Jambura Physics Journal (2023) Vol. 5 (1): 37-48
DOI: 10.34312/jpj.v5i1.19358

Jambura Physics Journal

p-ISSN: 2654-9107 e-ISSN: 2721-5687
Journal homepage: http://ejurnal.ung.ac.id/index.php/JPJ

THERMAL PERFORMANCE OF RESIDENTIAL HOUSE USING GREEN ROOF BY UTILIZING THE PASSION FRUIT PLANTS (*Passiflora edulis*) AS ROOF COVER

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Received: 08 April 2023. Accepted: 29 April 2023. Published: 01 May 2023

ARTICLE INFO

Keywords:

Green roof, vegetation; temperature

How to cite:

Mopangga, S., Jahja, M., Setiawan, D.G.E., Mursalin, Supu, I., Demulawa, M., Djafar, A.G., *et.al*. (2023). Thermal Performance of Residential Hause Using Green Roof by Utilizing The Passion Fruit Plants (*Passiflora edulis*) as Roof Cover. *Jambura Physics Journal*, 5 (1): 37-48

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https://doi.org/10.34312/jpj.v5i1.19358

ABSTRACT

Urbanization is the movement of people from villages to cities, this has caused an increase in population growth in urban areas resulting in increased demand for development which has reduced land for green spaces, green roofs are present as a farming concept amidst limited land in urban areas as well as assisting in passive cooling. The process of photosynthesis must play a role in roof shading. The selection of vegetation in the form of passion fruit vines as a roof covering material can spread up to 24 m, the object of research is a house in a housing complex by comparing two rooms, using a vegetation roof cover and without a vegetation roof cover, based on the results obtained a room with a vegetation roof cover experienced a decrease in temperature as the growth of vines covered the roof, the results obtained were a comparison between the two rooms, namely 0.1°C in January, 1.1°C in February and 2.6°C in March when the peak temperature is during the day.

1. Introduction

The rise in population growth has resulted in the growth and urbanization of cities, which has subsequently increased the need for new buildings and homes. This increase in demand for construction is a direct result of the expansion of urban areas due to population growth. Based on data from the Gorontalo Province Central Bureau of Statistics, the city of Gorontalo is experiencing population growth every year. Global economic expansion and population growth have led to urban expansion and urbanization, which has a negative impact on environmental heat accumulation (Aldawi et al., 2012; Yuliani et al., 2021) In addition, population growth causes an increase in energy use (Aldawi et al., 2012; Yuliani et al., 2021) Residential homes are one of the world's largest energy users and contribute greatly to greenhouse gas emissions, this is triggered by the use of air conditioners as active coolers (Yahaya & Ahmad, 2011).

Green buildings emerge as one of the concepts that provide solutions in low carbon development (Aldawi et al., 2012; Stein, 2018). One of them is by using passive cooling as a strategy in controlling the thermal comfort of the room, one which is by utilizing vegetation which can act as a direct barrier to solar heat which can be utilized around buildings such as the use of vegetation on roofs (green roofs) (Syamsul et al., 2022).

Achieving thermal comfort in green buildings depends on several factors, including air temperature, humidity, average surface temperature, metabolic activity, and clothing. In urban areas where space for conventional farming is scarce, green roofs can be a promising approach to incorporate vegetation into residential buildings. According to (Syahriyah, 2017)), green roofs can effectively regulate temperature and humidity levels in buildings, thus promoting thermal comfort for occupants.

The success of green roofs depends on their ability to integrate plant species that can adapt to the specific environmental conditions of the building, which may include wind, drought, and temperature. By selecting suitable plants, green roofs can effectively contribute to the roof's insulation and overall efficiency (Koryati et al., 2021; Yuliani et al., 2021) This passive cooling utilizes vegetation as a roof cover to create shadows which will certainly reduce the high temperature of the room (Fauzi & Yuslim, 2021) In addition, vines equipped with a wire frame as a media for vines will function to maintain humidity in dry areas, muffle sound, absorb dust and combustion gases, withstand exposure to radiation from the sun, and help lower room temperatures in buildings (Fibrianto & Hilmy, 2018) In addition to aesthetic appeal, passive systems can have a positive impact on the environment by improving air quality. This is achieved by increasing oxygen levels, among other benefits.

