The automatic temperature control device that stimulate the silkworms' food intake to increase the quantity and quality of native silk varieties.

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Abstract

Growing mulberries and creating products from silkworms has been considered Thai wisdom for a long time. Kalasin Province is another province where fibers from silkworms are applied. By weaving it into Praewa silk until becoming famous around the country. The organizing team therefore raised it in different places and the silkworms grew differently. Silkworms that raised by using temperature-controlled equipment grew better than those that raised without using temperature-controlled equipment. It was found that the average weight of 100 silkworms was 10.60±1.33 grams, the average length was 38.70±4.98 millimeters, the average width was 4.78±1.00 millimeters. The pods of the silkworms that raised by using temperature-controlled equipment entered the pods 4 days earlier than the silkworms that raised without using temperature-controlled equipment and also it was found that the size of the silkworm pods was larger. The weight of 100 pods was 46.38 grams, the average length was 33.06 ± 1.27 millimeters, and the average width was 11.38 ± 2.15 millimeters.

And when the silk threads obtained from silkworms using a temperature control device were able to withstand a tensile force of 11.41±1.53 newtons with a cross-sectional area of 0.02±0.00 square millimeters can be used to calculate the tensile stress as 600.80±132.78 newtons per square meter more than silk from silkworms that raised without using temperature-controlled equipment can withstand a tensile force of 9.58±1.31 newtons with a cross-sectional area of 0.02±0.01 square millimeters can be used to calculate the tensile stress as 482.46±114.78 newtons per square meter

Keywords: silkworm, silk quality, automation system

Introduction

The cultivation of mulberries and the production of products from silkworms have long been regarded as hallmarks of Thai wisdom. Kalasin Province stands out as a region where silkworm fibers are transformed into the renowned Praewa silk, particularly the "Kalasin Praewa Silk," which is distinguished by its quality, reputation, and unique characteristics, setting it apart from Praewa silk produced in other regions (Nittaya Wannakit: 2020).

Currently, farmers face challenges in silkworm cocoon production, especially during winter, which adversely affects the growth of silkworms. The temperature level and duration significantly influence the hatching of silkworm eggs, subsequently reducing the income of farmers engaged in silkworm rearing (Racha Rerksuphamongkol and Rungthip Masmethathip: 2015). Optimal conditions for silkworm development include temperatures of approximately 25-29 degrees Celsius and relative humidity between 65-80 percent (Department of Sericulture: M.P.P.). In discussions with farmers, Mrs. Penjai Phayangke and Mr. Phumjai Phayangke highlighted another issue: exposure to inappropriate temperatures results in reduced appetite among silkworms, leading to the excessive leftover of mulberry leaves provided for their consumption.

Anticipating these issues, the organizing team proposed that regulating the temperature in the silkworm rearing environment to optimal levels could significantly enhance their growth. Such regulation, coupled with careful monitoring of the silkworms' dietary intake, would ensure that they consume an adequate amount of mulberry leaves without waste, thereby addressing the issue of reduced cocoon production. Consequently, the team envisioned the integration of scientific knowledge and technology to innovate an automatic temperature control device. This device aims to stimulate the silkworms' appetite, thereby augmenting the quantity and quality of indigenous silk varieties.

Objectives

- To develop the automatic temperature control device that stimulate the silkworms' food intake to increase the quantity and quality of native silk varieties.

- To increase the quantity and the quality of native silk varieties.

Methodology

Part 1 Study weather changes during 2018 – 2022

Part 1.1 Study weather changes in the area of Kalasin Province.

Request information from the Upper Northeast Meteorological Center to study the temperature and relative humidity in Kalasin Province from the year 2018 to 2022. Then, compare the data obtained in each year. Weather changes include temperature and relative humidity.

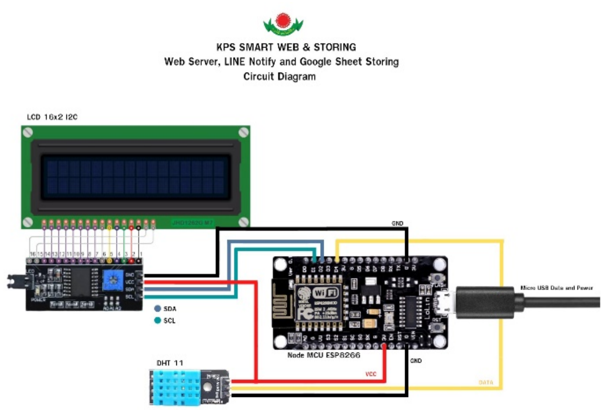
Part 1.2 Studying weather changes during the month of October 2022 to January 31, 2023.

