrigation, System 2 for opening flowers in a greenhouse with soil pellets to help preserve moisture, and the third system is a system for opening flowers in a greenhouse with soil pellets to help preserve moisture and controlling watering with an automatic control system that uses time conditions. Observation of the temperature and humidity data of the air in the three irrigation systems shows that the use of clay pellets can help reduce the average temperature by 0.87ºC, and the use of automation also helps reduce the average temperature. down 3.69ºC. Considering the humidity of the air, it can be seen that the system that added soil blocks increased the average humidity value by 16.15%RH and the use of automation also helped to increase the average humidity value by 19.76%RH. Use water and energy. When comparing the system with earthen lumps to the manual watering system, it can be seen that the use of earthen lumps helps improve the quality of the air inside the house without affecting the amount of water used. Electrical energy consumption but the introduction of automatic control systems will have a significant effect on water and energy use compared to manual watering systems. The results of the study showed that the clay blocks were able to retain water in the system, which is consistent with another research. There are people who study the preparation of materials. or the ability to store moisture in the pottery itself [15-17]. The yield increased by approximately 11.94% and the increased yield from using clay pellets combined with an automatic system increased by 22.41%. When the cost of energy and production are taken into account as profit, it can be seen that when mushroom cultivation with quantities starting from 2,500 blocks, farmers will have a daily profit of approximately 450 baht and a payback period of 3.54 months.

5. Acknowledgements

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