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Rahul Prasad Choudhary
Research Scholar, Department of Farm Machinery and Power Engineering, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Baban Yadav
Assistant Professor, Department of Farm Machinery and Power Engineering, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Vikki Prasad Sahu
Research Scholar, Department of Farm Machinery and Power Engineering, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Shivesh Chandra Pandey
Research Scholar, Department of Farm Machinery and Power Engineering, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Rahul Prasad Choudhary
Research Scholar, Department of Farm Machinery and Power Engineering, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Development of microcontroller based site specific water applicator for planter

Rahul Prasad Choudhary, Baban Yadav, Vikki Prasad Sahu and Shivesh Chandra Pandey

Abstract

During sowing of seeds by using developed planter, it is seen that most of the farmers using flood irrigation which is consumes more water with less efficiency. As a result desired plant population per unit area is not obtained causing reduction in yield. To minimize the loss of water for seeds, a sensor system has been developed for planter. This study presents the devolvement of microcontroller-based site-specific water applicator system that integrates seed detection within seed tubes using IR sensors, combined with precise water application facilitated by relays and solenoid valves. The system aims to optimize agricultural irrigation by delivering water.

The system architecture includes IR sensors embedded within seed tubes, enabling the detection of seeds during the planting process. These sensors communicate with a microcontroller unit, which processes the seed detection data and coordinates water distribution. Utilizing an algorithm tailored for seed-specific irrigation, the system activates relays to control solenoid valves, directing water exclusively to seed locations within the field.

The laboratory evaluation of the developed microcontroller based sensor system with pre-existing planter reveals that the variations of actual no. of seeds dropped and display reading of the LCD screen was found to be 5.33% at 1.0 km/h, 8.0% at 1.5 km/h and 11% at 2.0 km/h operating speed. It was found that the seed detection variation increases with increase in speed. The average water discharge from the nozzle was found to be 31.37, 42.54 and 55.24 ml at 0.5, 0.8 and 1.0 second activation time of solenoid valve respectively. It was observed that, water discharge increases when increases in activation time of solenoid valve. After activating sensor system average water saving was found to be 46.28% at 0.5 sec, 32.86% at 0.8sec, and 14.29% at 1.0 sec. It was observed that water saving % decreases when increases in activation time of solenoid valve in both the conditions.

Keywords: Microcontroller, site-specific water applicator, IR sensor, seed detection, solenoid valve, relay

1. Introduction

India is one of the developing countries of Asia having lower land productivity as compared to the developed nation due to low level of farm mechanization. India is an agricultural country as agriculture is considered to be the back bone of Indian economy. Involvement of farm machinery in agriculture is an important input to enhance production and productivity as well as reduce the cost of cultivation. Recent developments on farm machinery are aimed at optimum utilization of inputs and proceed towards precision farming.

Water management is paramount in countries with water scarcity. Thus, studies aimed at saving water usage in the irrigation process have increased over the years. Typical commercial sensors for agriculture irrigation systems are very expensive, making it impossible for smaller farmers to implement this type of system. However, manufacturers are currently offering low-cost sensors that can be connected to nodes to implement affordable systems for irrigation management and agriculture monitoring. We determine the parameters that are monitored in irrigation systems regarding water quantity and quality, soil characteristics and weather conditions. We provide an overview of the most utilized nodes and wireless technologies. Lastly, we will discuss the challenges and the best practices for the implementation of sensor-based irrigation systems. (Laura García *et al.*, 2020) [5].

During the dry season, the plants will suffer insufficiency in water supply which would stunt the growth of plants that have been planted. Many individuals forget to water their plants owing to their hectic daily schedules, and as a result, their plants suffer from a variety of ailments and eventually die. Therefore, it is essential to manage the supply of water to plant efficiently (Olayiwola, J.O, Adamu, Dahiru, 2022) [10].

Automatic irrigation system proves to be very helpful for those who travel. If designed and coded properly, automatic irrigation systems can be very cost effective and can do a lot of water conservation. Watering with a pipe or with oscillator wastes water and none of these method aim plant roots. Automatic irrigation systems can be designed in such a way which gives required amount of water in a targeted area, and which will also promotes water conservation. (Bishnu Deo Kumar *et al*., 2017) [17].

The technology of smart irrigation is developed to increase the production without the involvement of large number of man power by detecting the level of water, temperature of the soil, nutrient content and weather forecasting. The Machine to Machine technology is been developed to ease the communication and data sharing among each other and to the server or the cloud through the main network between all the nodes of the agricultural field (Shekhar *et al*., 2017) [11].

The idea of efficient and automated irrigation system by developing remote sensors using the technology of Arduino which can increase the production up to 40%. (Savitha and Uma Maheshwari, 2018) [7].