The system's effectiveness is based on how much the area will be protected from sunlight. In addition, natural vegetation makes a significant contribution to the production of thermal comfort. Vegetation around the house can provide shade (sunshade) in order to maximize the amount of indirect sunlight that reaches the house's surface. In urban areas with high population densities and rapid growth, urban plants can occasionally have an impact on the environment. The aim of this study was to figure out how the warm presentation and temperature decrease came about while utilizing passion fruit as a rooftop covering.

In summary, Sri Yuliani's study on the thermal behavior of green roofs in the humid tropics demonstrated that these roofs have significant thermal insulation capabilities. Specifically, the study found that green roofs can reduce thermal conductivity by up to 57.1% on concrete roofs and 90% on corrugated tin roofs. In addition, compared to non-green roofs, green roofs were found to significantly reduce heat transfer, with reductions of up to 56% on concrete roofs and 50.8% on corrugated zinc roofs. These findings suggest that green roofs can be a promising strategy for improving thermal comfort and energy efficiency in buildings in tropical regions.

The results of the moisture study (Bollman et al., 2021) showed that the shade structure managed to reduce the media temperature of the green roof during the day and increase the media temperature at night relative to the open media tray while reducing the light intensity (PAR) by around 40%.

The purpose of this study was to determine the condition of the roof surface temperature produced by a room with a roof covering and without a roof covering, the difference in thermal performance produced in rooms using a roof covering and without a roof covering, and what is the thermal comfort in a room using a roof covering. plants and without a roof covering.

2. Methode

Green roof is one of the ideas in thermal control that uses plants through scene plan, obtainment of fabricated vegetation and has become one of the wellknown ideas that arise in supporting improvement to limit carbon by executing approaches and projects to expand energy, water and building material reserve funds and increment the utilization of low innovation. Carbon [5,11]. This concept can diminish poisons as CO^2 in light of the fact that during the time spent photosynthesis free carbon is bound (fixed) into sugar as an energy stockpiling particle and deliveries oxygen (Rizaludin et al., 2020).

Vegetation plays a significant part in limiting air temperature and diminishing temperature or making a microclimate by using daylight to create nourishment for plants, and furthermore keeping direct openness to daylight so the surface temperature of building materials diminishes (Indrawati et al., 2020).

Previous research discussing the effect of vegetation in reducing room temperature has been carried out by Sri Yuliani, Jumriya regarding the effect of shade plants on houses and houses without shade plants and Boolman managed to reduce sun exposure in buildings by around 40% through the effect of shading vegetation (Bollman et al., 2021; Jumriya et al., 2019).

This green roof research was done quantitatively using experimental methods by comparing the thermal performance of buildings in rooms with and without roofs. Software and hardware will be used to analyze the obtained results. This analysis will be completed in the future for further development.

This research is located in a residential building which is Griya Otolomo Syariah Housing, Dembe II Village, Kota Utara District, Gorontalo City.

Figure 1. Research Location (Front View)

The object used in the study is a room with a roof covering that, measures 3 meters in length, 3 meters in width, and 3 meters in height, while a room without a roof covering measures 5.5 meters in length, 3 meters in width, and 3 meters in height. On the portion of the roof that is covered, a Sakura roof made of metal measures 4 x 3.2 meters.

This study measures building performance using vegetation from the ground propagated to the roof in the form of stilts and scaffolding in the form of para-para made of bamboo and iron wire, which provides the plant with support, furthermore, as a spot for plants to spread, as depicted in Figure 2.

The parts of the building that will be collected data taken in 3 layers of the building as shown in figure 3, are the roof surface temperature using a Thermo gun, the temperature and humidity of the attic air then the temperature and humidity of the room are taken using a Thermohygrometer.

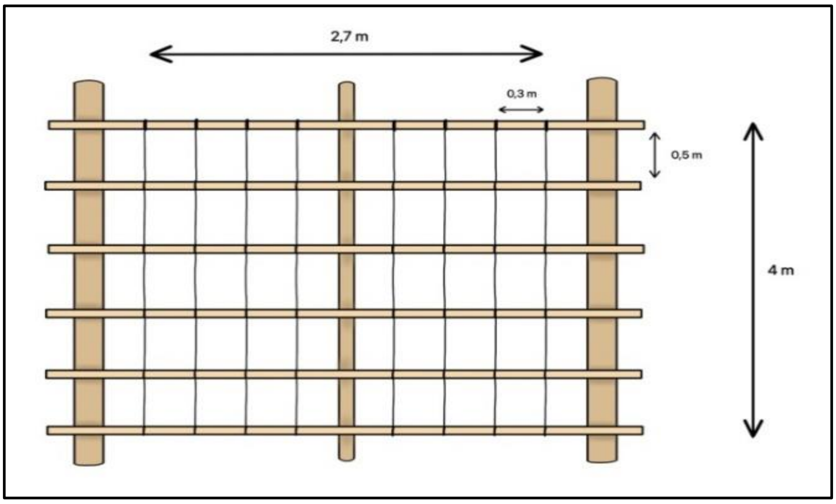


Figure 2. Para-para design.

