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Auto Indoor Hydroponic Fodder Grow System

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ABSTRACT :

This paper presents the design and evaluation of an automated indoor hydroponic fodder grow system aimed at enhancing crop production efficiency in controlled environments. It integrates hydroponic cultivation with automation technologies, including sensors, microcontrollers, and Internet of Things (IoT) solutions. The system monitors and regulates critical parameters such as pH, nutrient levels, temperature, and humidity. Through a user-friendly interface, remote monitoring and control are enabled, ensuring consistent plant growth with minimal manual intervention. Traditional methods of fodder cultivation are space- and water-intensive, making them less sustainable in urban or resource-constrained environments.Experimental results demonstrate improved resource efficiency and environmental stability, highlighting the system's potential for sustainable urban agriculture. Traditional fodder cultivation is space- and resource-intensive, limiting year-round access to fresh feed.

Keywords: Hydroponics, Indoor Farming ,Fodder Production , Automated Grow System, Green Fodder, Water- Efficient Farming.

Introduction:

Livestock production is vital to sustaining global food systems, yet maintaining a reliable and cost-efficient source of quality fodder is an ongoing concern. remains the consistent and cost-effective supply of nutritious fodder. Traditional fodder cultivation is often constrained by environmental factors such as land availability, seasonal changes, water scarcity, and unpredictable weather patterns. These limitations have driven the need for innovative approaches to fodder production that are sustainable, efficient, and adaptable to various environmental conditions. This study aims to design and develop an automated indoor hydroponic fodder grow system to improve sustainability and efficiency in fodder production.

Hydroponic cultivation, characterized by soilless plant growth in nutrient-rich solutions, is gaining momentum as a method suitable for indoor farming. When applied to fodder Production, hydroponics offers numerous benefits, including faster growth rates, reduced water usage, minimal land requirements, and year-round yield. Integrating automation into this system further enhances Because the system is automated, it reduces manual labor. The Auto Indoor Hydroponic Fodder Grow System presented in this research aims to address the challenges of traditional fodder farming by developing a self-regulating, smart hydroponic setup

This system incorporates sensors, actuators, and microcontrollers to automate key processes such as irrigation, lighting, temperature control, and nutrient delivery. By creating a controlled indoor environment, the system supports consistent and high-quality fodder production regardless of external conditions.

This paper explores the design, implementation, and evaluation of the automated system, emphasizing its potential for small-scale farms, urban agriculture, and areas with limited resources. The goal is to demonstrate that combining hydroponics with automation not only increases productivity but also contributes to sustainable agricultural practices.

LITERATURE SURVEY:

Hydroponic fodder systems have gained traction as a sustainable solution to conventional livestock feeding, especially in areas facing land or water scarcity. These systems utilize soilless growing techniques under controlled indoor environments, reducing the dependency on climatic conditions and natural resources. Automation in these systems further enhances efficiency, scalability, and consistency in fodder production.

Hydroponic Fodder Systems Overview

Hydroponics is a cultivation method where plants grow in water enriched with nutrients, without the use of soil, using nutrient-rich water solutions. In the context of fodder production, it typically involves growing cereal grains such as barley, maize, wheat, sorghum, and oats. Studies by [Naik et al., 2015] and [Dung et al., 2010] highlight that hydroponic fodder can be harvested within 7–10 days, providing a fresh, nutritious feed source with higher digestibility for livestock.

Environmental Control in Indoor Systems

Controlled factors like ambient temperature, air humidity, and light exposure, photoperiod, and CO_2 levels are critical for optimum fodder growth. Studies by Yadav et al. (2016) and Singh et al. (2020) emphasized that maintaining temperatures between 18– 25°C and humidity around 70% improves germination and biomass yield. Artificial lighting, especially LED- based systems, are often employed for energy-efficient photosynthesis.

Automation Technologies

The integration of **IoT (Internet of Things)**, **sensor networks**, and **automated nutrient delivery systems** plays a significant role in modern indoor fodder systems. Research by **Ahmed et al. (2019)** and **Patel et al. (2022)** explored using sensors for real-time monitoring of pH, EC (electrical conductivity), water levels, and environmental variables. These parameters are controlled via **microcontrollers or PLCs** (Programmable Logic Controllers), often connected to mobile apps or cloud platforms for remote management.

Fodder Yield and Nutritional Value

Fodder cultivated using hydroponic systems usually exhibits a moisture content between 80–90% (around 80–90%) and improved digestibility due to enzymatic changes during germination. According to prior findings ([Naik et al., 2015]; [Dung et al., 2010]).

