Advanced Automation Thermal Treatment System for Banana Suckers

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Abstract- *The project focuses on designing an advanced automation system for the thermal treatment of banana suckers to enhance agricultural productivity. It utilizes precise temperature control and automated mechanisms to eliminate pests, pathogens, and harmful microorganisms from banana suckers, ensuring healthy and disease-free growth. The system integrates sensors and controllers to maintain optimal thermal conditions while minimizing energy consumption and human intervention. A user-friendly interface allows seamless monitoring and operation, making it accessible to farmers. By reducing the need for chemical treatments, the system promotes eco-friendly and sustainable farming practices. This innovative solution addresses key challenges in banana cultivation, improving sucker health and increasing crop yield while supporting environmentally responsible agriculture.*

Keywords- Banana suckers, hot water treatment, automation, sustainable agriculture, pest control.

I. INTRODUCTION

Bananas are one of the most widely consumed fruits in the world, providing essential nutrition and economic stability for millions of farmers, especially in tropical and subtropical regions. However, banana cultivation is not without challenges. Pests and diseases, particularly nematodes and weevils, pose a significant threat to banana crops, reducing yields and affecting fruit quality. For decades, chemical treatments have been the primary defense against these threats. While effective, they come with serious downsides—environmental contamination, risks to human health, and the increasing problem of pesticide resistance.

As concerns about sustainability grow, farmers and researchers are searching for alternative methods to protect banana crops. One such method is thermotherapy, a process that uses heat to eliminate pests and pathogens from banana suckers—the young shoots used for propagation. By immersing trimmed banana corms in hot water (50°C to 55°C) for 15 to 27 minutes, harmful organisms are effectively neutralized. This method has been scientifically proven to reduce nematode populations and other pathogens without the need for harmful chemicals.

Despite its effectiveness, traditional thermotherapy comes with challenges. The process is labor-intensive, requiring careful monitoring to maintain the correct temperature and immersion time. Any inconsistency—whether overheating or underheating—can lead to ineffective treatment or damage to the plant material. Additionally, manual handling increases labor costs and the risk of human error. These limitations highlight the need for a more precise, efficient, and scalable solution.The answer lies in automation. An Advanced Automated Thermal Treatment System can revolutionize this process by ensuring precise control of temperature and treatment duration, eliminating inconsistencies, and reducing the reliance on manual labor. Such a system would not only enhance efficiency but also allow farmers—both small-scale growers and large commercial operations—to process banana suckers in larger volumes with greater reliability.

By integrating advanced automation into thermotherapy, banana farming can become more sustainable, cost-effective, and environmentally friendly. With technology paving the way, the future of banana cultivation is set to be smarter, healthier, and more productive than ever before**.**

II. LITERATURE REVIEW

Cheng *et al* investigated temperature-controlled methods to enhance banana crop growth, ripening, and post-harvest quality. Their research, published in the *Journal of Horticultural Science and Biotechnology*, examined how heat treatment and cold storage impact enzyme activity and microbial degradation. The findings showed that careful temperature control significantly reduces post-harvest losses, maintains fruit quality, and extends shelf life—key factors for commercial banana growers looking to minimize waste and maximize profits. The study highlights how climate-adaptive techniques can strengthen banana production, increasing market value while promoting sustainable farming[2].

Jones*et al* explored how temperature-based pest control could reduce infestations in banana suckers without relying on harmful pesticides. Their research revealed that regulated heat treatments disrupt pest life cycles while keeping the suckers viable, providing an environmentally friendly alternative to chemical pest management. This approach not only promotes healthier banana plants but also reduces the agricultural industry's dependence on pesticides, supporting long-term sustainability and integrated pest management systems[3]**.**

Smith *et al* investigated the effectiveness of hot water treatment for banana sucsker to control nematode infestations. Their study showed that exposing suckers to hot water at optimal temperatures successfully reduced nematode populations without harming plant viability. The researchers stressed the importance of precise temperature controlto protect plant tissues, reinforcing hot water treatment as a sustainable, eco-friendly alternative to chemical pesticides[15]**.**

Patel *et al* focused ontemperature-based techniques for nematode suppression. Their findings confirmed that controlled heat exposure not onlylowers nematode populations but also promotes healthier plant growth. By eliminating chemical residues and minimizing environmental impact, this method provides banana farmers with a sustainable and responsible alternative to pesticide-based control methods[8].