An automatic watering plant that works both in the rainy season and the dry season is necessary to design. The device used a microcontroller chip programmed based on the detection of agricultural soil moisture sensors. When the soil was dry, the device automatically watered the plants. Conversely, if the soil was wet, the device would not water them. It led to healthy plants because the need for water had been fulfilled all the time (Ipin Prasojo, *et al*., 2020) [3].

Many researchers have tried to detect the flow of seeds in delivery tube of a planter by using detection technologies such as visual LED sensors, capacitive type sensors, microwave sensor, piezoelectric sensor, ultrasonic sensor and image processing techniques. Among these IR technology was found better because of high accuracy, smaller size, less power consumption, low cost and easier control of input/output signals (Raheman and Kumar, 2018) [4].

2. Materials and Methods

2.1 Components used for Development of Microcontroller Based Site Specific Water Applicator for Planter

Various simple electronic components used for development of microcontroller based site-specific water applicator for planter. The detail specifications of used components in the present investigation are as follows.

1	Microcontroller	7	Relay Switch
2	Arduino UNO CH340 board	8	DC motor high pressure diaphragm pump
3	16*2 LCD display with I2Cmodule	9	Hose pipes and connectors
4	IR obstacle sensor	10	Spraying Nozzle
5	IR transmitter	11	12V DC Power supply
6	IR receiver Solenoid valve		

2.2 The Performance Evaluation of Developed Microcontroller Based Site-Specific Water Applicator for Planter

The development of microcontroller based site specific water applicator was evaluated under laboratory and actual field conditions it is essential to test with respect to Seed detection (%), Amount of water discharge (ml), Water saving (%), water missing index percentage (%). For the 20 revolutions of ground wheel for the three different speed which is (1.00 km/h, 1.5 km/h, 2.00 km/h) and the diameter of seed tube mouth opener (10mm, 15mm, 20mm) and the test was replicated three times for more accuracy. The parameters measured and results obtained during the evaluation discussed in the following paragraphs.

Table 1: Design of experimental parameters

S.no	Variable	Parameters	No. of levels	Levels values
1	Independent	Speed of ground wheel	3	(1, 1.5, 2.0) km/h
		Diameter of seed tube mouth opener	3	D (10, 15, 20) mm
		Activation time of solenoid valve	3	(0.5, 0.8, 1.0) sec
2	Dependent	Seed detection (%)		
		Variation in seed detection (%)		
		Amount of water discharge (ml)		
		Water missing index percentage (%)		
		Water saving percentage (%)		

2.3 Laboratory evaluation

In the present investigation, were selected for mounting of IR sensors and solenoid valves a plastic water tank with a capacity 10 lit was used as a water tank in the present study. The pin configurations of the sensors were connected to the microcontroller and the solenoid valves were connected to the pre fixed pins of the relay switches board. The VCC, GND pin was connected to the 5V pin and ground pin of microcontroller and water pump was directly connected to the battery terminals and on/off switch is used to operate the circuit to switch ON the developed sensor system and switch OFF the system. IR sensor was mounted on the seed tube and covered by the help of black tap to prevent form the sun and can pass its infrared beam through the seed tube

3. Results and Discussion

3.1 Development of Microcontroller Based Site Specific Water Applicator

A development of microcontroller based site specific water applicator was developed for delivering the water at required time, by detecting the seed in seed delivery tube using IR sensor and activation of solenoid valve for delivering site specific water. Accordingly relay switch were also used for activation of the solenoid valve. An Arduino UNO CH340 Microcontroller board was used to read and process the IR sensor signals and also to activate the solenoid valve. The output pin of the IR sensor was connected to the digital pin 7 of the microcontroller.

3.2 Seed detection

Seed detection was obtained at different speed of ground wheel (1.0, 1.5, 2.0) km/h for 20 revolutions and (10, 15, 20) mm diameter of the seed tube mouth opener it replicated three times for more accuracy result the observations were recorded at each speed of operation and the average values are shown in the following tables given below.

Table 2: Seed detection at 1 km/h operating speed for 20 revolutions of ground wheel

Diameter of Seed tube mouth opener (mm)	Replicate	No. of seed drop	Actual no. of seed detected	Average seed detected, (%)
D1= 10	R1	100	84	83.66
	R2	100	82	
	R3	100	85	
D2 = 15	R1	100	93	94.66
	R2	100	96	
	R3	100	95	
D3 = 20	R1	100	89	91
	R2	100	93	
	R3	100	91	
Seed detection at 1.5 km/h operating speed for 20 revolutions				
D1= 10	R1	100	84	85.66
	R2	100	87	
	R3	100	86	
D2 = 15	R1	100	92	92
	R2	100	89	
	R3	100	95	
D3 = 20	R1	100	85	85.66
	R2	100	83	
	R3	100	89	
Seed detection at 2 km/h operating speed for 20 revolutions				
D1= 10	R1	100	80	82
	R2	100	84	
	R3	100	82	
D2 = 15	R1	100	89	89
	R2	100	91	
	R3	100	87	
D3 = 20	R1	100	85	85.33
	R2	100	87	
	R3	100	84	

It is observed from table 1, the Average seed detection (%) at speed of 1 km/h for 20 revolutions. D1 = 83.66%, D2 = 94.66%, D3 = 91% Hence, the lowest seed detection is in the D1 = 83.66% and the highest seed detection % in D2 =94.66%.

