



IRAQI
Academic Scientific Journals



العراقية
المجلات الأكاديمية العلمية

TJAS
Tikrit Journal
for Agricultural
Sciences

ISSN:1813-1646 (Print); 2664-0597 (Online)

Tikrit Journal for Agricultural Sciences

Journal Homepage: <http://www.tjas.org>

E-mail: tjas@tu.edu.iq

Evaluation of oome modifications of langstroth hives used in breeding *Apis Mellifera* L. honey bees and measuring changes in temperature and humidity using a new computer system

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KEY WORDS:

Thermal contrast; *Apis mellifera* L.; computer system.

Received: 21/10/2023
Revising: 18/04/2024
Proofreading: 28/04/2024
Accepted: 29/04/2024
Available online: 30/06/2024

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ABSTRACT

The study was conducted in the researcher's apiary located in the Salah al-Din governorate / Iraq. The experiment took place during the winter months of January, December, and February of the year 2021-2022 Which aims to evaluate the Overwintering period based on the temperature and humidity inside Lancastroth cells using a computer monitoring system. 15 cells were used in the experiment. were divided into different treatments: T1 as the control treatment using the usual Lancaster cells, T2 using Langstroth hives coated with secondary ceilings, and T3, T4, and T5 using Langstroth hives coated with adhesive walls of cork, Polyvinyl chloride (PVC), and Alkabon, respectively. The results of the statistical analysis of the data obtained from the computer control system showed that the treatments led to the preservation of heat inside the cells by preventing heat leakage to and from the cells. Additionally, there was a highly significant decrease ($P \leq 0.01$) in the relative humidity recorded inside the cells and brood by the computer control system during all experimental periods and the general average. The average temperature during winter 22.30, 30.25, 27.64, and 27.53 °C, while the humidity was 79.93, 66.81, 64.95, 61.34, and 62.44% in the treatments.

تقييم بعض التحويلات لخلايا لانكسترت المستخدمة في تربية نحل العسل *Apis mellifera*

L. وقياس التغيرات في درجات الحرارة والرطوبة باستخدام نظام حاسوبي جديد

محمد شاكر منصور

قسم وقاية النبات، كلية الزراعة، جامعة تكريت، العراق

الخلاصة

اجريت هذه الدراسة في منحل يقع في محافظة صلاح الدين خلال أشهر كانون الثاني، كانون الاول و شباط من فصل الشتاء للعام 2021-2022 وتهدف تقييم التشتية على درجات الحرارة و الرطوبة داخل خلايا لانكستروت باستخدام منظومة المراقبة الحاسوبية، استخدم في التجربة 15 خلية تم توزيع الخلايا على المعاملات هي T1 : معاملة السيطرة (خلايا لانكستروت اعتيادية)، T2 : خلايا لانكستروت مغلقة بالسقوف الثانوية T3، T4 و T5 خلايا لانكستروت مغلقة بلاصق الجدران من الفلين، البولي فينيل كلوريد (Polyvinyl chloride) PVC و الكابون على التوالي، بينت نتائج التحليل الاحصائي للبيانات المتحصل عليها من منظومة المراقبة الحاسوبية أن المعاملات ادت الى الحفاظ على الحرارة داخل الخلايا من منع تسرب الحرارة من و الى الخلايا كذلك انخفاض عالي المعنوية ($P \leq 0.01$) في الرطوبة النسبية المسجلة داخل الخلايا و الحضنة بواسطة منظومة المراقبة الحاسوبية خلال كافة فترات التجربة و المعدل العام اذ بلغ معدل الحرارة خلال فصل الشتاء 22.30، 30.25، 27.64 و 27.53 م° في حين بلغت نسبة الرطوبة 66.81، 64.95، 61.34 و 62.44 % في المعاملات T2، T3، T4 و T5 على التوالي.

الكلمات الافتتاحية: التباين الحراري، *Apis mellifera* L.، منظومة حاسوبية.