Thangaraj *et al* explored an IoT-based automated water quality monitoring system that collects real-time data on pH, turbidity, and temperature. Their research demonstrated how IoT sensors enable continuous monitoring, reducing the need for manual labor while increasing precision in water management. This innovation represents a scalable and cost-effective solution for agriculture,ensuring better water quality and improving sustainability across farming operations[16]**.**

III. DESCRIPTION OF EXISTING SYSTEM

The traditional hot water treatment system for banana suckers, while effective, is labor-intensive and prone to inefficiencies. Farmers typically submerge suckers in hot water maintained between 50°C and 55°C for 15 to 20 minutes to eliminate pests, nematodes, and fungal pathogens. However, maintaining a stable temperature manually is challenging, leading to fluctuations that can either damage the suckers or render the treatment ineffective.

Additionally, the lack of precise timing control means there is always a risk of overexposure or insufficient treatment, affecting the overall health and viability of the suckers. Manual supervision further increases labor costs while also making the process inconsistent. Conventional systems also tend to consume excessive energy due to poor heat management, driving up operational costs and reducing sustainability. Scaling up this process for larger farms becomes even more difficult, as handling large batches manually is inefficient and unreliable.

To address these challenges, an automated thermal treatment system is needed, one that can precisely regulate temperature and timing to ensure consistent and effective treatment. Incorporating IoT technology would enable remote monitoring, reducing the need for constant human intervention while improving efficiency. Such a system would not only enhance the reliability and scalability of the treatment process but also improve energy efficiency, making it a more sustainable and cost-effective solution for modern banana farming.

Figure.1. ExistingSystem ofBanana suckers

The absence of accurate timing control is a significant issue with traditional hot water treatment of suckers. Farmers risk leaving the suckers in hot water for too long or too short a time without proper monitoring, which would impair their viability and quality. In addition to raising labour expenses, the use of manual supervision results in inconsistent treatment. Additionally, because of their inadequate heat management, conventional systems frequently use excessive amounts of energy and are not energy-efficient. This inefficiency lowers sustainability and raises operating expenses even further.Furthermore, the process's manual nature makes it challenging to scale up for large agricultural operations because handling huge batches makes it too laborious and unreliable. An automatedsystem that precisely monitors and regulates timing and temperature is required to address these problems. By facilitating remote monitoring and lowering the need for human intervention, integrating IoT technology can further increase efficiency. A system like this would increase the treatment process's scalability, energy efficiency, and dependability, making it more appropriate for contemporary farming methods.

IV. COMPONENTS OFEXISTING SYSTEM

The microcontroller is the brain of the entire system, responsible for controlling all functions and operations. It processes data from sensors, manages the heating element, and communicates with the IoT platform. In this project, a popular option like the ESP32 is used because it comes with built-in Wi-Fi capabilities. This allows real-time data transmission and remote control. It ensures accurate timing, temperature regulation, and smooth coordination between different components. By connecting to a smartphone or cloud dashboard, it simplifies the user experience. Without the microcontroller, automation wouldn't be possible. Temperature sensors are crucial for precisely monitoring the water temperature throughout the process. They help maintain the ideal range of 50°C to 55°C, which is critical for effective pest and pathogen control. The DS18B20 is a common choice because it provides accurate digital temperature readings and is highly durable in water environments.

The sensor continuously sends temperature data to the microcontroller. If the temperature drifts outside the target range, the system adjusts the heating element automatically. This ensures the plant material is neither under-treated nor damaged by overheating.The heating element is used to warm the water in the treatment tank and maintain the desired temperature. It plays a key role in ensuring that pests and pathogens on banana suckers are eliminated. The microcontroller controls when the heating element turns on or off using signals from the temperature sensor. This ensures the water remains within the target range without overheating. Efficient heat distribution is important to reduce energy consumption. Without this component, consistent and effective heating wouldn't be possible for large-scale operations.