Materials and equipment

1. NodeMCU board
2. 1 male-male and female-female jumper cable
3. Breadboard
4. Electrical wires (220v)
5. 1 Box
6. NodeMCU Shield (1 unit)
7. Sensor humidity & Temperature (1 unit)
8. LCD screen (1 unit)

Operation method:

1. Set the point to study at longitude 103°43'38” and latitude 16°27'24”, which is and area for farmers. Measure the temperature and relative humidity by installing an automatic system as shown in the diagram."



Picture 1 Automatic System Installation Diagram

2. Temperature measurement from October 2022 to January 31, 2023. Afterward, send the filled-in information to https://www.globe.gov/globe-data/data-entry.

3. Prepare a place to raise 100 silkworms aged 3 and 7 days, divided into two parts. In Part 1, 50 silkworms are raised in a room where the temperature fluctuates between 20 and 35 degrees Celsius. In Part 2, 50 larvae are raised in a room with a controlled temperature range of 18-20 degrees Celsius.

4. Divide the feeding of the worms into 3 meals: breakfast at 6:00 a.m., lunch at 1:00 p.m., and dinner at 6:00 p.m. During feeding, observe the remaining food by measuring the weight before and after giving.

5. Analyze the data to determine the relationship between the silkworms' food intake and the average daily temperature."

Part 2 Study the raising of silkworms involves the use of automatic temperature control equipment that promotes the feeding of silkworms.

Materials

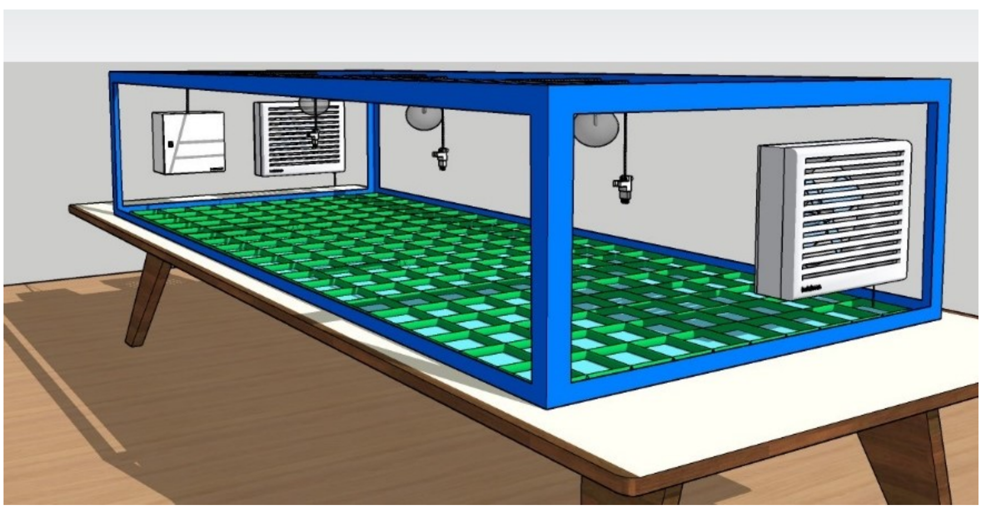
1. Control circuit board	4. Server box
2.Temperature sensor	5.Cover box
3.Incandescent bulb 60w	6.Ventilation fan 80w model LOOSEN

Operation steps

1. Bring third-stage silkworms, 7 days old, and raise them in an area equipped with automatic temperature control equipment. There are different temperature limits. Prepare two types of silkworm rearing areas: one room that uses the automatic temperature control equipment and another room that does not use it.

2. Conduct a comparative study of food quantities and growth rates of 100 silkworms by measuring the average worm weight, average length, average width, number of days before entering the pupal stage, and size of the cocoon of silkworms raised in rooms with different temperature controls.

The design of the automatic temperature control equipment shown in the picture.



Picture 2 draft of the automatic temperature control equipment.

Picture 3 the automatic temperature control equipment.

Working diagram of the equipment system

Install the equipment system as shown in the following diagram.

