TILLAGE AND SEEDING DEPTH MONITORING SYSTEM FOR SEEDERS

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CONTENTS

ABBREVIATIONS

A Ampere

C Celsius/ Centigrade

cm Centimeter

cm Centimeter

DC Direct Current

DC Direct Current

EM38 Electromagnetic Soil Mapping Mg/ha

EM38 Electromagnetic Soil Mapping Mg/ha

GNSS Global Navigation Satellite System

GPS Global Positioning System

GR Germination Rate

Ha/h Hectare per Hour

in Inches

IR Infrared

ISO International Organization for Standardization

Kg Kilogram

Km/h Kilometer per Hour

KN Kilo Newton

KN Kilo Newton

LC Liquid Crystal Display

LVDT Linear Variable Differential Transformer N

LVDT Linear Variable Differential Transformer N

mAh Milliamp Hours

MICRO Micro-Industry Credit Rural Organization Data Acquisition System DSP

MICRO Micro-Industry Credit Rural Organization Data Acquisition System DSP

Mm Millimeter

Mm Millimeter

MR Magnetic Damper

OFF — Object Factory Framework

ON — Operation Navigation

PCRWR — Pakistan Council of Research in Water Resources

PCRWR — Pakistan Council of Research in Water Resources

PID — Proportional Integral Derivative

PLC — Programmable Logic Controller

RC — Complete Randomized Design LIDAR

RS — Reference Surface

RTC — Real Time Clock

SD card — Secure Digital Card FFT

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SDCS — Seed Depth Control System LED

SDCS — Seed Depth Control System LED

TX2 — Sensor

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ABSTRACT

Among many issues in the cultivation process the most important is the tillage and adequate seeding depth. These factors are crucial for the soil–water–plant ecosystem, time of emergence and germination rate, as it ultimately affects the overall yield and quality. To solve these problems economically and effectively, we introduce a low-cost real time depth monitoring design assembly using ultra-sonic sensors to monitor tillage and seeding depth with displaying screen on tractor. Using this assembly, a tractor operator can get instructions (up/down/level the machine) to maintain the optimum tillage and seeding depth required for specific crops during operation. This system assembly consists of a controller, ultrasonic sensors, fixed plates (made of MS sheet and iron bars) used for reference value for each sensor, program, and display. The seed depth control system effectively managed and maintained the seed depth with the aid of metal plates functioning as reference points for the sensors. The system-utilized height differences as reference values and stored the seeding depth data on an SD card. Results demonstrated that implementing a real-time depth control system in existing seeders significantly improved plant population and achieved uniform germination. We applied this system for monitoring seed depth during field trials in groundnut. With the seed depth control system, the average cumulative germination rate (GR) of groundnut using the seed depth control system was 14 plants/m^2, compared to 12 plants/m^2 with the conventional seed drill. The expected groundnut yield with the depth control system was projected to be 730 kg/acre, whereas the conventional drill yielded 680 kg/acre. As a result, monitoring systems significantly enhance crop yield by ensuring proper seed placement at the required depth with no variation in ground reference level. This assembly can be mount with tillage and seeding equipment available in local market and will be highly acceptable by manufacturer as well as farmer due to low cost, simple and adoptable design which ultimate helpful to improve the soil–water–plant ecosystem, time of emergence, germination rate, and overall yield.

Keywords: Digital Agriculture, Monitoring, Yield, Seeding Depth, Germination Rate

CHAPTER 1
INTRODUCTION

Pakistan's economy heavily relies on agriculture, which also directly or indirectly supports 70% of the population. With agriculture contributing to 21.6% of domestic production and employing 52% of the labor force, it plays a vital role in the country's economic stability. Furthermore, agriculture generates 75% of Pakistan's foreign exchange earnings and serves as a crucial source for meeting the nation's food and fiber requirements (Agriculture Finance Division, 2020). Given the growing population, expanding industries, and a developing economy, ensuring food security is a significant concern in Pakistan. Wheat production alone accounts for 80% of the country's total production, making its cultivation essential for guaranteeing food security (Pakistan Bureau of Statistics, 2019).