INTRODUCTION

Bees are incredibly valuable insects due to their beneficial contributions to humans, plants, and the environment. They produce various products that are both nutritional and therapeutic, making them highly valuable to humans. Beekeeping is known for its high productivity and flexibility, as bee colonies have a significant storage capacity and there is a constant and uninterrupted demand for their products from consumers. This distinguishes beekeeping from other agricultural products (Rasha *et al.*, 2021). Climate effects are a crucial factor that affects the activity of honey bee colonies. Bees react to extreme climate conditions either behaviorally or physiologically. If such factors persist, bees lose their energy, and their density inside hives decreases (Husain *et al.*, 2020). The decrease in honey bee production continues until it eventually ceases, and their resistance to pests and pathogens is lowered. This can ultimately lead to the complete death of the colonies (Daniel *et al.*, 2023). Low temperatures play a significant role in affecting honey bee colonies.

Bees respond to low temperatures by forming a cluster inside the hive, tightly surrounding the brood area. This clustering helps maintain warmth and protect the brood from the cold environment. As the air temperature decreases, bees compact and adhere to each other more tightly, resulting in a smaller cluster size. This behavior helps conserve energy consumption for heating (Krouholé *et al.*, 2022). Bees employ a kinetic mechanism in their bodies to convert cold air into hot air, effectively distributing heat throughout the cluster. Workers flap their wings to expel cold air currents and reposition themselves from the cluster's center to hotter areas, and vice versa. Periodically, workers at the cluster's periphery, which directly face the outside air, cool down until the temperature reaches the appropriate natural levels (Ferland *et al.*, 2019 & Ahmed and Ren, 2023). Accurate temperature regulation is,

therefore, essential for proper development, with brood temperature strictly controlled within a temperature range of 32 to 36°C (Ugoline *et al.*, 2023). Bees spend the winter without any deterioration or damage to their tissues, particularly the reproductive tissues. Female worker bees gather in a clustered form with the queen at the center, providing the necessary heat (Stabentheine *et al.*, 2010; Salih *et al.*, 2023). During the winter, low temperatures cause a significant decrease in egg production, with the queen ceasing to lay eggs. This reduction in egg production leads to a decrease in the population of worker bees, either due to their natural aging process or the increased efforts they make to support their colony.

Required from Honeybees to maintain a specific temperature range within the cells to ensure optimal bee activity and development (Flores *et al.*, 2018; Usha *et al.*, 2020; Jalil, 2023). Furthermore, the prevalence of varroa mite infestation is heavily influenced by temperature. It spreads more rapidly in colder climates compared to warmer ones. So, this study aimed to evaluate the measuring changes in temperature and humidity by using a new computer system in some modified langstroth beehives during winter season.

MATERIALS AND METHODS

The study was carried out at a private apiary owned by the researcher, the issue of low temperatures in apiaries. The study also examined the impact of different affordable packaging methods, readily available in local markets, on thermal and humidity fluctuations inside the hive. To monitor temperature and humidity levels, a computer-based system known as the Thermal Regulation Monitoring System in Bee Hives, along with the BEEHIVE weather station program.

The experiment involved the use of 15 hybrid bee cells *Apis mellifera* L. sourced from Iraqi apiaries. Figure (1) shows the layout of the experiment, with three cells labeled A, B, and C. Each cell contains one hive on five frames. The hives are identical in terms of the strength of the bees, breed, and the age of the queens. The frames and hive boxes are made of the same type of wood and have similar shapes and measurements. It is ensured that the boxes are free of diseases and pests. Transactions with three cells for each transaction are: And as in Figure (1):

- A.** T1: control treatment.
- B.** T2: Lancaster cells encapsulated secondary ceilings.
- C.** T3: Langstroth hives coated with cork wall adhesive
- D.** T4: PVC-coated Langstroth hives
- E.** T5: Alcabon-encapsulated Langstroth hive.