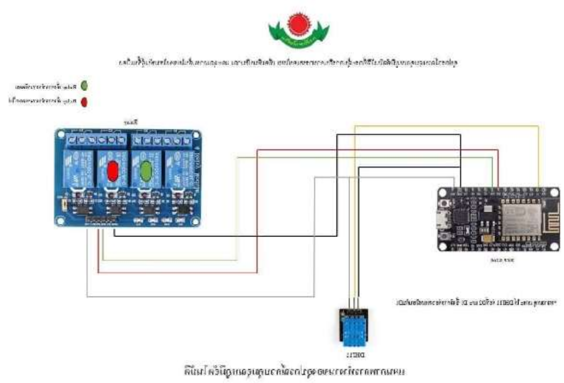


Diagram of the working principle of the automatic temperature control system

Working principle of the automatic temperature control device

Install a temperature control circuit within the facility, incorporating the automatic temperature control device to stimulate the feeding of native silkworms and maintain optimal conditions for their growth. When the temperature inside the control device drops to or below 24 degrees Celsius, the system will activate the heater, consisting of four 60W incandescent bulbs, until the temperature inside reaches at least 24 degrees Celsius. If the temperature inside the control device reaches or exceeds 28 degrees Celsius, users can activate the exhaust fan, comprising two 80W units, until the temperature inside drops to below 28 degrees Celsius. Additionally, integrate real-time data collection into a Google Sheet for monitoring purposes.

Part 3 Comparative study of the quality of silk from different rearing locations.

Materials

1. Force sensor model DFS-BTA 2. Vernier model Electronic digital caliper

3. Cienytec Vernier Labquest 2   4. Ruler

5. Hook.

Method of operation

1. Take the cocoons of the silkworm and ask for help from Mrs. Penjai Phayangke, a farmer of Ban Dong Kluai, Na Champa Subdistrict, Don Chan District, Kalasin Province. who has good experience in reeling silk to get silk threads of the same size.

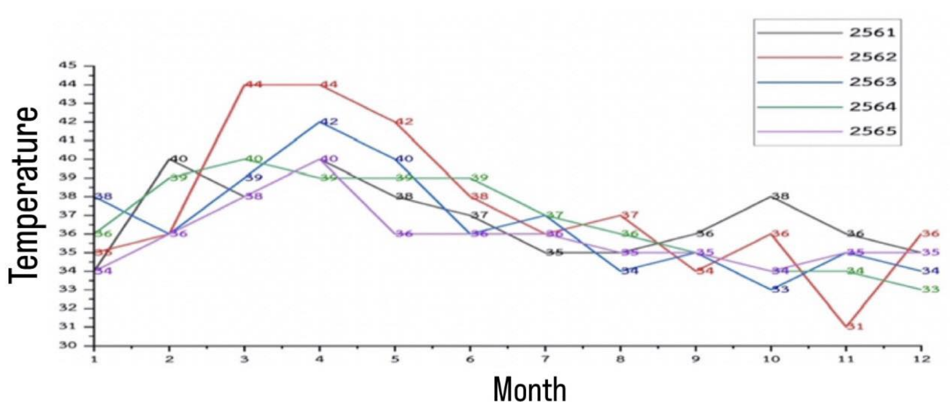
2. Cut silk threads to a length of 30 centimeters and measure the mechanical properties of the silk threads, i.e. the maximum tensile strength, the distance at the maximum tensile point, to calculate the tension, stress and modulus of elasticity of the silk thread. Compare the quality of silk from farming with and without equipment.

Experimental results and Discussion

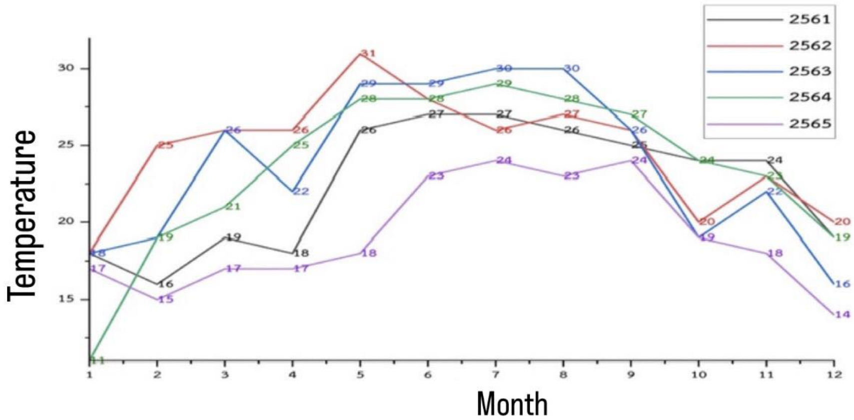
Part 1 studies weather changes during 2018-2022.

Part 1.1 studies weather changes in the area of Kalasin Province.

Using data from the Upper Northeast Meteorological Center, the study focuses on the temperature and relative humidity in Kalasin Province from 2018 to 2022. The results of the data analysis are as follows:



Picture 4 shows the average highest temperature in the Kalasin Province area from 2018 to 2022.