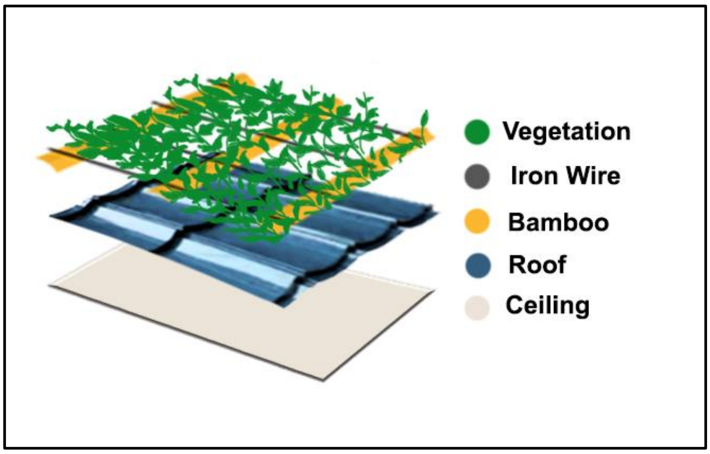


Figure 3. Illustration of research subjects arranged in layers on buildings

The study began on January 1, 2022, and ended on March 30, 2022, for a total of three months. It started by taking measurements every day for 24 hours of the room's temperature and humidity, the attic's temperature and humidity, and the material's surface temperature and solar radiation. The radiation occurred over the three days when the sun was hot.

3. Result and Discussion

Radiation has an intensity that changes every time, 13:00 as the highest point gives exposure to heat on the roof surface, the increase in heat is seen to rise higher during the day before falling back in the afternoon, this is in accordance with the intensity of solar radiation data in Figure 4.

According to Figure 4. an increase in solar radiation from morning to noon has an effect on exposure to solar heat flux on the material's surface. At 6:00 a.m., the roof's initial temperature was 25.5 °C on the outside with the vegetation covering and 25.6