To enhance agricultural output and farm profitability, it is crucial to optimize the various systems involved in agriculture, including biological, hydrological, chemical, and mechanical aspects. Among these inputs, mechanization stands out as a significant factor in increasing agricultural productivity. Agricultural mechanization encompasses the use of tools, machinery, and equipment for land development, preparation, crop production, harvesting, storage, and on-farm operations. By effectively utilizing agricultural machinery, tools, and equipment, farmers can simplify previously labor-intensive tasks and reduce production costs, leading to increased productivity and improved precision. Mechanization also addresses the challenge of low production and quality resulting from unskilled labor.

However, Pakistan has been slow in adopting agricultural mechanization due to various obstacles, with limited land availability being a key factor. The majority of farmers in the country own small plots of land, making it financially difficult for them to afford expensive agricultural equipment. Surveys indicate that 79% of landowners in Pakistan possess less than 5 hectares of land, indicating their limitations in acquiring sophisticated and expensive agricultural machinery, which could significantly boost yields. To support small farmers in mechanizing their farming practices, it becomes crucial to provide practical and affordable agricultural equipment. Establishing Agro service centers can be a potential solution, enabling small and medium farmers to access machinery on a custom-hire basis when needed. Additionally, the lack of facilities for equipment servicing, maintenance, and repair poses challenges for many farmers. Hence, the development of machinery that requires minimal maintenance and can be repaired on-site by farmers themselves becomes advantageous.

Another barrier to automation in agriculture is the high cost of farm equipment, which small-scale farmers often cannot afford. To address this issue, the idea of developing cost-effective and economical casting machinery specifically targeting small farmers emerged. In developing countries like Pakistan, conventional seeding methods such as broadcasting, line sowing in furrows, and manual seeding are still prevalent. However, these methods have drawbacks, including susceptibility to pest damage, ineffective germination, and vulnerability to rainfall. The continued reliance on these conventional techniques hinders efficient harvesting and mechanized intercultural processes, thereby contributing to low agricultural output in the country. Proper seed planting in rows is crucial for optimal crop growth and yield, and the effectiveness of seed distribution along the rows relies on well-functioning metering apparatus. Ensuring good soil-seed contact is essential to guarantee uniform germination and growth. To mitigate losses and production costs, an automated seed sowing procedure becomes imperative.

In summary, elevating Pakistan's agricultural sector is imperative due to its significant contribution to the economy and livelihoods. Overcoming challenges in adopting agricultural mechanization, providing affordable equipment to small farmers, and transitioning from conventional seeding methods to automated procedures can lead to increased productivity, improved yields, and enhanced food security in the country.

The following important tasks should be adopted in seeding equipment in order to increase farm profit, increase output, and reduce production costs.

1. To plant seeds at the proper depth and spacing.
2. Prepare a seed bed by opening a furrow.
3. To meter seed at a controlled rate in order to achieve the optimal plant population for maximum output.
4. Cover seeds with soil to a proper depth.
5. Increase soil seed contact for the desired germination.

The appropriate seed rate plays a crucial role in the successful sowing of wheat. Achieving a uniform and accurate distribution of seeds in the soil is essential for obtaining precise and favorable results. The performance of a seed drill, which is responsible for sowing seeds at the desired depth per unit area in the field, directly impacts the quality and quantity of the yield. However, during the operation of a seed drill, the operator lacks visibility into the sowing process, making it difficult to monitor the performance of the equipment in real time. Therefore, there is a need to develop a system that can effectively assess the sowing process while the seed drill is in the working position.

Similarly, in Pakistan, where most farmers own small plots of land, purchasing expensive machinery is often beyond their means. Therefore, it is necessary to develop a low-cost seed depth monitoring system that enables farmers to sow seeds at the appropriate depth, thereby enhancing crop yield. The primary objective of the current study is to design tillage and seeding depth monitoring system that addresses the challenges faced by farmers with limited resources and small land holdings, ultimately improving agricultural output and farm mechanization.

1.1 OBJECTIVES

The objectives of this project are as follows:

1. Develop and design a tillage and seeding depth monitoring system specifically tailored for tracking tillage and seed depth during the planting process. This system will enable continuous and accurate measurements of

seed depth, providing valuable data for optimizing seeding practices.

2. By analyzing these variables, we aim to gain insights into the relationship between seed depth and successful germination, as well as identify the optimal depth for achieving higher yields.

