AUTOMATED SPRINKLER IRRIGATION FOR IMPROVED ONION CROP PRODUCTION

Sundharan M [0], Yukash K [1], Chandru S [2]

[1] *Assistent Professor, Department of Agricultural Engineering*

[2,3,4] *UG Students, Department of Agricultural Engineering*

[1,2,3,4] *Kongunadu College of Engineering and Technology, Trichy, TamilNadu, India*

[1]sundharmahendren96@gmail.com, [2]yukash.k2005@gmail.com , [3]coauthor@mailserver.com

Abstract — Efficient water management plays an important role in improving onion crop growth and yield. Traditional irrigation methods often lead to uneven water distribution, excessive water use, high labor demand and lower productivity. This study presents a smart automated sprinkler irrigation system powered by solar energy to enhance irrigation efficiency in onion cultivation. The system uses a solar panel to generate power, which is stored in a battery and supplied to a VCN-4 controller. Farmers can operate the system remotely through the Dcon Ag mobile application by scheduling irrigation cycles. When a command is sent from the application, the air station communicates with the controller to activate the motor, allowing water to flow through valves and sprinklers for uniform field irrigation. The motor automatically stops after the preset irrigation period. Field implementation of the system showed improved irrigation management and crop performance. The automated sprinkler irrigation system produced an onion yield of 3.5 tons, indicating better water utilization and consistent moisture supply to the crop. This automated approach reduces manual labor, conserves water and ensures timely irrigation, thereby supporting better crop growth and improved yield. The energy-efficient design also helps reduce operational costs and promotes sustainable agricultural practices while supporting precision irrigation in onion cultivation.

Keywords — Solar Energy, Automation, Sprinkler Irrigation, Onion Cultivation and Mobile-Based Control.

I. INTRODUCTION

In Onion is an important crop that is widely consumed across the world. In India, onion cultivation plays a significant role in ensuring food supply, supporting farmer income, and maintaining agricultural stability. Depending on the region, onion is grown under irrigated conditions or relies partly on seasonal rainfall. Among the various factors affecting onion production, proper water management is one of the most critical, as it directly influences bulb size, quality, and overall yield. Traditionally, farmers use manual or flood irrigation methods to supply water to onion fields. These methods often lead to uneven water distribution, excessive water usage, and wastage. In many cases, some plants receive more water while others receive less, resulting in inconsistent growth. Over-irrigation can also cause problems such as waterlogging, nutrient loss, and increased risk of diseases. At the same time, labour availability for manual irrigation is decreasing, making it difficult for farmers to manage irrigation efficiently. An automated sprinkler irrigation system addresses these challenges by ensuring uniform and controlled water distribution across the field. In this system, sprinklers are arranged in a planned layout and powered by pumps and control units. Water is sprayed in the form of fine droplets, similar to rainfall, covering the crop evenly. Sensors and timers can be integrated to regulate water flow based on soil moisture levels and crop requirements. Energy flows through the system to operate pumps, valves, and rotating sprinkler heads, which distribute water uniformly while the system moves or operates in fixed positions. This automation reduces human effort and ensures timely irrigation. In the field, the sprinkler system operates more efficiently than traditional methods, conserving water and improving crop health. Because water distribution remains consistent, each onion plant receives an adequate amount of moisture. This leads to better root development, uniform growth, and ultimately higher yield and improved crop quality.

II. LITERATURE SURVEY

Work on irrigation systems in recent years has increasingly focused on automation, aiming to improve water efficiency, reduce labour dependency, and ensure consistent crop growth, especially in water-sensitive crops like onion. Researchers have studied how traditional irrigation methods compare with modern sprinkler and automated systems in both performance and resource utilization. Automated systems, according to Rath et al. (2025), reduce human involvement, save time, and provide uniform water distribution across the field, unlike manual irrigation which often leads to uneven application. During the same period, Vatta (2024) highlighted how farmers in regions like Punjab shifted toward automated irrigation practices due to labour shortages after the pandemic, adopting sprinkler systems to maintain crop productivity. Similarly, data collected by Samal et al. (2024) in Odisha showed that sprinkler irrigation systems can cover larger areas in less time while maintaining efficient water usage compared to conventional flood irrigation methods. Field conditions play an important role in the effectiveness of irrigation systems. Proper land leveling and soil preparation improve water distribution efficiency, as noted by Joshi and Dhakal (2023). A step toward affordability and adaptability came with Pandit (2022), who developed a low-cost sprinkler setup suitable for small-scale farmers, making automation more accessible. System design and operational mechanisms are also critical; Mishra (2021) emphasized that nozzle type, pressure control, and layout design significantly influence irrigation performance.