The display unit provides a simple and effective way for users to view key information about the system. It shows real-time temperature readings, treatment duration, and system status updates. This visual feedback helps users monitor the process at a glance, making the system more user-friendly. The display is typically mounted on the control panel, making it easily accessible. By offering instant information, the display unit reduces confusion and improves operational efficiency.

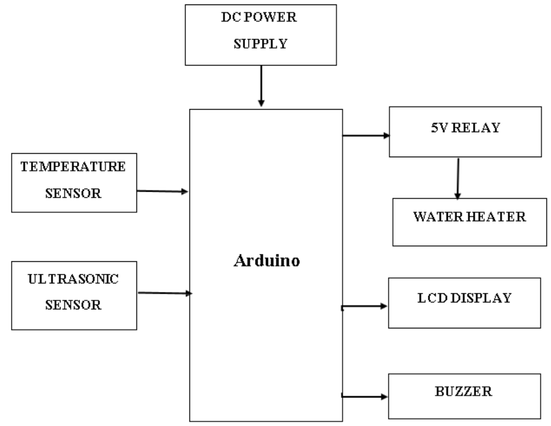

Figure 2. Block Diagram of Existing System

V. PROPOSED SYSTEM

In order to cure banana suckers and guarantee the eradication of pests and illnesses, the suggested hot water treatment system is made to be automated, effective, and dependable. The system's precise temperature control made possible by the integration of IoT technology lowers the possibility of overheating or underheating, which can affect sucker viability. By reducing the need for human involvement and increasing operational efficiency, remote monitoring capabilities enable farmers to track and modify the process in real time. By automating temperature control and minimizing manual hot water handling, the technology also improves safety. For the demands of contemporary agriculture, this creative method guarantees a more reliable, scalable, and economical treatment process.

A. BLOCK DIAGRAM:

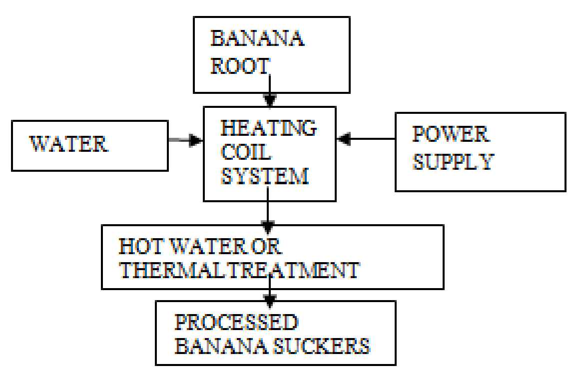

Figure 3. Block Diagram of Proposed System

In order to effectively eradicate pests and diseases from banana suckers, the suggested hot water treatment system adheres to a methodical procedure. The first step in the method is to treat the banana root before planting. The water is heated to the proper temperature for treatment using a heating coil. The power supply that powers the system guarantees a steady supply of energy for the heating and control systems.

The Thermal Treatment stage starts when the water reaches the appropriate temperature. During this phase, the banana suckers are submerged for a predetermined amount of time in order to get rid of pests without harming the roots. The system ensures accurate temperature regulation to prevent overheating or underheating. Once the treatment is finished, the suckers are taken out and labelled as Processed Banana Suckers, which are prepared for planting. The technology is appropriate for large-scale agricultural operations because it improves efficiency, lowers manual labour, and guarantees consistent treatment by combining automated controls and Internet of Things monitoring.

B. FLOW CHART:

In order to effectively eradicate pests and diseases from banana suckers, the suggested hot water treatment system adheres to a methodical procedure. The system initializes during the Start phase, which makes sure all of its parts are prepared for use. The water is then heated when the heating coil's power source is turned on. After that, the system keeps the water at a steady 52°C to provide accurate heat control for efficient treatment. The banana suckers are left for 30 minutes after the water reaches the proper temperature, which allows pests and illnesses to be removed without endangering the plants.