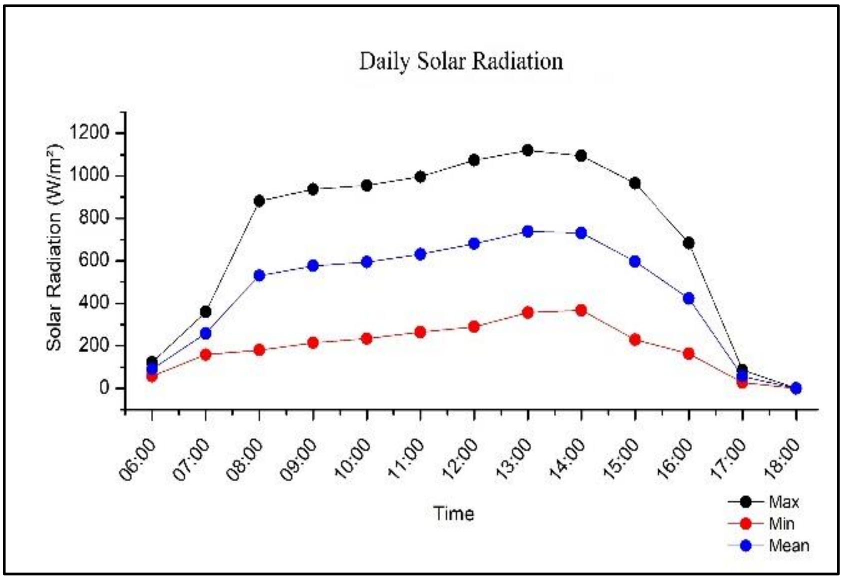
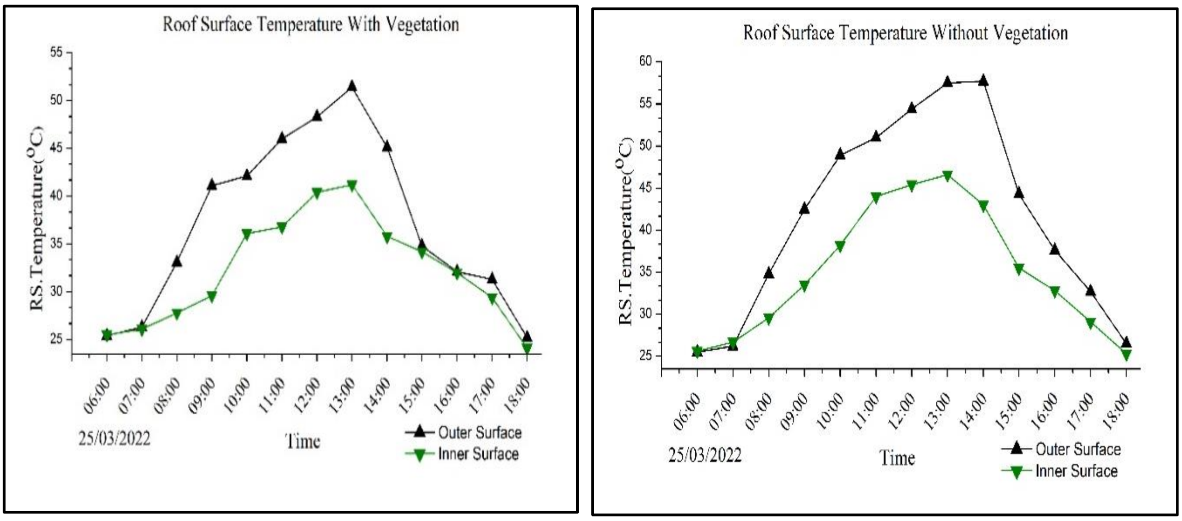


Figure 4. Daily Solar Radiation



(a) (b)

Figure 5. Roof surface temperature (a) with vegetation, (b) without vegetation

°C inside. This difference is because the material will equalize the air around it, which means that the air outside is cooler than the air inside the attic. The beginning of solar radiation, which began to raise the temperature of the surrounding air, was the cause of the subsequent rise in temperature, which began at 07:00. The outer surface temperature was 0.7°C higher than the inner surface temperature. This rises on an hourly basis until the difference decreases at 10:00. This could be because clouds are blocking the sun's rays. Up until 13:00, the temperature on the roof's outer surface reaches 51.4 degrees Celsius when covered with vegetation, while the temperature on the roof's inner surface drops to 41 degrees Celsius when covered with vegetation and 47 degrees Celsius when covered without vegetation. The temperature difference between the two outer surfaces of the roof is 6.3 degrees Celsius. The inside surface of

