Smart Agriculture Solution for Remote Pesticide Application

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Abstract- This paper explores the health risks associated with pesticide application in agriculture and proposes an automated IT solution. By implementing a smart greenhouse system with remote control and sensor monitoring, farmers can execute spraying tasks without physical presence in the danger zone. The proposed system ensures precise dosing, safety logging, and minimizes human exposure to toxic chemicals.

Keywords- Smart Agriculture, IoT, Automation, Pesticide Safety, Greenhouse Management.

I. INTRODUCTION

Farmers heavily rely on chemical agents to protect their crops from damage caused by pests, weeds, and diseases. In the context of modern global agriculture, the pressure to produce high yields is constantly increasing due to the growing human population and the shrinking availability of arable land. If these chemical protection methods were not utilized, a significant percentage of crops would be lost to insects, fungi, and competing weeds, leading to global food shortages and significantly higher prices for end consumers. However, the application of these necessary "poisons" presents a severe occupational hazard that has been a concern for decades.

Traditional methods often require the farmer to be physically present in the field or greenhouse, wearing protective gear that may fail, be of poor quality, or be used improperly due to discomfort or lack of training. In many developing regions and parts of Eastern Europe, small to medium-sized farms still utilize outdated knapsack sprayers. These manual devices often leak and require the operator to walk directly through the cloud of chemicals they are dispersing. While personal protective equipment is theoretically mandatory, in practice, during hot summer months inside greenhouses where temperatures can exceed 40 degrees Celsius, farmers often discard heavy protective suits to avoid heatstroke. This creates a paradoxical situation where the farmer must choose between the immediate risk of heat exhaustion and the long-term risk of chemical poisoning.

The solution to this dilemma lies not in removing the chemicals, which are currently essential for food security, but in removing the human from the immediate environment of application. This paper discusses the integration of Information Technology (IT) software and automated systems designed to execute spraying tasks remotely. By utilizing centralized management software and Internet of Things (IoT) connectivity,farmers can schedule and execute hazardous operations without any physical contact with the toxins.

The concept of Agriculture 4.0 implies a significant shift from manual operations to data-driven automated processes, and this paper proposes a concrete implementation of that concept focused on health and safety.

II. THE PROBLEM: EXPOSURE RISKS

The primary risk in conventional farming is the proximity of the operator to the chemical mist. Despite safety regulations, training programs, and warning signs, the "danger zone" remains the immediate area where the spraying occurs. Health organizations and rural clinics note that long-term exposure can lead to chronic health issues, including respiratory problems, skin conditions, and neurological damage. The absorption of pesticides occurs primarily through the skin and the respiratory system. When a farmer uses a manual sprayer, the fine mist created by the nozzle often drifts back onto their clothing and skin, especially in poorly ventilated spaces like greenhouses or polytunnels.

While warning signs (e.g., "DANGER PESTICIDES") serve as a passive deterrent to bystanders, they do nothing to protect the active operator. Active prevention requires a technological intervention that creates a physical buffer between the toxin and the human. The issue is compounded by the "re-entry interval," which is the time required after spraying before it is safe for a human to enter the area. In manual systems, the farmer is present during the most dangerous time—the application itself. Furthermore, the cleaning of manual equipment often leads to accidental spills and high-concentration exposure. The goal of modern agricultural engineering is to eliminate these touchpoints entirely. By automating the process, we remove the necessity for the farmer to breathe the air inside the greenhouse during the application and for a defined period afterward, effectively nullifying the exposure risk during the most critical phase of crop protection.

III. THE IT SOLUTION: AUTOMATION AND REMOTE CONTROL

To solve the issue of exposure, we propose a shift to Smart Agriculture systems, often referred to as Precision Farming. This involves a complex ecosystem of hardware components, such as sensors, solenoid valves, and sprinklers, all controlled by a sophisticated software layer that manages the logic and communication.

A. Architecture of the System

- The system is built upon a robust client-server architecture. It consists of a central server or cloud platform that communicates with a local controller installed directly in the greenhouse or field. The local controller serves as the brain of the operation, typically utilizing a microcontroller with Wi-Fi capabilities, such as the ESP32 or similar embedded systems.
- User Interface (UI): The entry point for the farmer is a web or mobile application. This interface allows the user to log in securely from a remote location, such as their home office or a different city. The interface provides a dashboard displaying the current status of the greenhouse, including temperature, humidity, and connection status.
- Logic Controller: This is the program running on the local hardware. It processes user commands received via the internet and cross-references them with data from local sensors. It is responsible for the decision-making process, ensuring that valves are only opened when it is safe and appropriate to do so.
- Actuators and Hardware: The physical execution relies on electronic solenoid valves and misting systems. These valves are electrically operated and control the flow of the liquid pesticide from the central tank to the nozzles. The system uses relays to interface the low-voltage logic of the controller with the higher voltage required by the pumps and valves.