CHAPTER 2
REVIEW OF LITERATURE

The significance of conducting a literature review lies in its ability to provide a comprehensive understanding of the problem at hand, thereby preventing redundant efforts and guiding the research in the right direction. In this study, the review of previous research plays a crucial role in establishing the context and orientation of the problem. It helps build upon existing knowledge and avoids unnecessary duplication of efforts. Specifically, the review focused on exploring previous studies conducted worldwide on the monitoring of seed sowing techniques, performance evaluations, automation, and advancements in seed drill components for observing seed sowing. By examining these related studies, valuable insights were gained, enabling the researchers to leverage existing knowledge and build upon it to develop an effective tillage and seeding depth monitoring system. The review serves as a foundation for the current investigation, incorporating the lessons learned from previous research to enhance the understanding and development of seed sowing technologies.

2.1 SEED DRILL

A seed drill is sowing equipment that places seeds precisely in the soil before covering them. Seeds were typically planted by hand before the invention of the seed drill. In addition to being inefficient, planting was exceedingly unplanned, which resulted in an uneven distribution of seeds and low yield.

2.1.1 Manual Seed Drill

In 2019, Rani Sarker designed and developed a manual seed drill capable of planting various crops such as paddy, wheat, dark gram, mung bean, lentil, mustard, and radish in neat rows. The machine consisted of two wheels, two drums with different peripheral openings in seven columns, two furrow openers, two furrow closers, and a handle. The drum openings could be adjusted to accommodate different types of seeds, while the column division allowed for precise seed placement. The machine weighed 14 kg and required a pulling power of 103 Newton. Optimal drum filling conditions were determined for rice, wheat, black gram, mung bean, radish, mustard, and lentil, ranging from 0.25 kg to 2.2 kg, depending on the crop. The recommended operating speed for the machine was found to be between 2 km/h and 4 km/h. At a speed of 2.58 km/h, the average effective field capacities were measured to be 0.17 ha/h (80 cm wide) and 0.24 ha/h (120 cm wide), with corresponding field efficiencies of 82.22% and 78.6%, respectively.

Ahmed and Choudhary (2015) developed a seed sowing cart to address the challenges faced by farmers and laborers in the field, particularly regarding the high costs and labor-intensiveness of planting operations. The aim was to create affordable, multifunctional, and user-friendly agricultural equipment. The seed sowing cart was designed for planting wheat and soya beans, ensuring precise seed depth, uniform seed spacing, and proper soil coverage. The machine operated by pulling it along, and as the base wheel rotated the chain sprocket, the seed-metering device planted the seeds in the soil. The use of three wheels provided better stability in wet fields. The study suggested that lightweight equipment with more wheels was beneficial for wet farming conditions. It was also recommended to maintain a row spacing of 22.5 cm and a sowing width of 15 cm for optimal yields.

Singh and Moses (2018) developed a manual-operated push-type rotary dibbler seed drill specifically designed for bold and medium-sized seeds. The device featured a rotating dibbling head with a covering cum transport heel, penetrating jaws, a seed hopper, and a handle. The parts of the drill were fabricated from mild steel, except for the seed roller. The number of jaws varied from 5 to 8, depending on the size and shape of the seeds as well as the desired seed-to-seed distance. The hopper was filled with seeds, and as the dibbler was pushed forward, the jaws penetrated the soil and dropped the seeds. The weight of the device was 21.5 kg, and the spacing between the jaws was set at 225 mm.

These innovative seed drill designs and developments showcased the efforts to improve seed sowing techniques, enhance precision, and simplify the planting process for various crops. By addressing the challenges faced by farmers and incorporating features such as adjustable drum openings, row spacing, and improved stability, these machines aimed to optimize yields and contribute to the agricultural sector.

2.1.2 Semi-Automatic Seed Drill

In 2011, Tahir Iqbal, Manzoor Ahmed, and Bader Naseem Siddiqui conducted a study on the development of a self-propelled multi-crop seed drill. The aim was to create a cost-effective solution that would benefit small landholders and reduce the expenses associated with agricultural machinery. The study focused on farmers who owned less than 5 hectares of land. The researchers designed a self-propelled seed drill suitable for planting wheat, soybean, and cotton. This innovative machine allowed seeds to be planted at the desired depths with accurate spacing, and it could accommodate various row widths. The speed of the machine was adjusted to match the walking speed of a person, resulting in lower fuel consumption and time savings. The seeds were loaded into a container and placed at the required depths and distances. The self-propelled seed drill had a lower operating cost and required a 5.5hp power source for pulling.