It is observed from table 2, the Average seed detection (%) at speed of 1.5 km/h for 20 revolutions D1 = 85.66%, D2 = 92%, D3 = 85.66%, Hence, the lowest seed detection is in the D1 = 85.66% and the highest seed detection % in D2 =92%.

It is observed from table 3, the Average seed detection (%) at speed of 1.5 km/h for 20 revolutions. D1 = 82%, D2 = 89%, D3 = 85.33%, Hence, the lowest seed detection is in the D1 = 82% and the highest seed detection % in D2 =89%.

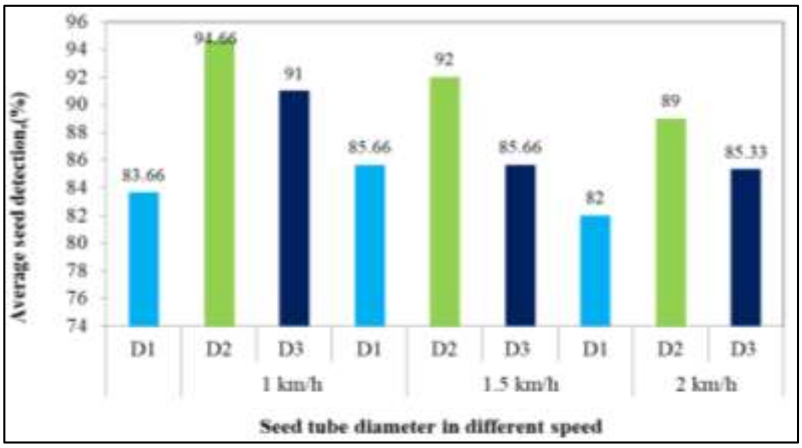

Fig 4.1: Average seed detected in three different speeds for 20 revolutions of ground wheel

3.3 Variation between actual no. of seeds dropped and seed detection

Average variation between actual no. of seeds dropped and seeds detection was observed at 3 operating speeds of (1.0, 1.5, 2.0) km/h for 20 revolutions observations were recorded at each speed of operation and the average values were shown in figures given below.

Table 3: Variation in seed detection at 1.0 km/h operating speed for 20 revolutions of ground wheel

Diameter of seed tube mouth opener(mm)	Replicate	No. of seed dropped	Actual no. of seed detected	V(%)	AV (%)
D1= 10	R1	100	84	14	15.66%
	R2	100	82	18	
	R3	100	85	15	
D2 = 15	R1	100	93	7	5.33%
	R2	100	96	4	
	R3	100	95	5	
D3 = 20	R1	100	89	11	9.00%
	R2	100	93	7	
	R3	100	91	9	
Variation in seed detection at 1.5 km/h operating speed for 20 revolutions					
D1= 10	R1	100	84	16	14.33%
	R2	100	87	13	
	R3	100	86	14	
D2 = 15	R1	100	92	8	8.00%
	R2	100	89	11	
	R3	100	95	5	
D3 = 20	R1	100	85	14	13.33%
	R2	100	83	16	
	R3	100	89	11	
Variation in seed detection at 2 km/h operating speed for 20 revolutions					
D1= 10	R1	100	80	20	18.00%
	R2	100	84	16	
	R3	100	82	18	
D2 = 15	R1	100	89	11	11.00%
	R2	100	91	9	
	R3	100	87	13	
D3 = 20	R1	100	85	15	14.66%
	R2	100	87	13	
	R3	100	84	16	

V= Variation between actual no. of seeds dropped and seed detected
AV= Average variation between actual no. of seeds dropped and seed detected, (%)