Picture 5 shows the average lowest temperature in the Kalasin Province area from 2018 to 2022.

It is observed from the charts that the climatic temperature in the area of Kalasin province between 2018 and 2022 exhibits varying average maximum and minimum temperature values each year. Additionally, it is evident that there are different average maximum and minimum temperatures each month throughout the years."

Part 2 Studying the raising of silkworms involves the use of automatic temperature control equipment that promotes the feeding of silkworms.

Study the growth and number of days before entering the pupal stage for 100 cocoons, as well as the size of each cocoon. Analyze the comparative data from the entire test. The results are as follows:

Table 1 shows the growth of silkworms raised both with and without the equipment.

Measured characteristics. Locations	Average weight of 100 silkworms (grams) (N=100)	Average length (mm) (N=100)	Average width (mm) (N=100)
With the equipment	10.60 ± 1.33	38.70 ± 4.98	4.78 ± 1.00
Without the equipment	9.24 ± 0.44	37.80 ± 2.08	4.18 ± 1.06

According to the table, it is evident that silkworms raised in different locations exhibited varying growth rates. Silkworms raised in locations equipped with automatic temperature control devices showed superior growth compared to those raised in areas without such devices. The average weight of 100 worms was 10.60 ± 1.33 grams, with an average length of 38.70 ± 4.98 mm and an average width of 4.78 ± 1.00 mm.

Table 2 shows the information regarding the cocoons of silkworms raised both with and without the equipment.

Measured characteristics. / Locations	Number of days before entering the cocoons, stage 3 - stage 5 (days)	weight of 100 cocoons (grams)	average length (mm) (N=100)	average width (mm) (N=100)
With the equipment	16	46.38	33.06 ± 1.27	11.38 ± 2.15
Without the equipment	20	44.32	30.52 ± 2.87	11.33 ± 2.05

According to the table, it is evident that the cocoons of silkworms raised using temperature-controlled equipment entered the cocoon stage 4 days earlier than those raised in places without temperature control equipment. Additionally, the cocoon size was observed to be larger in silkworms raised with temperature control. Specifically, the cocoons from silkworms raised with a temperature control device had a weight of 46.38 grams for 100 cocoons, with an average length of 33.06 ± 1.27 mm and an average width of 11.38 ± 2.15 mm.

Part 3 Comparative study of the quality of silk from different rearing locations.

When measuring the mechanical properties of silk threads to determine the maximum tensile force, the stretching distance at the point of maximum tensile force, and the modulus of elasticity of silk, and comparing them with silk grown without using the equipment, the results of the experiment are as follows:

Table 3 shows the quality of silk raised both with and without the equipment.

The quality of silk / Locations	Tensile force (Newtons)	Cross-sectional area (mm^2)	Stress (N/m^2)
With the equipment	11.41 ± 1.53	0.02 ± 0.00	600.80 ± 132.78
Without the equipment	9.58 ± 1.31	0.02 ± 0.01	482.46 ± 114.78

From the table above, it is evident that silk threads obtained from silkworms raised in locations equipped with temperature control equipment can withstand a tensile force of 11.41 ± 1.53 newtons, with a cross-sectional area of 0.02 ± 0.00 mm^2. This yields a tensile stress of 600.80±132.78 N/m^2, which is higher than that of silk from silkworms raised in locations without temperature control equipment. The latter can withstand a tensile force of 9.58 ± 1.31 newtons, with a cross-sectional area of 0.02 ± 0.01 mm^2, resulting in a tensile stress of 482.46 ± 114.78 N/m^2.

Table 4 shows the mechanical properties of silk grown with and without the equipment.

Silk quality	Stress (N/ m^2)	strain	Young's modulus (N/ m^2)
With the equipment	600.80 ± 132.78	1.08 ± 0.05	557.97 ± 131.56

Without the equipment	482.46 ± 114.78	1.09 ± 0.05	443.74 ± 103.31

From the provided comparison, silk obtained from silkworms raised in locations equipped with temperature control equipment exhibits a higher tensile stress, measured at 600.80 ± 132.78 N/m². The calculated strain is recorded at 1.08 ± 0.05. When these mechanical property values are utilized to determine the Young's modulus, it yields a value of 557.97 ± 131.56 N/m². In contrast, silk obtained from silkworms raised without temperature control equipment shows a lower tensile stress, measured at 482.46 ± 114.78 N/m², with a calculated strain of 1.09 ± 0.05. When these mechanical property values are used to calculate the modulus, it results in a value of 443.74 ± 103.31 N/m².