B. Workflow for Safety

- Instead of walking through rows of crops with a heavy sprayer on their back, the farmer follows a strict, software-driven workflow designed to maximize safety and efficiency.
- Remote Login and Authentication: The farmer accesses the system from a secure device. This step prevents unauthorized usage.
- Schedule Configuration: The user inputs the specific parameters for the operation, including the start time, the duration of the spray, and the specific zones to be treated. This allows for precise planning.
- System and Environmental Check: Before any chemical is released, the software analyzes environmental conditions via connected sensors. It checks if the temperature is too high, which could cause rapid evaporation, or if the humidity is too high, which could prevent the chemical from adhering to the leaves.
- Automated Execution: Once the checks pass, the system activates the spraying infrastructure. The greenhouse doors can be equipped with magnetic locks that engage automatically, and visual or auditory alarms can be triggered to warn anyone nearby. The spraying occurs autonomously.
- Completion and Reporting: Upon finishing the task, the system sends a notification to the farmer's device confirming the job is done. It also logs the event in a database for future reference.

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IV. IMPLEMENTATION AND BENEFITS

Real-world implementations, such as those seen in modern smart farms and pilot projects like the Nikolagro installations using ONDO systems, demonstrate the practical viability and immense value of this approach. The transition to automation brings several key advantages that justify the initial investment in technology.

Zero Contact and Health Preservation The most significant benefit is the absolute separation of the worker from the hazardous material. The farmer is never in the greenhouse during the "active" phase of the poison application. This effectively reduces the risk of inhalation and skin contact to zero during the spraying process. Over a career spanning decades, this protection significantly lowers the probability of developing chronic occupational diseases associated with pesticide toxicity.

Precise Dosing and Economic Efficiency Manual spraying is inherently inconsistent; a human operator may walk faster or slower, leading to uneven application. In contrast, software control ensures exactly the right amount of fluid is used. By controlling the pressure and the open-duration of the valves, the system ensures uniform coverage. This precise dosing reduces chemical runoff, which saves money on expensive preparations and protects the soil from contamination caused by overdosing.

Logging, Traceability, and Compliance In the modern regulatory environment, traceability is crucial. The software keeps a permanent digital record of what was sprayed, when it was sprayed, and in what quantity. This automated logbook is invaluable for meeting legal compliance standards required by food safety authorities and export markets. It eliminates the need for manual record-keeping, which is prone to human error and memory lapses. Furthermore, this data can be analyzed over time to optimize crop protection strategies and reduce overall chemical usage.

V. CONCLUSION

While pesticides remain a necessary tool for avoiding crop loss, the method of their delivery must evolve. By utilizing IT programs and software automation, we can decouple the act of farming from the risk of poisoning. Technology allows the farmer to protect their crops while maintaining their own health, ensuring that the "poison" affects only the pests, not the people.

REFERENCES

1. Beyond Pesticides, "Pesticide-Induced Diseases Database," Beyond Pesticides, Washington, D.C. [Online]. Available: https://beyondpesticides.org. [Accessed: Dec. 13, 2025].
2. Scott Free Clinic, "Farming and Pesticide Safety Resources," Scott Free Clinic. [Online]. Available: http://www.scottfreeclinic.org. [Accessed: Dec. 13, 2025].
3. ONDO Smart Farming, "Automation in Greenhouse Complexes: Client Case Study Nikolagro," ONDO. [Online]. Available: https://ondo.io/bg/clients/nikolagro/. [Accessed: Dec. 13, 2025].
4. Z. Gunaydin and B. Eredzheb, "Smart Agriculture Solutions," Dept. of Computer Systems and Technologies, Rousse University, Rousse, Bulgaria.
5. J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," Future Generation Computer Systems, vol. 29, no. 7, pp. 1645-1660, 2013.
6. World Health Organization, "The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification," WHO Press, Geneva, 2020.
7. K. Ashton, "That 'Internet of Things' Thing," RFID Journal, vol. 22, no. 7, pp. 97-114, 2009.
8. A. Ray, "Internet of Things for Smart Agriculture: Technologies, Practices and Future Direction," Journal of Ambient Intelligence and Humanized Computing, vol. 8, pp. 395–420, 2017.