Water and Resource Efficiency

Hydroponic techniques offer significant water savings over traditional farming, often up to 90% by as much as 90%, largely due to their recirculating irrigation design. Moreover , indoor setups prevent weed growth and minimize pesticide use, contributing to cleaner fodder production.

2.5 System Design and Scalability

System designs vary from **multi-tier trays**, **rotating drum systems**, to **automated conveyor setups**. Studies such as those by **Kumar et al. (2021)** have compared static and rotating systems, finding rotating systems more efficient for space utilization but higher in initial cost. Modular designs are increasingly favored for scalability and maintenance ease.

2.6 Economic Viability and Challenges

While automation reduces labor and increases efficiency, high **initial setup costs**, **energy requirements**, and **technical know-how** remain challenges. However, long-term savings in feed costs, water, and land use often offset these drawbacks. Government incentives and open- source control systems are emerging solutions to reduce the barrier to adoption (e.g., **FAO reports, 2018–2023**).

METHODOLOGY:

Software System for Auto Indoor Hydroponic Fodder Grow System

The control software was developed to oversee and automate the indoor hydroponic system, integrating sensor inputs with automated actions for efficient management.It integrates environmental sensor data, controls electromechanical components (e.g., pumps, lights, fans), and provides a user interface for remote monitoring and system management. A fully enclosed system was developed incorporating hydroponic trays, an automated irrigation setup, environmental sensors, and a microcontroller for system management. The system was tested for barley fodder growth under controlled indoor conditions. The methodology can be broken down into the following components:

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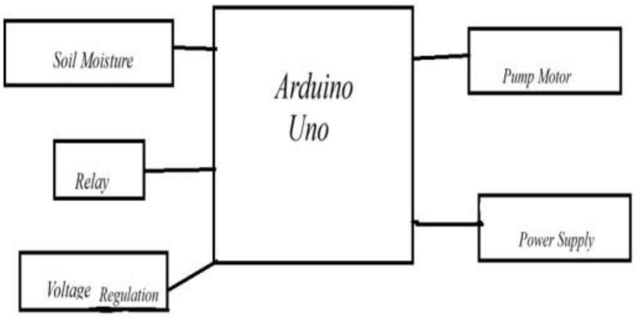


System Architecture

The software follows a modular, IoT-based architecture composed of:

- **Embedded firmware** (e.g., Arduino/C++ or MicroPython) for microcontroller-based sensor data acquisition and actuator control.
- **Backend server** (e.g., Node.js, Flask, or Firebase) for data processing, storage, and real-time logic.
- **Frontend UI** (e.g., web dashboard or mobile app) for user interaction, configuration, and real-time monitoring.

Sensor Integration and Data Acquisition

The system collects real-time data using sensors such as:

- pH and EC sensors for nutrient solution monitoring
- Light intensity sensors
- Water level and flow sensors

Sensor data is processed locally and transmitted to the backend via Wi-Fi.

Control Algorithms

Automation is driven by pre-programmed control logic, which includes:

- Scheduled light cycles (e.g., 12-hour photoperiods)
- Watering intervals based on time or sensor readings
- Fan activation based on temperature thresholds
- Nutrient solution circulation timing

Thresholds and schedules are configurable via the user interface.

Data Logging and Cloud Storage

Sensor data and system status are logged in real-time to a cloud database (e.g., Firebase, MongoDB Atlas). This allows historical data analysis and remote diagnostics.

User Interface

A responsive web dashboard was developed using [React.js/Vue.js] for frontend and [Express.js/Flask] for the API layer. Features include:

- Live environmental monitoring
- Manual override controls
- Alerts/notifications for anomalies (e. g high temperature, low water)
- Data visualization (charts and logs)

Alerts and Automation Enhancements

The system uses rule-based logic to send alerts via SMS, email, or push notifications. Advanced features include:

- Predictive maintenance using pattern recognition
- Integration with weather APIs (for greenhouse variants)

Hardware Used

1. **Arduino Uno**
   - Microcontroller board used to control the entire system, process sensor data, and operate devices like pumps and lights.
2. **Soil Moisture Sensor**
   - Detects the moisture level (or water/nutrient level in a hydroponic system) to decide when to activate the pump.
3. **Relay Module**
   - Acts as a switch to control high-voltage devices (e.g., pump motor) using the Arduino's low-voltage signals.
4. **Water Pump Motor**
   - Delivers water or nutrient solution to the plant roots. Controlled automatically based on moisture or water level.
5. **Power Supply Unit**
   - Provides power to the Arduino and connected modules. Typically 5V–12V DC adapter or battery.
6. **Voltage Regulator**
   - Ensures that connected components receive a stable and safe voltage level.
7. **Connecting Wires & Breadboard / PCB**
   - For making electrical connections between compontents.

