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# Role of Artificial Lightining and Automation in Advanced Protected Cultivation

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Agriculture plays a major role in economic expansion, creating jobs and emulating the experiences of small-scale farming. However, unpredictable weather patterns, natural disasters, and unwanted intruders pose a serious threat and cause the owner to suffer significant financial losses. The goal of this project is to create an IoT-based automation greenhouse that is integrated with an intrusion detection and prevention system in order to address these issues. In addition to improving agricultural productivity and offering ideal environmental conditions for crop growth, automation greenhouses can detect intrusions and provide prompt responses. Real-time monitoring and control are made possible by the automation greenhouse's IoT-based intrusion detection and prevention system, which instantly notifies users via a mobile application. Thus, the invention of an IoT-based automated greenhouse creates a sustainable environment for crop growth and lowers crop losses from threats.

The two primary trends in artificial lighting for protected agriculture are the use of specific light spectra, particularly red and blue, to maximize photosynthesis and morphogenesis, and the integration of LED systems with digital sensors and controllers for increased precision. Though there is a lot of room for adoption and expansion, the use of these technologies is still relatively new in developing countries like Colombia. Additionally, this bibliometric analysis provides a strong foundation for identifying critical areas for improvement and guiding future research toward more efficient and sustainable farming practices. The use of particular light spectra (especially red and blue) to maximize photosynthesis and morphogenesis, as well as the integration of LED systems with digital sensors and controllers for improved precision, are the primary trends in artificial lighting for protected agriculture. However, the use of these technologies is still in its infancy in developing nations like Colombia, offering enormous potential for adoption and growth. Furthermore, this bibliometric analysis offers a solid basis for pinpointing important areas for development and directing future studies toward more effective and sustainable farming methods.

## Introduction

for boosting productivity, efficiency, and sustainability in light of the growing demand for premium produce A contemporary agricultural method called "protected cultivation" uses buildings like greenhouses, polyhouses, and net houses to grow crops under regulated environmental conditions. Modern technologies like automation and artificial lighting are essential and year-round production.

## Protected Cultivation with Artificial Lighting

### Artificial Lighting Concept

When natural sunlight is insufficient, artificial lighting refers to the use of additional light sources to provide the necessary light intensity, duration, and spectrum for plant growth.

**Artificial Light Types**

Fluorescent lights are used for seedlings and in nurseries.
Lamps with High Intensity Discharge (HID)
Halide Metal (MH)
Sodium at High Pressure (HPS)
Light Emitting Diodes (LEDs): The most sophisticated and effective
Because of their poor efficiency, incandescent lights are rarely used.

**Function and Significance**

1. Improvement of Photosynthesis

Particularly on overcast days or in the winter, artificial light guarantees sufficient light for photosynthesis.

2. Control of Photoperiod

Plants react to the duration of the day (photoperiodism). Artificial lighting aids in controlling flowering in:
Plants with short days
Long-day vegetation

3. Increased Crop Production

Biomass and yield are increased by continuous and ideal light exposure.

4. Consistent Growth

Ensures consistent plant growth by distributing light uniformly.

5. Production During Off-Season

Allows for year-round farming regardless of the amount of daylight.

6. Optimization of Spectrum

LEDs provide control over the red and blue portions of the light spectrum, which affects:
Blue light-induced vegetative growth
Fruiting and flowering (red light)

**Benefits**

Enhanced output
Higher-quality produce
Energy-saving choices (LEDs)
Regulated growth of plants

**Restrictions**

High initial installation expenses
Use of energy
Technical expertise is necessary.

## Protected Cultivation Automation

**Automation Concept**

Automation is the process of automatically controlling environmental factors like temperature, humidity, irrigation, and ventilation through the use of sensors, controllers, and machines.

**Functions and Roles**

1. Climate Management

Sustains optimal
The temperature
Humidity
$CO_2$ levels

2. Automation of Irrigation

Systems for drip irrigation
Fertigation (irrigation plus fertilizer)
minimizes the waste of water

3. Cooling and Ventilation

Vents that open and close automatically
Cooling systems with fans and pads

4. Management of Nutrients
Plant growth is enhanced and fertilizer loss is decreased when nutrients are supplied precisely.
5. Monitoring of Diseases and Pests
Early indicators of a pest or disease attack are found by sensors and AI-based systems.
6. Reduction of Labor
reduces manual labor and boosts productivity.

**Automation System Components**

Sensors
Sensors for temperature
Sensors for humidity
Sensors for soil moisture
Sensors for light
Controllers
PLCs, or programmable logic controllers
Microcontrollers
Actuators
Supporters
Pumps
Valves
Motors
Systems of Software
Software for climate control
Computer-based or mobile monitoring systems

**Advantages**

Precise farming
Efficient utilization of resources
Reduced labor expenses
Enhanced output and caliber
Real-time monitoring
Limitations
High setup costs
Requires professional performance.
Dependence on electricity and technology
Integrating Artificial Lighting with Automation
Combining the two technologies yields the following outcomes:
An entirely controlled agricultural setting
Greenhouses with intelligence
Maximum output with the least amount of resources

**For example:**

Automatic LED lighting systems adjust their intensity based on the amount of sunlight.
Sensors activate irrigation and lights automatically.
Applications
Vegetable production in commercial greenhouses
Floriculture (rose, carnation, and gerbera)
Growing a nursery
Vertical farming and hydroponics

## Challenges and Future Directions

1. High Initial Costs
2. Requirement of energy
3. Trends for Future

**Context for Adoption**

China and Netherland are top in this field . India are increasing in high-tech polyhouse for agriculture food security or climate risk . Government related schemes like (NHB) National Horticulture Board or (MIDH) Mission for Integrated Development of Horticulture offer subsidies for high-tech polyhouse.

**Prospects for the Future**

Artificial Intelligence (AI) Use
Smart farming using the Internet of Things (IoT)
Solar-powered automated systems
Agriculture that is climate resilient

## Conclusion

By guaranteeing ideal growing conditions, effective resource use, and higher productivity, artificial lighting and automation are transforming protected cultivation. These technologies are necessary for modern, sustainable agriculture and have long-term benefits despite their higher initial costs.

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