In 2020, Kumar developed a semi-automatic turmeric planting machine. The project aimed to implement an agricultural robot model that could effectively control the movement of the robot. The ATmega8 microcontroller was used to ensure smooth operation. The seeder component of the machine provided autonomous and precise planting of turmeric with high accuracy. The robot's movement was controlled through steerable wheels, ensuring precise navigation. The machine was designed to be hitched to a tractor, which not only provided a stable path for the robot but also supplied power. This setup reduced ground shrinkage and allowed for straight and controlled planting. The system incorporated various controls and calculations to enable precise and efficient operation.

2.1.2.1 Automatic seed drill

Jan and Roman developed tilling and sowing machines that incorporated a cultivation aggregator and seed drill. Their machines featured a modern and compact mechanism for pre-sowing soil cultivation, allowing the soil preparation and sowing process to be completed in a single trip. The system included a control and measurement mechanism, with a key component being the MICRO DAQ module. This module combined control and measurement functionalities with real-time processing using a DSP processor. The module was operated through MATLAB-Simulink software, and its measurement inputs were connected to sensors on a test stand. The system utilized a PID regulator to maintain a constant speed during operation (Jan, 2014).

Ahmadi developed a Precision Seed Drill specifically for oilseed rape. They made modifications to the roller-type metering device and incorporated a fluted seed metering device in a regular drill. Additionally, a steel gage wheel was added to the side of the opener to ensure precise depth control of the seeds. Their alterations demonstrated that seed division consistency was not as critical as in traditional drills. However, when it came to seed breakage, their experimental drill showed significant improvement compared to the traditional drill, with seed breakage levels maintained at a satisfactory rate of 5% (Ahmadi, 2008).

A study focused on computer-vision-based precision seed drill guidance assistance. The study aimed to develop a control component that could accurately position seed drills relative to previous planting lines. A machine vision framework was used to estimate the position, which was then utilized in a broad-sided control loop. Field tests showed a standard deviation of 23 mm for seed-to-seed distance and 100 mm for depth, meeting the requirements of the application. However, precise camera mounting was necessary, which could be achieved through sequential assembly (Leemans & Destain, 2007).

An automatic seed sowing machine was developed to reduce labor costs and improve efficiency. The machine was computerized to automate the planting process, resulting in cost reduction, improved quality, and time and labor savings. The seed planting machine consisted of a wheel drive, seed tank, various device components such as a motor driver, Arduino Uno, Wi-Fi module, DC motor, electric chamber, and two 12-volt batteries. Two DC motors were connected to the rear wheels, with separate motor drivers and connections to the Arduino and battery. The electric chamber controlled the seed flow through the opening and closing of a valve. The entire seed planting machine was controlled by code uploaded to the Arduino board, ensuring precise and automated operation (Sachinjith, 2020).

Kadu focused on automating the seed sowing process using microcontrollers and a robot. The goal was to improve seed planting equipment to achieve accurate seed dispersion within rows. The system relied on a microcontroller to facilitate cultivation activities such as cultivating, treating, and maintaining pre-assigned distances and depths. DC motors and a two-port solenoid valve were used for boring and seed dropping, respectively, with their operations displayed on an LCD. The Seed Sowing Robot utilized electronic sensors and regulators to ensure highly precise seed planting. Sensor-based control allowed for optimal spacing between crops and controlled seed rate, resulting in increased yield and minimized seed wastage (Kadu, 2019).

In summary, seed drills can be categorized into three types: manual seed drills, semi-automatic seed drills, and automatic seed drills. Manual seed drills rely on manpower, consume high energy, and require more time. The spacing between seeds is not fixed in manual drills. Semi-automatic seed drills utilize microcontrollers and sensors such as IR sensors, ultrasonic sensors, and photoelectric sensors. These drills require moderate manpower and less time, and the spacing between seeds is fixed. Automatic seed drills incorporate control systems, machine vision technology, and advanced sensors. They minimize energy consumption, require minimum time and manpower, and offer precise seed placement.