 ISSN: **3107-6513**

When comparing traditional irrigation methods with automated sprinkler systems, Vijay et al. (2020) observed improved water distribution uniformity, reduced water wastage, and lower physical effort, favoring mechanized solutions. Earlier developments also contributed to advancements in irrigation technology. Through various field experiments, Manikgam (2019) found that automated sprinkler systems performed consistently under different soil and climatic conditions.

III. COMPONENTS

The automated sprinkler irrigation system uses mechanical and electrical components to distribute water efficiently across onion fields. Stability of the system is maintained through a rigid framework, which supports all parts and ensures proper alignment during operation. Power begins at the motor or pump, which drives water through the system and enables continuous irrigation. From the pump, water flows through pipelines that carry it to different sections of the field. Control over water flow is maintained using valves, which regulate pressure and ensure proper distribution. Sprinkler heads are the key components responsible for spreading water; they rotate and spray water in fine droplets, covering the crop uniformly. To support smooth operation and reduce resistance in moving parts, fittings and joints are properly installed, allowing free flow of water without leakage. Pressure regulators help maintain a steady flow, preventing damage to the system and ensuring consistent performance. Water storage sources such as tanks or reservoirs supply the required water for irrigation. These components help in reducing manual effort and ensure timely watering. The entire system works together to deliver water evenly, improving crop growth and maintaining optimal soil moisture conditions for onion cultivation.

IV. METHODOOGY

This project was carried out to improve irrigation management in onion cultivation and to reduce water wastage and manual labor in farming. A solar-powered automated sprinkler irrigation system was designed and installed in the field. A solar panel was used to generate electrical energy from sunlight and the energy was stored in a battery to operate the system. The stored power was supplied to a VCN-4 controller, which controlled the operation of the water pump and irrigation process. Sprinklers and pipelines were arranged in the onion field to distribute water evenly. The irrigation system was connected to the Dcon Ag mobile application, allowing farmers to control and schedule irrigation remotely. When an irrigation command was sent from the mobile application, the air station transmitted the signal to the controller. The controller then activated the motor, allowing water to flow through the pipes and sprinklers to irrigate the field. After the preset irrigation time was completed, the motor automatically stopped. The system was implemented in the onion field to provide timely and uniform irrigation using solar energy. This method helps reduce manual effort, saves water and improves irrigation efficiency in onion cultivation.

V. WORKING PRINCIPLE

The solar panel captures sunlight and converts it into electrical energy through photovoltaic cells. This generated electrical energy is stored in a rechargeable battery so that the system can operate even when sunlight is not available. The stored energy is then supplied to the irrigation controller, which manages the overall functioning of the irrigation system. Farmers can easily control and monitor the irrigation process using a mobile application, where they can set specific irrigation schedules according to the water requirements of the onion crop. When the farmer sends a command through the mobile application, the signal is transmitted to the air station, which acts as a communication unit between the mobile application and the controller installed in the field. After receiving the signal, the controller activates the water pump motor. Once the motor starts, water is pumped through the pipeline network and distributed across the field using sprinkler units. The sprinklers spray water uniformly over the crop area, ensuring that all plants receive adequate moisture. The irrigation duration is set in advance through the mobile application. After the preset irrigation time is reached, the controller automatically stops the motor. This automatic switching system prevents excess water usage and reduces the need for manual monitoring. By using this method, the irrigation process becomes more efficient, reliable and convenient for farmers.

VI. DESIGN



VII. CALCULATION

Given Data:

Length = 67 m

Width = 63 m

 ISSN: 3107-6513

1. Filed Details

1 Area = 4047 m^2

Total Sprinklers = 25

Area per plant = row spacing x plant spacing

= 0.15 x 0.10

= 0.015 m^2

2. Zone Divison

Assume system divided into 5 zones to maintain pressure.

Sprinklers per zone = 25 / 5

= 5

3. Zone Time Calculation

Zone time = Total Irrigation Time / Number of zones Zone time = 120 / 5

Zone time = 24 minutes

4.Water Applied

Assume sprinkler discharge: 900 L / hr

Water per sprinkler in 24mins : 900 x 24 / 60 = 360 L

Water per zone : 5 x 360 = 1800 L

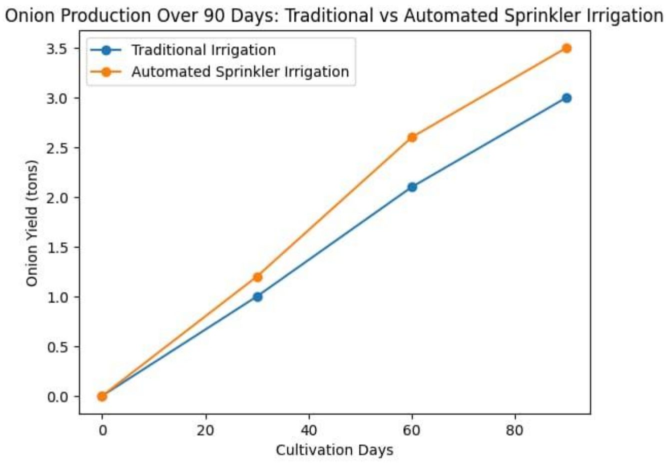
Total water applied : 1800 x 5 = 9000 L

Water per sprinkler	360 L / day
Water per zone	1800 L / day
Total water	9000 L / day
Yield	3.5 tons