Figure 1: the packaging of Langstroth hives with different types of wallpaper

Designing the computer control system

The computer monitoring system used in the experiment is an electronic system programmed to monitor fluctuations in temperature and humidity inside the hives. The system is equipped with a microcontroller that is connected to sensors and collects data periodically for 24 hours or more. This collected data is then compiled and analyzed using an analytical chart that indicates the areas of change and variation in temperature and humidity.,(Saleh, 2021). The system consists of two important parts:

Hardware: The hardware part includes three essential components that collectively form the electronic circuit of the system. These components are not specified in the provided information.

Software: The software part is responsible for programming and controlling the microcontroller. It enables the system to collect, store, and analyze the data obtained from the sensors. The specific details of the software are not mentioned in the given information.

- A: Start by connecting the first end of the sensor cable to the ports installed on the container box of the system. Make sure that each sensor port is connected to the corresponding sensor that represents the intended cell.
 - B. Place the second end of the cable, which contains the sensor, in the cell and in the brood area of the beehive. Ensure that the sensor is positioned correctly for accurate readings.
 - C. Once the sensors are connected, the system will start collecting data on the temperature and relative humidity within the beehive.
 - D. The collected data is then processed by the software component of the system. This involves analyzing and organizing the data for further use.
 - E. The processed data is presented to the user through a user-friendly interface. This interface can be accessed either through software installed on a computer or through a mobile application.
 - F. The user can monitor the temperature and relative humidity readings of the beehive in real-time through the interface. Graphs or charts may be used to visualize the data for easier understanding.
 - G. The system also enables the user to set up alerts or notifications based on predefined thresholds. For example, if the temperature in the beehive exceeds a certain limit, the user can be notified via email or SMS.
 - H. The data collected and processed by the system is stored securely. This ensures that the user can access historical data and track changes in temperature and relative humidity over time.
- Overall, the system helps beekeepers manage and monitor the temperature and relative humidity levels in their beehives, providing valuable insights and enabling them to take necessary actions to ensure the well-being of the bees the figure (2) shows Method of connecting the thermal regulation system of honey bee cells to ten cells.

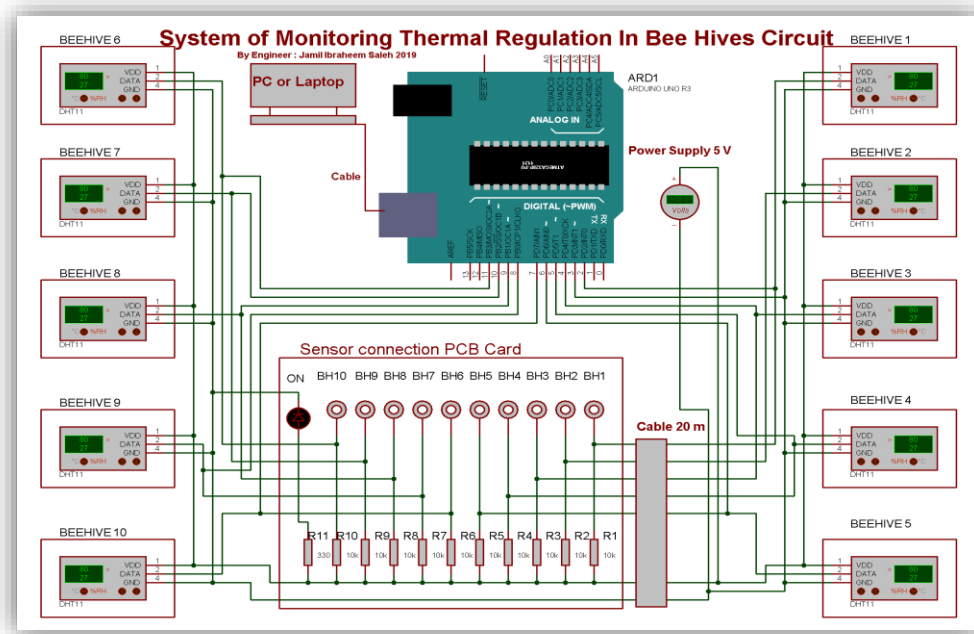


Figure 2: The computer monitoring system of honey bee cells to ten cells,(Saleh, 2021)