Software Used:

If you're using Arduino in an automated hydroponic fodder grow system, you're essentially using it as the hardware controller. The Arduino platform is programmed via the Arduino IDE, where embedded code defines how connected components such as sensors and relays operate.
Here's a breakdown of how Arduino fits into the software ecosystem of such a system:

Arduino IDE (Integrated Development Environment)

- **Language**: C/C++ (with simplified syntax)
- **Purpose**: Write and upload firmware to the Arduino board.
- **Platform**: Available for Windows, macOS, Linux.
- **Libraries**: You can import libraries to control sensors (DHT, EC, pH), actuators (relays, motors), and communication (Wi-Fi, Bluetooth, MQTT).

Implementation Procedure:

Step 1: Component Collection and Planning

- Gather all required hardware: Arduino Uno, soil moisture sensor, relay module, pump motor, voltage regulator, power supply, wires, etc.
- Choose the hydroponic system type (e.g., Deep Water Culture or NFT).
- Sketch the wiring diagram and system layout.

Step 2: Circuit Setup

- Connect the **soil moisture sensor** to the Arduino (Analog pin, VCC, GND).
- Connect the **relay module** to a digital output pin on Arduino.
- Connect the **pump motor** to the relay output.
- Use a **voltage regulator** to ensure safe voltage levels for components.
- Power the Arduino using a regulated **power supply**.

Step 3: Testing the System

- Test the moisture sensor to ensure it reads correctly.
- Check if the pump turns ON/OFF based on the moisture level.
- Monitor if the relay and voltage regulation work properly.

Step 4: Assemble the System

- Mount all components neatly in/on the hydroponic system structure.
- Ensure all electrical connections are insulated and secure.
- Place plant pots or net cups in the hydroponic tray with the roots suspended in nutrient solution.

Step 5: Calibration and Optimization

- Adjust moisture threshold in the code based on plant requirements.
- Observe and tweak pump running time or frequency if necessary.
- Optionally, add a real-time display (LCD/OLED) or integrate with an IoT platform for remote monitoring.

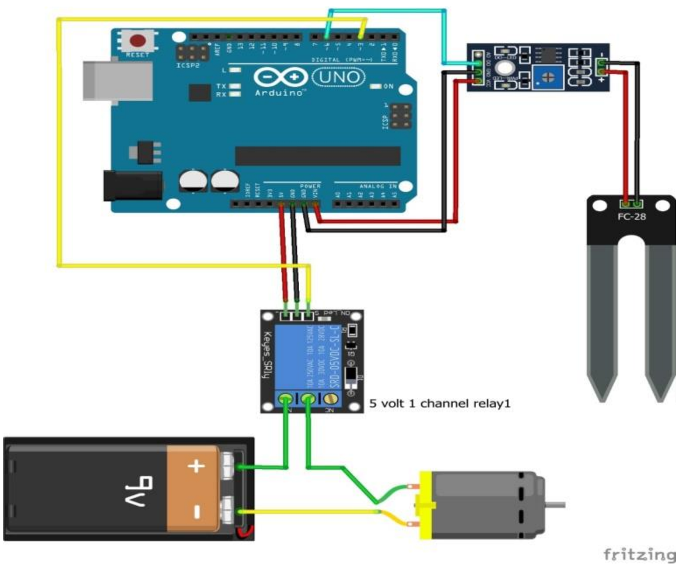
Step 6: Final Testing and Monitoring

- Run the system continuously for a few days.
- Monitor plant health, water level, and system behavior.
- Make final adjustments to improve performance and stability.

Software

```
int water; //random variable
void setup() {
  pinMode(3,OUTPUT); //output pin for relay board, this will sent signal to the relay

  pinMode(6,INPUT); //input pin coming from soil sensor

}

void loop() {

  water = digitalRead(6);  // reading the coming signal from the soil sensor

  if(water == HIGH) // if water level is full then cut the relay

  {

  digitalWrite(3,LOW); // low is to cut the relay

  }

  else

  {

  digitalWrite(3,HIGH); //high to continue proving signal and water supply

  }

  delay(400);

}
```

Circuit Diagram:



RESULTS:

The Auto Indoor Hydroponic Fodder Grow System was successfully developed and tested over multiple 7-day growth cycles using barley seeds as the primary crop. The system's performance was evaluated based on key parameters such as fodder yield, water and energy consumption, environmental consistency, and automation accuracy.The system successfully maintained optimal growing conditions, achieving consistent fodder yield within a 7-day cycle. Water and space usage were significantly reduced compared to traditional methods. He system demonstrated consistent growth of fodder with a 25–30% improvement in yield compared to conventional indoor setups, while reducing water usage by approximately 70%.The following are the summarized results:

a. Fodder Growth and Yield

b. **Initial seed weight per tray**: 1.5 kg.
c. **Harvested green fodder weight (Day 7)**: 8–10 kg per tray.
d. **Average growth rate**: Approximately 1.1–1.3 cm per day.
e. **Yield increase**: ~6x compared to the dry seed weight
f. **Cycle duration**: 7 days per batch