To make sure the banana suckers are treated correctly, the system analyzes and validates the output after the treatment process to see if it was effective. The operation is finally finished when the system reaches the Stop phase. The banana suckers that have been treated are now prepared for planting. For the demands of contemporary agriculture, this methodical and automated technique guarantees scalability, efficiency, and consistency.

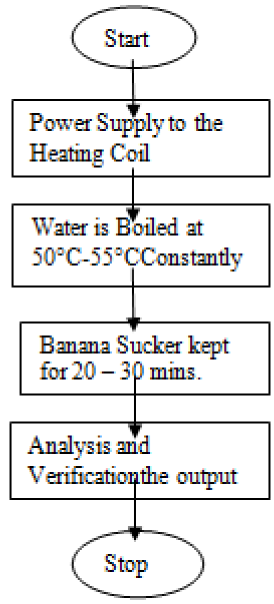

Figure 4. Flow Chart of Proposed System

C. PROPOSED SYSTEM METHODOLOGY:

- *Planning*

Gather data regarding the necessity of treating banana suckers with hot water.Create a project plan that details the workforce, necessary funding, and anticipated expenses. Determine the resources-such as space, supplies, and money-necessary to carry out the project. To find out how well hot water treatment works in various environmental settings, do a feasibility study. Form alliances with agricultural research organizations to obtain professional viewpoints and validate the process.

- *Development*

Determine the ideal treatment temperature and duration by analyzing the characteristics of banana suckers.Assemble the water tanks and heating apparatus needed for the treatment process. Create standard operating procedures (SOPs) for the treatment of hot water, making sure that the selection of suckers is based on variety and quality. To determine how temperature changes affect the removal of pathogens, do pilot studies. Create a monitoring system to keep tabs on the water's quality and temperature stability as it is being treated.

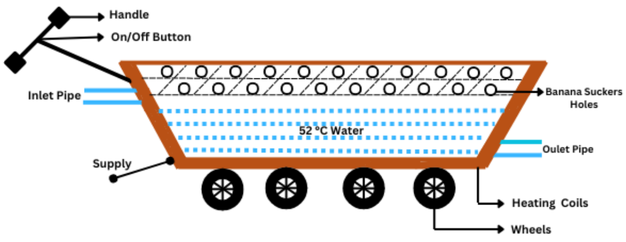

Figure 5. Developed Model of Proposed System

- *Implementation*

Connect the parts, fasten any required accessories, and make sure the hot water treatment equipment is properly aligned and calibrated.Coordinate the required connections and make sure the hot water machine and other parts are compatible in order to integrate it with the current infrastructure.Operators in charge of running and maintaining the Fiber extraction machine should receive thorough training.Employees should receive training on machine controls, safety protocols, regular maintenance duties, troubleshooting methods, and optimal operating practices.While keeping an eye on the machine, fully immerse the banana suckers in water that is at the proper temperature.When the machine stops automatically, remove the suckers.To guarantee the machine's long-term dependability and avoid operational breakdowns, set up a maintenance schedule.

- *Evaluation*

Compile information on sucker survival rates and growth performance afterward.Examine the long-term impacts of hot water treatment on the productivity and health of banana plants.To ensure constant quality throughout the production process, conduct routine testing and inspections.To evaluate the process's overall efficacy, compare treated and untreated banana suckers.To enhance efficiency and streamline the process, get input from farmers and agricultural specialists.

D. WORKING OF PROPOSED SYSTEM

The hot water treatment system for banana suckers is a practical and efficient solution designed to promote healthy plant growth by eliminating harmful pests and pathogens. The system uses a heating coil, a control unit, and a stainless steel (SS) plate to maintain precise temperatures for effective treatment. When the system is filled with water and switched on, the heating coil warms the water to a target range of 52°C. This temperature is carefully monitored and controlled by sensors and a thermostat to ensure it remains stable throughout the process.