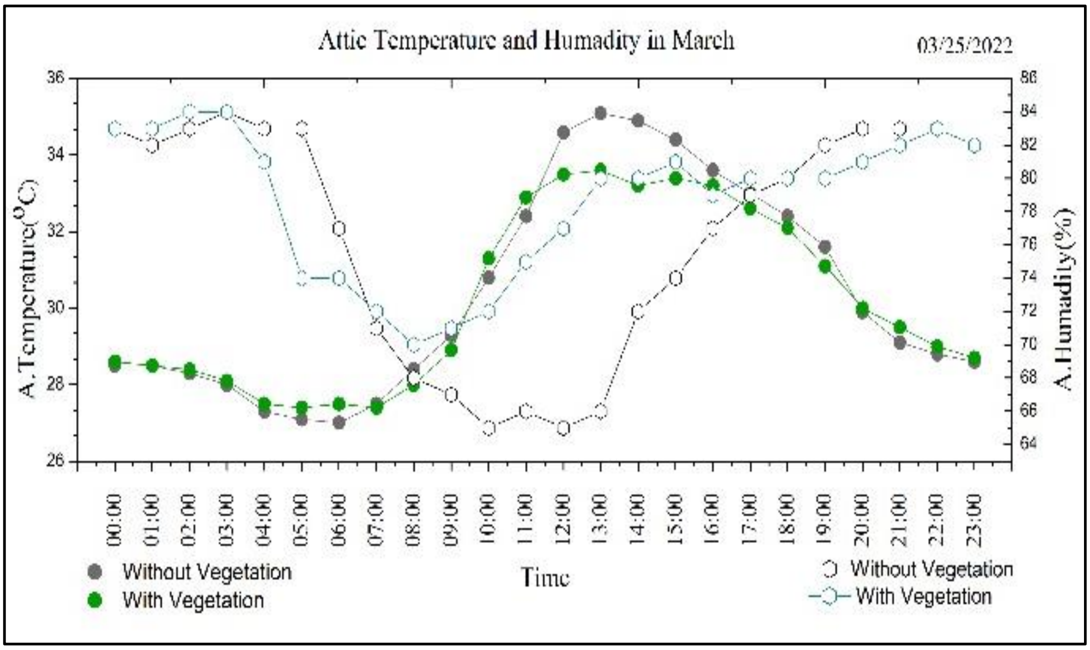


Figure 6. Daily attic temperature and humidity in March

the roof with vegetation at 10.4°C is significantly warmer than the outside surface of the roof with no vegetation at 10.7°C, so the difference in temperature between the two surfaces is significant.

According to the results of the measurements, the attic temperature began to rise during the day and gradually fell during the afternoon. As can be seen in figure 6, the measurements that are produced on roofs that do not contain vegetation are higher than those that do contain plants. Measurements taken on March 25, 2022, when it was hot. The attic without a vegetation roof cover had temperatures around 35.1°C at its highest point at 13:00, while the attic with a vegetation roof cover had temperatures around 33.9°C at its lowest point at 06:00, which is 27.4°C. The difference between the two attics, with and without a vegetation roof cover, is 0.3°C when the peak temperature is 1°C and when the lowest temperature is 07:00, which is 27.4°C.

The attic humidity shown in Figure 6, demonstrates that the attic without a vegetation roof cover has the lowest humidity, at 65 percent, at 10:00 and 12:00, while the attic with a vegetation roof cover has the lowest humidity, at 70 percent, at 07:00, and the highest humidity, at 03:00, both were the same, namely 84 percent humidity at night in the room with a lower roof covering, which caused the room temperature to be higher than in the room without vegetation cover.

Room Thermal Performance

Figure 8. illustrates the thermal performance of a room in January according to the condition of the vegetation cover in figure 7 The measurement results show that the room temperature without vegetation in January looks slightly greater than the temperature in the room without plants, the average temperature difference produced is 0.11°C per day at the peak at 13:00. In figure 8, the highest temperature is 32.3°C at room with a vegetation roof cover, while in a room without vegetation cover, which is 32°C, the difference produced by the two roofs is 0.1°C. The lowest temperature was at 05:00 with temperatures ranging from 27.1°C in a room with a vegetation roof cover