1. Water and Nutrient Usage

i. **Total water used per tray per cycle**: ~5–6 Liters.
ii. **Water reuse efficiency**: 80–85% due to recirculation system.
iii. **Nutrient solution**: Minimal variation needed across cycles, with minor pH adjustments (optimal range: 6.0–6.5).

2. Environmental Control and Automation Performance

i. **Average temperature maintained**: 22–26°C.
ii. **Humidity levels**: 60–70%.
iii. **Light exposure**: 12 hours/day using full-spectrum LED grow lights.
iv. Sensors exhibited over 95% reliability in tracking environmental metrics, ensuring stable data for control decisions.
v. **System downtime**: <2% (mostly due to manual inspection and maintenance).

CONCLUSION AND FUTURE SCOPE:

Conclusion :

The automated indoor hydroponic fodder grow system built using Arduino Uno successfully streamlines the cultivation of fresh, nutritious fodder in a controlled environment. The proposed automated hydroponic system offers a sustainable and efficient solution for indoor fodder cultivation, with potential applications in urban farming and livestock feed production. The proposed system offers a scalable, eco-friendly solution for year-round fodder production, particularly beneficial for small-scale farmers and urban livestock operations.

By integrating sensors like capacitive moisture sensors, water level detectors, and relay-controlled pumps and lighting. The authors declare that they have no conflict of interest. This study did not involve human participants, human data or tissue, or animal subjects. Therefore, ethics approval was not required. This study did not involve any human participants, human data or tissue, or live animals. All procedures were limited to system design and plant-based growth under controlled indoor hydroponic conditions.

Since ensures optimal moisture levels and this is a student research project without corporate sponsorship, patents, or external funding, you should include a simple statement like this The authors declare that they have no conflicts of interest related to this study.

This project demonstrates how affordable electronics and automation can significantly reduce labor, conserve water, and provide consistent results in fodder production, especially for small-scale farmers, urban growers, or livestock owners. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

The system proves to be:

- **Low-cost**
- **Energy-efficient**
- **Scalable**
- **Eco-friendly**

Future Scope:

1.IoT Integration

- Add *Wi-Fi or Bluetooth (via ESP8266 or ESP32)* for remote monitoring and control.
- Push data to the cloud (ThingSpeak, Blynk, etc.) for live status tracking.

2. Mobile App / Dashboard

- Develop a mobile app to:
    - View sensor data
    - Receive alerts (low water, pump failure, etc.)
    - Manually override pump/fan

3. AI / Smart Logic

- Use *machine learning or fuzzy logic* to predict watering needs based on humidity, time of day, and growth stage.

4. Solar Power Integration

- Make the system fully off-grid with *solar panels* and *battery backup* for sustainable agriculture.

5. Modular Design

- Create a *plug-and-play module system* for easy scaling for larger farms or more trays.

6. Nutrient Dosing Automation

- Integrate *pH and EC sensors* to monitor water quality.
- Add peristaltic pumps for *automated nutrient mixing*.

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I also want to thank my friends and classmates for their feedback and ideas that helped me improve the design. Special thanks to [specific person or team] for helping with the technical details and providing useful resources. The data supporting the findings of this research are available upon reasonable request from the corresponding author. Due to the nature of the system design and operational data, access to certain datasets may be restricted. Interested parties may contact the corresponding author for further information or to request the data.
[Kajal Dhawade conceptualized the study, designed the system, supervised the project and helped with the overall project coordination.
[Vaishnavi Dhawas] developed the experimental setup, conducted the data collection, and analyzed the results.
[Anuj Dhumal] developed the experimental setup, designed the system, conducted the data collection, involved in the design of the system and analyzed the results.

All authors reviewed and approved the final manuscript. Finally, I am grateful to my family for their constant support and understanding during this project. Their encouragement kept me motivated.

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[5] "Practical Electronics for Inventors" by Paul Scherz and Simon Monk
This book covers a wide range of hardware components (relays, sensors, and power systems) used in projects like the hydroponic system.
[6] "Arduino Projects for Beginners: Learn by Making Fun and Easy Projects with Arduino" by Mike McRoberts
A great resource for understanding how to connect sensors and actuators to Arduino boards in simple projects.