VIII. PERFORMANCE ANALYSIS

The performance analysis of an automated sprinkler irrigation system in onion cultivation over a 90-day crop period shows clear improvements in water management, labour efficiency, crop uniformity and yield compared to traditional irrigation methods. The automated sprinkler system provides uniform water distribution across the field, maintaining optimum soil moisture levels essential for proper bulb formation and root development. As a result, onion yield increases from about 3.0 tons under traditional irrigation to approximately 3.5 tons using sprinkler irrigation within the same cultivation duration. The system also reduces labour requirements significantly, since irrigation scheduling can be controlled automatically, minimizing manual supervision and field visits. Water-use efficiency improves due to controlled application and reduced runoff losses, making it suitable for areas facing water scarcity. In addition, the sprinkler system supports better plant spacing moisture balance, improved bulb size uniformity, and healthier crop growth, which contributes to higher market quality produce. Economically, the automated sprinkler irrigation system lowers operational costs over time through savings in labour and water while increasing productivity per unit area. Overall, the performance evaluation indicates that automated sprinkler irrigation is a reliable, efficient and cost-effective irrigation method for improving onion crop production compared to conventional irrigation practices.

IX. RESULT AND DISCUSSION



Automated sprinkler irrigation reduces the time, labour and water usage compared to traditional manual irrigation methods, lowering labour input significantly and improving water-use efficiency while increasing onion yield from about 3.0 tons to 3.5 tons within the same 90-day cultivation period. It also ensures uniform water distribution, better plant growth, improved bulb size and higher crop uniformity, making automated sprinkler irrigation an efficient and cost-effective alternative to traditional irrigation practices for onion crop production.

X. CONCLUSION

The automated sprinkler irrigation system provides an effective solution for improving water management in onion cultivation. By integrating solar power, a controller unit and mobile-based remote operation, the system ensures timely and uniform water distribution across the field. Compared to conventional irrigation methods, this system reduces water wastage, minimizes manual labor and improves irrigation efficiency. The use of automated scheduling allows farmers to manage irrigation more conveniently while maintaining optimal soil moisture conditions for onion crop growth. In addition, the solar-powered operation supports energy efficiency and promotes sustainable agricultural practices. Overall, the implementation of an automated sprinkler irrigation system can enhance onion crop productivity, optimize resource utilization and contribute to modern precision agriculture.

References

[1]. Y. E. Kunt; "Development of Smart Autonomous Irrigation System Using IoT and Artificial Intelligence for Crop Production"; 2025.

[2]. D. Silberberg; "Sensor-Based Irrigation Management for Improving Storage Onion Yield and Water Productivity"; Sustainable Agriculture Research Project; 2024.

[3]. Agricultural Water Management Research Group; "Comparison of Sprinkler, Drip and Furrow Irrigation Efficiencies for Onion Production under Different Field Conditions"; 2024.

[4]. Cambridge Agricultural Science Researchers; "Effects of Nitrogen Fertilization and Micro-Sprinkler Irrigation on Soil Moisture, Yield and Economics of Onion Production"; 2024.

[5]. X. Ding, W. Du; "Optimizing Irrigation Efficiency Using Reinforcement Learning for Precision Agriculture Applications"; 2023.

[6]. B. T. Agyeman, M. Naouri, W. Appels, J. Liu, S. L. Shah; "Integrating Machine Learning Techniques for Smart Irrigation Scheduling Optimization"; 2023.

[7]. E. B. G. Feibert, C. C. Shock, L. D. Saunders; "Evaluation of Onion Production under Sprinkler and Drip Irrigation Systems"; 2022.

[8]. Irrigation Engineering Study Team; "Performance Evaluation of Sprinkler Irrigation System for Vegetable Crop Production under Field Conditions"; 2021.

[9]. Precision Agriculture Research Unit; "Impact of Automated Irrigation Systems on Water-Use Efficiency and Yield Improvement in Vegetable Crops"; 2020.

[10]. Agricultural Engineering Research Institute; "Comparative Study on Traditional Irrigation and Sprinkler Irrigation Methods for Onion Cultivation"; 2019.

[11]. Horticultural Irrigation Technology Group; "Effect of Micro-Sprinkler Irrigation on Growth, Yield and Uniformity of Onion Crop"; 2018.