Figure 7. Vegetation Roof Cover Condition in January

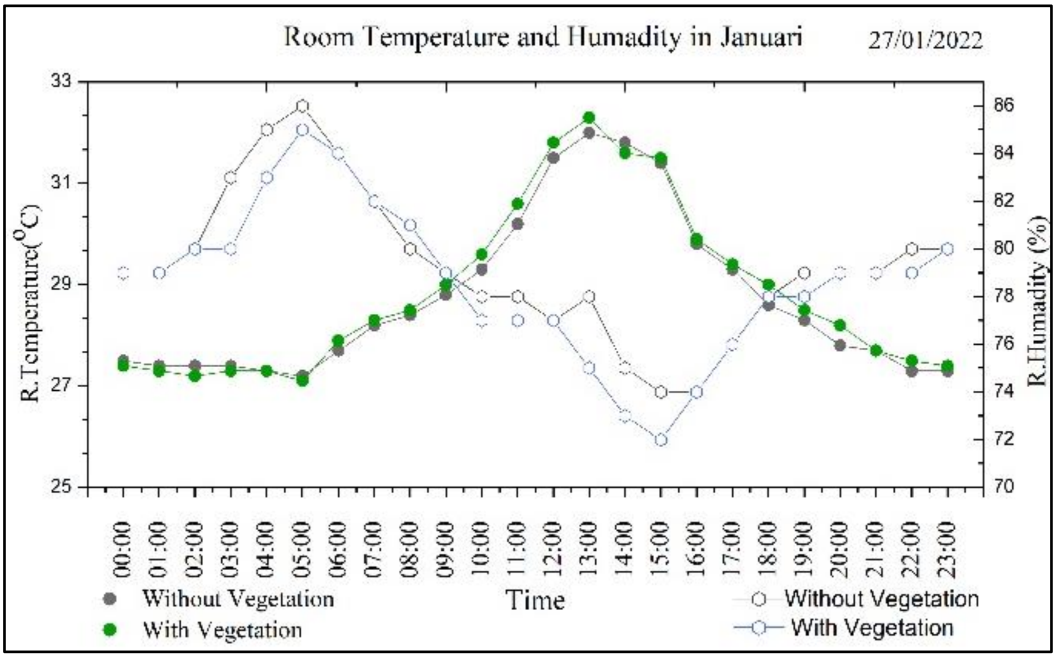


Figure 8. Thermal condition in January

while the temperature recorded in a room without vegetation cover at that time reached 27.2 °C.

The most noteworthy dampness in the room utilizing a rooftop cover is 86% and in the lower vegetation room is 85%. At the peak temperature of 13:00, the room humidity differs by 78% in the room without roof cover and by 72% in the room without roof cover, a difference of approximately 6%. At 13 o'clock, using vegetation cover or without vegetation cover, the highest humidity value is at 05:00, with a value of 85.3% in rooms using vegetation roof cover and 85.03% in rooms without a roof covering.

The lowest temperature of the room with vegetation is 27.44°C at 02:00 while without a roof covering at 04:00 with a temperature of 27.31°C. The temperature of the room

Figure 9. Plant growth in February

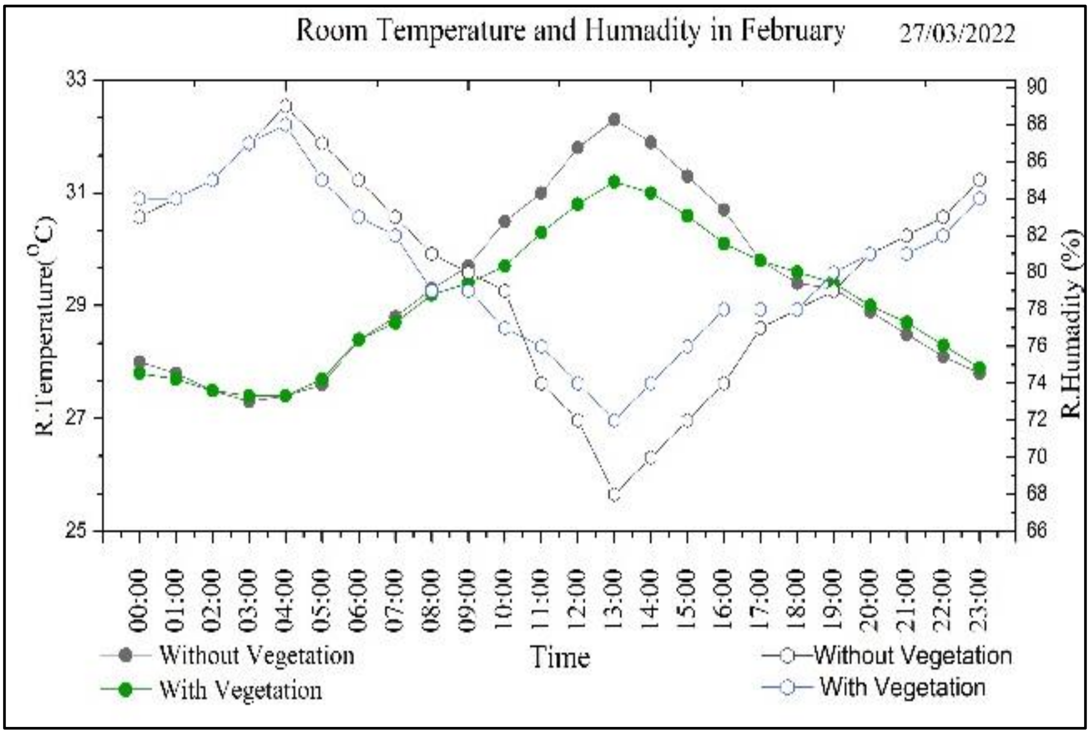


Figure 10. Thermal Condition in February

with vegetation becomes higher starting at 16:00 when radiation decreases rapidly. There are several things that might affect this in a room using vegetation cover, such as the presence of metabolic activity in the room and also the insulation effect caused by vegetation.