It is seen from Table 4, the average variation between actual no. of seeds dropped and seed detection at speed of 1 km/h for 20 revolutions, D1 = 15.66%, D2 = 5.33%, D3 = 9.0%. Hence, the lowest Variation between actual no. of seeds dropped and seed detected, in the D2
= 5.33% and the highest in D1 = 15.66%.
It is seen from Table 4 that the average variation between actual no. of seeds dropped and seed detection at speed of 1.5 km/h, D1 = 14.33% D2 = 8.0% D3 = 13.33%, Hence the lowest Variation between actual no. of seeds dropped and seed detected, is in the D2 = 8% and the highest in D1 = 14.33%.
It seen from Table 4 that the average variation between actual no. of seeds dropped and seed detection at speed of 2.0 km/h, D1 = 18.0%, D2 = 11.0%, D3 = 14.66%. Hence, the lowest Variation between actual no. of seeds dropped and seed detected, % is in the D2 = 11% and the highest in D1 = 18%.
It is found that the variation between actual no. of seeds dropped and no. of seed detection less in D2= 15mm which is (5.0 to 11.0) %, and more in D1= 10mm which is (14.0 to 18.0) % at three operated speeds the variation increases with increase in speed. From (1.0 to 2.0) km/h Hence, the sensor system was detected variation the no. of seeds with less percentage in D2 = 15mm in all the 3 operating speed
It clearly observed the average variation of speed and seed detection is very less at the speed of 1.0 km/h and diameter of seed tube mouth opener at D2 = 15 mm is less and effective in 3 operated speed for the developed sensor system.

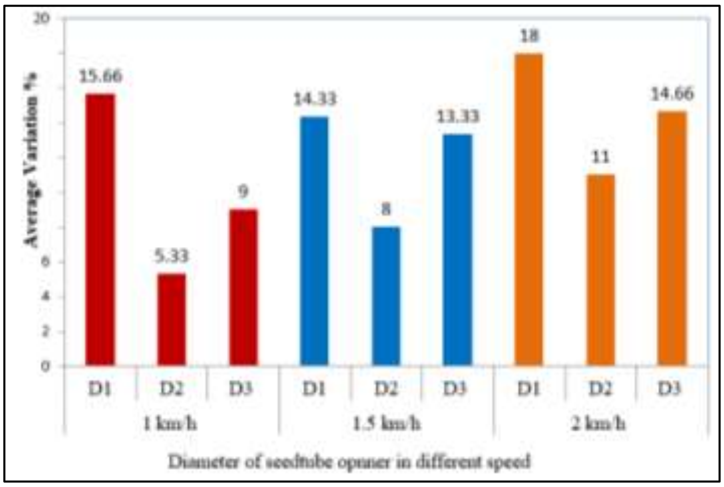

Fig 4.2: Average variation between actual no. of seeds dropped and seed detected %

3.4 Amount of water discharge measured

The developed electronic control unit was tested under laboratory condition to find its working accuracy. The IR sensors were responded well while focusing the seed in seed delivery tube, apart from the activation of the sensor, it was also observed good response from the solenoid valves. It was observed that output discharge of 0.5 sec activation of solenoid valve fixed in seed tube to vary from 30.90 to 31.80 ml with the average of 31.37 ml. Similarly the output discharge of 0.8sec activation solenoid valve found to vary from 42.10 to 43.00 ml with an average 42.54 ml, whereas the output discharge of 1.0 sec activation solenoid valve were seen to vary from 54.80 to 55.80 ml with an average of 55.24 ml. It clearly shows that, the discharge of solenoid valve is irrespective of the number of seeds dropped at a time. This reveals the suitability of IR sensors and solenoid valve based electronic control unit for delivering uniform discharge of water at required place and time.

Table 4: Amount of water discharge measured from the solenoid valve

No. of Replication	Amount of water discharge measured (ml)		
	Solenoid valve (S1)		
	Activation time (0.5 sec)	Activation time (0.8 sec)	Activation time (1.0 sec)
R1	31.8	42.1	55.6
R2	30.9	43	54.8
R3	31.4	42.5	55.8
Avg.	31.37	42.54	55.24

4. Conclusion

The functions of IR sensor relay module, solenoid valve, water pump and LCD display were observed in both laboratory and field conditions. It was seen that all the components of developed microcontroller system working properly and seeds were detected and water applied respective effectively by the sensors system. The laboratory evaluation of the developed microcontroller based sensor system with pre-existing planter reveals that the variations of actual no. of seeds dropped and display reading of the LCD screen was found to be 5.33% at 1.0 km/h, 8.0% at 1.5 km/h and 11% at 2.0 km/h operating speed the variations of actual no. of seeds dropped and display reading of the LCD screen interface varies from 5% to 15%.. It was found that the seed detection variation increases with increase in speed. The average water discharge from the nozzle was found to be 31.37, 42.54 and 55.24 ml at 0.5, 0.8 and 1.0 second activation time of solenoid valve respectively. It was observed that, water discharge increases when increases in activation time of solenoid valve. After activating sensor system average water saving was found to be 46.28% at 0.5 sec, 32.86% at 0.8 sec, and 14.29% at 1.0 sec. It was observed that water saving % decreases when increases in activation time of solenoid valve in both the conditions. The water consumption with using developed sensor system with the pre-existing planter is less as compare to without using sensor system.

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