Overall, silk derived from silkworms raised with temperature control equipment demonstrates superior mechanical properties, with higher tensile stress and Young's modulus values, compared to silk from silkworms raised without such equipment.

Conclusion

Silkworms reared using automated temperature control equipment exhibited superior growth compared to those raised without equipment. It was observed that the average weight of 100 worms was 10.60 ± 1.33 grams, with an average length of 38.70 ± 4.98 mm and an average width of 4.78 ± 1.00 mm. Moreover, silkworms raised in temperature-controlled environments cocooned 4 days earlier than those raised conventionally. Additionally, the cocoons of silkworms reared in controlled environments were notably larger than those of their conventional counterparts, with a weight of 46.38 grams for 100 cocoons, an average length of 33.06 ± 1.27 millimeters, and an average width of 11.38 ± 2.15 millimeters.

Furthermore, silk threads obtained from silkworms raised using temperature-controlled equipment demonstrated enhanced mechanical properties. They withstood a tensile force of 11.41 ± 1.53 newtons with a cross-sectional area of 0.02 ± 0.00 square millimeters, resulting in a tensile stress of 600.80 ± 132.78 Newtons per square meter. This surpasses the tensile strength of silk obtained from silkworms reared in conventional farmer greenhouses, which withstood a force of 9.58 ± 1.31 newtons with a cross-sectional area of 0.02 ± 0.01 square millimeters, yielding a tensile stress of 482.46 ± 114.78 Newtons per square meter.

A comparative analysis of the silk quality derived from silkworms raised in temperature-controlled environments and those from conventional farmer greenhouses revealed that silk from temperature-controlled environments exhibited superior mechanical characteristics. The calculated tensile stress was 600.80 ± 132.78 Newtons per square meter, with a strain of 1.08 ± 0.05. Conversely, silk obtained from conventional farmer greenhouses demonstrated a tensile stress of 482.46 ± 114.78 Newtons per square meter, with a strain of 1.09 ± 0.05. The calculated Young's modulus value for silk from temperature-controlled environments was 557.97 ± 131.56 N/m², indicating superior mechanical resilience compared to silk from conventional farmer greenhouses, which had a Young's modulus value of 443.74 ± 103.31 N/m².

Discussion

The air temperature in Kalasin province from 2018 to 2022 exhibited varying average maximum and minimum temperature values each year, reflecting local weather fluctuations. Furthermore, monthly temperature averages also varied annually, complicating the planning of animal husbandry activities, particularly silkworm rearing. Hence, the implementation of a temperature control device to regulate the feeding environment for silkworms is deemed necessary.

Research indicated that silkworms raised with temperature control equipment matured approximately 4 days earlier than those without such equipment. Additionally, the cocoons from the controlled environment were larger, with 100 cocoons weighing an average of 46.38 grams, measuring an average length of 33.06 ± 1.27 mm, and an average width of 11.38 ± 2.15 mm. Moreover, the silk fibers harvested from these temperature-regulated silkworms demonstrated superior tensile strength, enduring a force of 11.41 ± 1.53 newtons across a cross-sectional area of 0.02 ± 0.00 square millimeters. This translates to a tensile stress of 600.80 ± 132.78 newtons per square meter. In contrast, silk from silkworms raised without temperature control withstood a force of 9.58 ± 1.31 newtons over a similar cross-sectional area, equating to a tensile stress of 482.46 ± 114.78 newtons per square meter.

The enhanced tensile stress in silk from temperature-controlled environments—600.80 ± 132.78 newtons per square meter compared to 482.46 ± 114.78 newtons per square meter from non-controlled environments—suggests that silk threads nurtured with temperature control are more resilient, bearing higher tensile forces without significant differences in cross-sectional area. Consequently, when these stronger fibers are woven into silk, the resulting fabric is more durable and less prone to breakage.

A comparative analysis of the silk's quality demonstrates that the calculated stress for silk from the controlled environment is 1.08 ± 0.05. When comparing the two sets of mechanical property values to determine the modulus value, silk from temperature-controlled environments shows a modulus of 557.97 ± 131.56, indicating its superior quality over silk from non-controlled environments, which has a calculated stress of 1.09 ± 0.05 and a lower tensile stress. This data underscores the benefits of using temperature control in silkworm rearing, yielding silk of higher tensile strength and quality.

References

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Appendix

The automatic temperature control equipment.

Measuring the maximum tensile strength and the distance at the maximum tensile point.

Silk from silkworms raised with the automatic temperature control equipment.