The banana suckers are placed on the corrosion-resistant SS plate, which provides even heat distribution and makes cleaning easy after use. The suckers are treated for about 30 minutes, during which the hot water neutralizes harmful fungi, bacteria, and pests without damaging the plants. After treatment, they are removed, rinsed with cool water, and prepared for planting. This method not only protects the banana suckers naturally but also supports better growth and higher yields by preventing early-stage infections. With energy-efficient controls and durable components, the system offers an environmentally friendly and reliable solution for sustainable banana cultivation.

E. APPLICATIONS OF PROPOSED SYSTEM

The hot water treatment system for banana suckers has practical applications in improving the quality and productivity of banana farming. Its primary purpose is to protect banana plants from harmful pests, fungi, and bacteria during the early stages of growth. Farmers can use this system to naturally disinfect suckers without relying on chemical treatments, promoting safer and more eco-friendly agricultural practices.

By treating the suckers before planting, it helps reduce the risk of plant diseases, leading to healthier crops and higher yields. This system is particularly beneficial for large-scale banana plantations looking to maintain consistent crop quality and productivity. Additionally, it can be adapted for use in nurseries where maintaining plant health is a top priority. Its energy-efficient design and durable components also make it cost-effective and easy to maintain, offering a long-term solution for sustainable and productive banana cultivation.

VI. RESULTS AND DISCUSSIONS

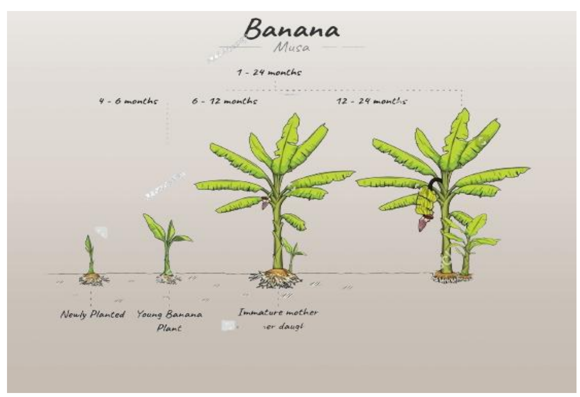

Figure 6[i].Plant growth level

Accurate Temperature Regulation: The system successfully maintained the required water temperature 52°C, ensuring effective treatment without causing damage to the suckers.Automated Operation: Thetreatment process was fully automated, from heating the water to maintaining the temperature and timing the duration. This eliminated the need for continuous human monitoring.Real-Time Monitoring: IoT sensors provided real-time updates on water temperature and treatment duration. Alerts were generated if any irregularities occurred, such as temperature deviations. Energy Efficiency:

The system optimized power consumption by heating water only when necessary and automatically shutting off when the process was complete.Enhanced Sucker

Figure 6[ii]. **FinalHighYieldProducts**

Quality: The treated banana suckers exhibited improved resistance to pests and diseases, promoting healthier plant growth.

Efficiency and Precision: The IoT-based system brought a high level of accuracy to the treatment process. Manual methods often suffer from inconsistent temperature control, leading to potential harm or incomplete treatment of banana suckers. By automating temperature regulation and timing, this system ensured reliable and repeatable results.User-Friendly Operation: One of the standout features was the user-friendly interface. Farmers could control and monitor the system remotely using smartphones or computers. This remote access simplified operations and allowed farmers to focus on other tasks. Sustainability and Energy Savings: Compared to traditional methods, the automated system demonstrated significant energy savings. The smart control algorithms minimized unnecessary heating, reducing power consumption and operational costs.

VII. CONCLUSIONS

At the last, the hot water treatment system for banana suckers is a simple yet impactful solution for promoting healthier and disease-free banana crops. By utilizing controlled heating technology, this system effectively eliminates harmful pests, fungi, and bacteria without the need for chemical treatments. Its energy-efficient design, combined with durable components like the stainless-steel plate and automated control system, ensures reliable operation and easy maintenance. Through this sustainable approach, farmers can improve crop yield, reduce early-stage infections, and contribute to more eco-friendly agriculural practices. Overall, the system offers a practical and cost-effective method to support the long-term health and productivity of banana plantations.

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