Statistical analysis

The statistical analysis of the data was carried out using the ready-made statistical program SPSS version 26 using the complete random design (CRD), and the differences between the means were compared using the Least Significant Difference L.S.D. test at the level of significance of < 0.05 .

RESULTS AND DISCUSSION

The computer monitoring system recorded temperatures and humidity inside the beehives during October 2021. The data collected was analyzed using the statistical program SPSS version 26. The statistical analysis was done using a complete random design (CRD), and the means were compared using the L.S.D. test at a significance level of 0.05. Based on the results and analysis, it can be observed from Figure 3 that encapsulating the honey bee cells had a significant effect on the temperatures and humidity recorded inside the hive. The study found that the temperatures recorded inside the encapsulated cells were significantly higher compared to the control treatment (T1). Treatments T3 and T5 recorded the highest temperatures, reaching 30.50 and 32.89 C, respectively, compared to 17.16 C in the control treatment. On the other hand, the percentage of humidity recorded in the encapsulated cells treatments was lower than that in the control treatment. The percentage of humidity recorded was 65.41%, 60.79%, 65.11%, 55.14%, and 57.59% in the treatments T2, T1–T5, respectively. It is worth noting that the control treatment had a higher humidity level compared to all the treatments that used encapsulated cells.

Overall, the results suggest that encapsulating the honey bee cells can lead to significantly higher temperatures but lower humidity levels inside the hive. This information can be useful for beekeepers to optimize hive conditions and improve honey bee health.

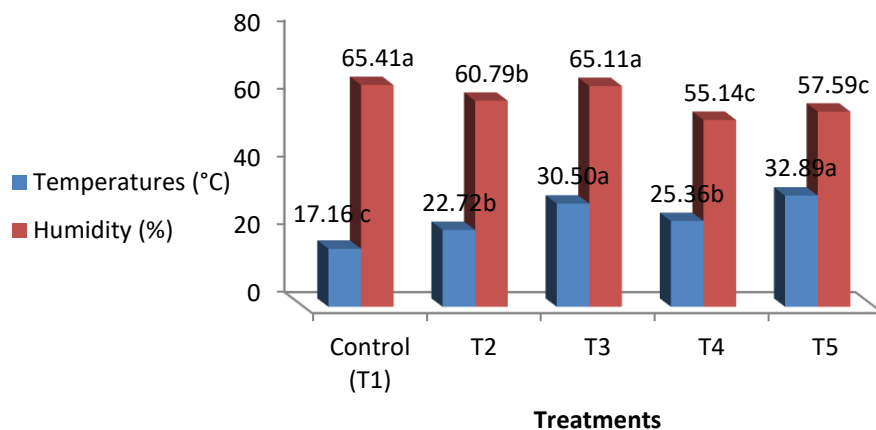


Figure 3: Temperatures (°C) and humidity (%) recorded inside the beehives by the computer monitoring system during October 2021

*T1 represents the control treatment, and T2, T3, T4, and T5 represent the cell wrapping treatments with secondary ceilings, wall adhesive, PVC, and Alkabon, respectively.

*Averages bearing different letters indicate a highly significant difference between the treatments

In November, the control treatment (T1) had the lowest temperature at 12.16°C, while treatments T3, T4, and T5 had the highest temperatures at 27.93°C, 29.72°C, and 27.23°C, respectively. Regarding humidity, treatment T5 had the lowest humidity percentage at 69.21%, followed by treatments T2, T3, and T3. These treatments did not differ significantly from each other. The control treatment had the highest humidity percentage at 89.45%.