Table 2.1: Comparison of Manual and Automatic Sowing Machine

Sr. No.	**Parameters**	**Manual SeedDrill**	**Semi-automatic Seed Drill**	**Automatic Seed Drill**
1	Manpower	More	Moderate	Less
2	Time	More	Less	Less
3	Technique for sowing	Manual	Automatic	Automatic
4	Seed distance	Not fixed	Fixed	Fixed
5	Wastage ofseed	Medium	Less	Less
6	Use of energy	High	High	Less
7	Pollution in environment	Nil	More	Nil
8	Cost	Less	High	High

CHAPTER 3
MATERIALS AND METHODS

The tillage and seed depth monitoring system designed and developed at the farm machinery workshop, which is part of the Department of Farm Machinery and Precision Engineering, Faculty of Agricultural Engineering and Technology, PMAS Arid Agriculture University Rawalpindi. For this study, materials were predominantly sourced from the local market, including components such as microcontrollers, ultrasonic sensors, RTC (Real-time clock) modules, SD (Secure Digital) cards, LCD (Liquid Crystal Display) screens, buzzers, a power battery (15000 mAh), switch buttons, and metal plates (iron).

The primary objective of this study was to monitor and maintain the required seeding depth. Additionally, the effects of seed depth on germination rate and yield were examined. The research aimed to enhance precision in seed placement and optimize agricultural productivity through the implementation of the tillage and seed depth monitoring system.

3.1 DESIGN CONSIDERATION

The design of the proposed system was built at Precision agriculture laboratory, FAE&T, PMAS Arid Agriculture University Rawalpindi. The developed system was mounted on conventional seed drill and conventional seed planter for sowing of groundnut.

3.1.1 Conventional Sowing Machinery

In Pakistan, seeds are sowed by using different sowing techniques i.e., Broadcasting, Hand seed drill, Seedbed planter, etc. The groundnut seed drill is especially designed to drill the seeds in the same way as farmers normally used.

3.1.1.1 Seed drill

A seed drill is a specialized sowing machine that revolutionized the process of planting seeds in agricultural practices. Prior to the invention of seed drills, seeds were manually planted by hand, resulting in inefficient and improper distribution of seeds, leading to low yields. The introduction of seed drills brought about significant improvements by enabling precise placement of seeds in the soil and covering them adequately. Unlike traditional methods that required prior tilling of the soil, modern seed drills can sow seeds directly without disturbing the soil structure. This helps to prevent soil erosion and moisture loss, as the soil remains intact until the seeds germinate and establish themselves. The conventional seed drill used in this study had nine times , which effectively placed the seeds in the soil and covered them.

Seed drills typically incorporate multiple runners or drills that are spaced evenly to match the desired distance between furrows. These drills expand the furrows uniformly before seed distribution. Behind the drills, metal discs known as presses are positioned to cut down the edges of the furrow and cover the sides where the seeds have been planted. This precise depth control mechanism allows farmers to determine the optimal planting depth for the seeds. Furthermore, seed drill machines offer flexibility in adjusting the row spacing, seed rate, and planting depth according to specific crop requirements. They are commonly used for sowing small seeds such as barley, wheat, sorghum, and similar crops where maintaining consistent spacing within the rows is not essential (Egbo et al., 1985).

3.1.1.2 Components of wheat seed drill

A simple description of a typical divided hopper type of seed drill is represented in table 1 below. However, the constituent sections of the drill may vary in shape and shape depending on the machine. However, they effectively carry out the tasks mentioned below:

Table 3.1: Seeds Drill Components and their Function

Component	Main Function
Seed box or hopper	To contain seeds
Seed metering device	To control the placement of seeds at a given rate
Furrow opener	To prepare the soil so that seeds can be planted.

Seed tube	To transport the seeds from the seed metering device to the furrow opener.
Seed covering device	A furrow opener is used to cover the seeds that have been placed in the furrows.
Transport device	i) To move the equipment between the store and the field and to move it over the soil while planting is taking place. ii) To supply the power source needed to operate the seed metering device
Frame	To offer a base over which all the above parts may be directly or indirectly integrated.

3.1.2 Seed Depth Control System Application Development

The tillage and seed depth monitoring system is composed of various components including a Micro-controller, Ultrasonic sensors, RTC module, SD card, LCD display, Buzzers, Power battery, Switch buttons, and Metal plates (Iron). The development of this system took place at the Precision Agricultural Engineering Lab, utilizing the programming language "C" to create the mechanism. A prototype of the system was successfully designed and assembled, with a specific focus on integrating ultrasonic sensors for its functionality.