The difference in room temperature is shown in Figure 12, a clear comparison between the two rooms where the peak temperature is 32.1℃ at 12:00 on the roof without vegetation cover, while on the roof with vegetation cover it has a peak value of 29.5℃. at 13:00 the resulting difference is 1.5 °C which is 31.7 °C in a room without vegetation cover and 30.2 °C in a room without vegetation cover. The daily temperature of the

Figure 11. Vegetation Roof Cover Condition in March

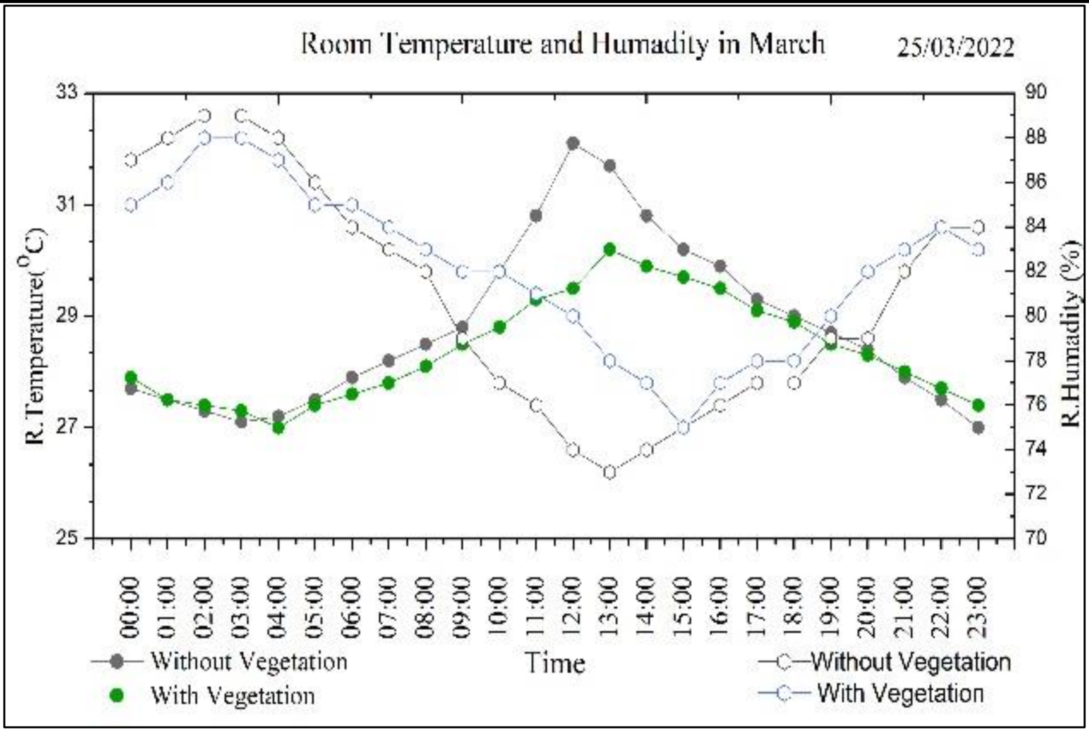


Figure 12. Thermal condition in March

room on March 16th represents the day with the highest daily temperature index, the condition of the passion fruit vines covering 90% of the roof, and weather conditions when it rains or when it doesn't rain have a different effect on the room's thermal performance. When it rains, the building receives less exposure to sunlight, so the performance of the room temperature will be lower than the room temperature when there is no rain.

The resulting temperature difference between the two rooms is 1.65°C, with the highest solar radiation occurring at 13:00. The insulation effect, the difference in area and volume between the two rooms, as well as the metabolic activity in the room, may be to blame for the higher room temperature in the room with the roof covering as afternoon approaches.

4. Conclusion

Based on the analysis of the results of measurements of the building's thermal performance in both rooms, it proves that Vegetation as a roof covering can reduce the temperature of the roof surface through vegetation shading as evidenced by the comparison of the two outer surfaces of the roof when it is 57.7°C on the roof surface using vegetation and 51.4°C on the roof surface without vegetation. This was also one of the references for decreasing the temperature in the room by looking at the differences in the condition of the vegetation roof cover during the study in January, February and March. The thermal performance in the two rooms resulted in temperature differences ranging from 0.11°C in January, 1.1°C in February and 2.6°C in March. The comfort condition of the house is still at a threshold condition when during the day in both rooms it ranges from 28.5°C-29.5°C in the room using vegetation and 29.5°C-32.3°C is the daily peak temperature in March**.**

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