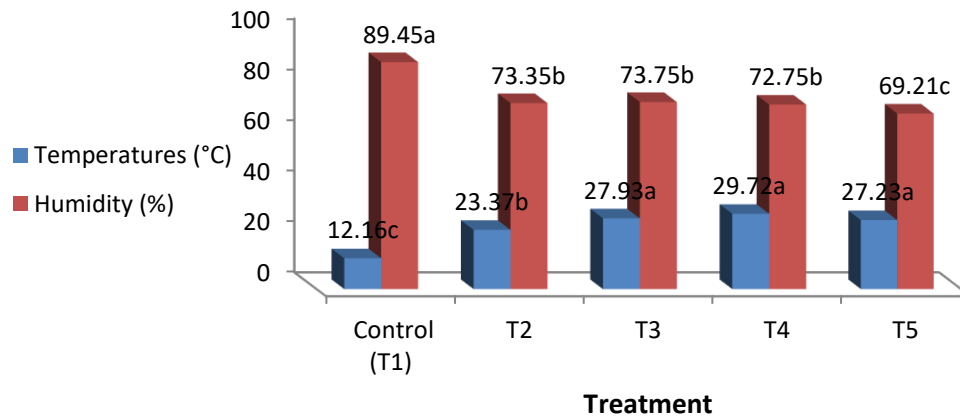


Figure 4: Temperatures (°C) and Humidity (%) recorded inside the beehives by the computer monitoring system during October 2022

T1 represents the control treatment, and T2, T3, T4, and T5 represent the cell wrapping treatments with secondary ceilings, wall adhesive, PVC, and Alkabon, respectively.

***Averages bearing different letters indicate a highly significant difference between the treatments**

From Figures (5) and (6), it is observed that treatments T3, T4, and T5 experienced a decrease in temperature and humidity compared to the control treatment. This decrease in temperature and humidity could have various implications for the beehives and the bees within them. Lower temperatures may affect the bees' metabolic rate and their ability to maintain an optimal internal hive temperature. Bees regulate the temperature inside the hive by fanning their wings to create air circulation or clustering together to generate heat. With decreased temperatures, bees may need to expend more energy to maintain the necessary warmth, potentially impacting their overall well-being and productivity.

Similarly, decreased humidity levels can influence the hive's moisture balance. Bees utilize humidity control to preserve the viability of stored food and maintain the proper consistency of nectar and honey. Insufficient humidity levels may lead to dehydration or desiccation of the hive contents, negatively affecting the bees and their food stores

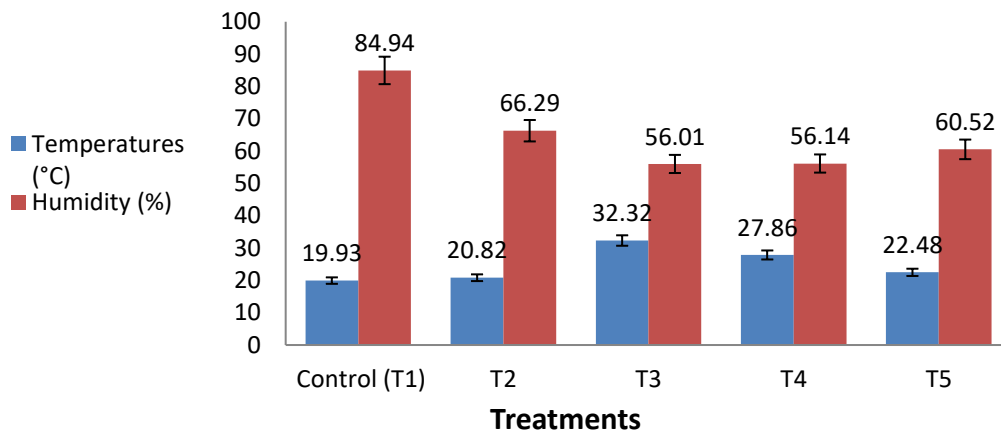


Figure5: Temperatures (°C) and humidity (%) recorded inside the beehives by the computer monitoring system during February 2022

T1 represents the control treatment, and T2, T3, T4, and T5 represent the cell wrapping treatments with secondary ceilings, wall adhesive, PVC, and Alkabon, respectively.