3.1.2.1 Programming

```
#include <LiquidCrystal.h>

const int rs = 3, en = 5, d4 = 9, d5 = 10, d6 = 11,
d7 = 12;Liquid Crystal lcd (rs, en, d4, d5, d6, d7);
```

```
 int trig Pin = 25;
 int echo Pin = 29;
 int trig Pin2 = 27;
 int echo Pin2 = 31;
 int Seed Depth = 0;
 long duration = 0;
 long duration2 = 0;

int button = 2;
int value = 0;
int buzzer = 4;
void setup() {

pinMode (trigPin, OUTPUT);
pinMode (echoPin, INPUT);
pinMode (trigPin2, OUTPUT);
pinMode (echoPin2, INPUT);
pinMode  (button, INPUT);

pinMode (buzzer, OUTPUT) ;
pinMode  (A5, OUTPUT) ;

Serial.begin (9600); // Starting Serial
Terminallcd.begin (16, 4);

// set up the LCD's number of
columns and rows:lcd.begin (16, 4);

 lcd.setCursor  (0,0);
 lcd.print ("TILLAGE ");

 delay (1000);

 lcd.setCursor (0,1);
```

```
  lcd.print("  MONITORING  ");delay(1500);

  lcd.setCursor(0,2);
  lcd.print("SYSTEM ");
  delay(1500);

  lcd.setCursor (0,3);

  lcd.print ("PMAS-AAUR ENCIB");

delay(1000); lcd.clear (); lcd.setCursor (0,1);

 lcd.print
 ("Initializing...");
 delay (1000);

 lcd.setCursor
 (0,2); lcd.print ("
 System...");
 delay(1000);
 lcd.clear();

 }

 void lcd_comSetup(void)

 {

 lcd.begin(16, 4);

 lcd.setCursor(0, 0);
 lcd.print("MainValue:");
 lcd.setCursor(0, 1);
 lcd.print("SeedDepth:");
```

```
lcd.setCurso
r(0, 2);
lcd.print("Pl
anter
Cond:");
lcd.setCurso
r(0, 3);
lcd.print("M
akePLanter:
");

}

void loop(){

lcd_comSetup(); int ultrasonicValue;

int ultrasonic2Value;

if (digitalRead(button) == 1)

{

lcd.setCursor(10, 0);
lcd.print(ultrasonic2Valu
e);lcd.setCursor(14, 0);
lcd.print("cm");

// 1st ultrasonic sensor
initialization
digitalWrite(trigPin, LOW);
delayMicroseconds(2);

// Sets the trigPin HIGH (ACTIVE) for 10
microsecondslcd.print("NOK");
```

```
 lcd.setCursor(12, 3); //
 DOWN UP
 lcd.print("DOWN");}

 else if (value >= 6 && value <= 9)

 {

digitalWrite(buzzer, LOW);  // turn the LED on (HIGH is the voltage
level)delay(500);

digitalWrite(A5,
HIGH);
delay(200)

lcd.setCursor(13, 2); //NOK
OKlcd.print("OK")

lcd.setCursor(12, 3); //
DOWN UP
lcd.print("Levl");}

else if (value >9)

{digitalWrite(buzzer,
HIGH);delay(500);

digitalWrite(A5,
LOW);dlay(200);
lcd.setCursor(13,
2); //NOK OK
lcd.print("NOK");
lcd.setCursor(12,
3); // DOWN UP
lcd.print("UP"); }
```

```
}

else if (digitalRead(button) == 0)

{

lcd.setCursor(10, 0); lcd.print(ultrasonic2Value);
lcd.setCursor(14, 0); lcd.prnt("cm");

}

Serial.print("MAIN_ULTRASONIC_VALUE=");
Serial.print(ultrasonic2Value);

Serial.print("cm");

Serial.print('\n');
Serial.println();Serial.print("Depth_ULTRASO
NIC_VALUE=");Serial.print(value;

Serial.print("cm");

Serial.print('\n');Serial.printl();
delay(1000);

}
```

3.1.3 Sensors

In this research, ultrasonic sensors were utilized for their capability to measure the distance to objects using ultrasound waves. These sensors emit ultrasonic waves and then receive the reflected waves from the target. By calculating the time interval between the emission and reception, the distance to the target can be determined. The range of the ultrasonic sensor in this study was up to 2 meters.

Ultrasonic sensors were specifically chosen over other sensor types due to their effectiveness in adverse environmental conditions such as rain, fog, and dirt. Their reliable performance in such challenging situations made them the preferred choice for object detection.

A comprehensive evaluation of the sensor properties was conducted, and a comparison was made among different sensor options. The findings of the evaluation clearly demonstrated that the ultrasonic sensor was the most suitable and optimal choice for object detection, outperforming other sensors in terms of its capabilities and functionality.