*Averages bearing different letters indicate a highly significant difference between the treatments

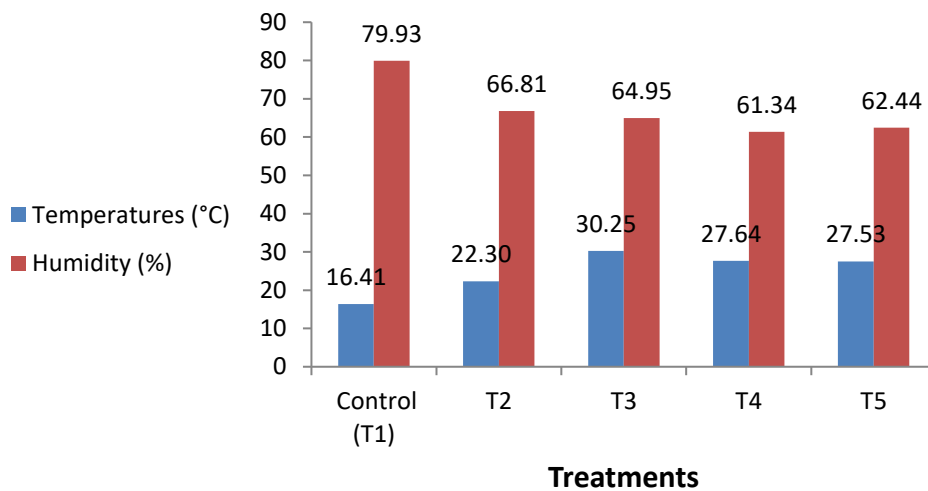


Figure 6: Average temperatures (°C) and humidity (%) recorded inside the beehives by the computer monitoring system during the winter season 2021-2022

T1 represents the control treatment, and T2, T3, T4, and T5 represent the cell wrapping treatments with secondary ceilings, wall adhesive, PVC, and Alkabon, respectively.

*Averages bearing different letters indicate a highly significant difference between the treatments

Based on the presented data, it can be observed that the utilization of wall adhesive composed of cork, carbon, and PVC for wrapping hives resulted in a significant elevation in internal temperature and a notable reduction in relative humidity within the bee cells. This can be attributed to the enhanced thermal insulation properties of the materials employed during the overwintering process, which effectively mitigated heat exchange between the hive interior and the external environment. Consequently, the honey bees were able to maintain temperatures within optimal and secure limits, thereby positively influencing their behavior, particularly regarding brood care and temperature regulation during the colder months of winter and early

spring. These outcomes are consistent with the findings reported by Popovska *et al.* (2021), Dostálková *et al.* (2021) Mohamed, Mansor (2023), Marion *et al.* (2022) and Ahmed (2023). In light of these findings, utilizing cork, carbon, and PVC materials for hive insulation during overwintering holds great potential to enhance honey bee husbandry practices.

CONCLUSIONS

Covering the hives with a wall adhesive composed of cork, carbon, and PVC resulted in a significant increase in temperature and a significant decrease in relative humidity recorded inside the hives and brood, As a result, this improvement positively affected various aspects of bee behavior. In preserving the open brood (eggs and larvae) from the destruction that results from low temperatures, the study also showed the appropriate temperatures for continued growth, reproduction, and preservation of colonies.

CONFLICT OF INTEREST

The author declares no conflicts of interest associated with this manuscript.

ACKNOWLEDGMENTS

The author expresses his gratitude to the staff of Plant Protection Department, College of Agriculture/Tikrit University] for their technical and general support.

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