Table 3.2: Properties of Different Sensors

Key Properties	**LIDAR**	**Ultra sonic**	**Machine vision**	**Infrared**	**Photoel ectric**	**Electrostatic**	**LDV**
Working range: >2m	-	yes	yes	yes	yes	yes	Yes
Working range: <50m	yes	no	-	yes	yes	yes	Yes
Angle measurement: <10	yes	-	yes	yes	yes	no	-
Angular resolving power	yes	-	yes	yes	-	yes	No
Direct velocity measurements	no	-	-	no	no	no	Yes
Functioningin	-	-	-	-	no	yes	Yes

rainfall							
Function during fog orsnow	-	yes	-	-	no	-	Yes
Function in dust	-	yes	no	no	no	yes	-
Functioningin night	no	-	-	yes	no	yes	yes

The field of agriculture has witnessed the development of innovative prototypes for seeding depth, offering various functionalities that surpass manual and conventional seed drill sowing practices. Over the past decades, scientists and engineers use many techniques for seed sowing. Those techniques involve fuzzy logic, use of runner and double disc, EM38 sensor, non-contact band sensor,surface reference plat, ordinal feed-forward control system, depth regulator, downforce hydraulic control device, computer vision system, PID controlalgorithms, discrete element methods of simulation, single disc wedge type generators, ultra-sonic sensors, electro-hydraulic actuators, magnetic dampers. Siemens PLC, linear position sensors TX2 and LVTD sensors. All techniques provide useful information for seed depth control.

Table 3.3: Sensors (Concept, Advantages, and Disadvantages)

Sensors	Basics	Advantages	Disadvantages
LIDAR	Measures the distance to object by using the laser beams	-High accuracy -Fast in working -Used in lighting conditions	-Poor working in corners detection -Have problems under hostile weather situations -High in cost
Ultrasonic	Measures the distance of the target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal	-Interface with microcontroller easily -It Easy to use -Not affected by the color of things -Low in cost	-Detection range is limited - Mostly sensors are used for the common purpose -Influenced by weather
Machine Vision	Providing automated imaging-based investigation and study for automatic evaluation and machine control.	-Strong enough for open field applications -Given a large amount of information -Give precise information	-Wide calculation requirement -Capable of direct sunlight -High in cost -Need recording procedures and proper calibration
Infrared	Measures and senses	-Low in cost	-Range is limited

	infrared radiation in its surrounding atmosphere.	-Use in day and nighttime -Use less power -Slight effect of temperature and humidity on target detection	-Low spatial resolution for agriculture use -Detection appears to be impacted by light intensity.
Photoelectric	Determine the absence or presence of an object and distance by using a light transmitter and a photoelectric receiver.	-Sense all kinds of material -Low in cost -Long sensing range -Reliable in use	-The sensing range is affected due to color and reflectivity of target
Electrostatic	Electrostatic sensors sense the intensity of electric field and calculate electric potential.	-Require less power -Less in weight -Reduce effects of friction and other mechanical non-linarites -Simple in structure	-Lack long term stability -High pH sensitive
LDV	Measures the velocity of flow field. Monochromatic laser beam is sent toward the	-Non-intrusive -High resolution -High accuracy -Wide dynamic	-Single-point measurement -High in cost

3.1.4 Microcontroller

A micro-controller is composed of different electronic components which are designed to control a specific operation in a proposed system. Typically, it consists of a processor, memory, and input/output devices.

3.1.4.1 Display Screen

LCD (Liquid Crystal Display) is a type of flat panel display that utilizes the light modulating characteristics of liquid crystals in conjunction with polarizers. It serves as a visual output device that presents information on a screen in a visible manner. LCD displays can render various forms of content, including graphics, text, and images. They come in a range of sizes and shapes, catering to specific usage and application needs. Whether it is for displaying images, presenting textual information, or showcasing graphics, LCDs offer versatility and are widely utilized across different industries and contexts.

3.1.5 Hardware Assembled and Installation

The real-time monitoring system program, which was developed, involved the integration of various components including the RTC (Real-Time Clock) module, SD card module, buzzers, LCD display, and switch buttons. These components were electronically connected to the microcontroller through electronic circuits, ensuring their seamless operation within the system. Additionally, ultrasonic sensors were incorporated into the developed system to accurately measure the depth. The flow diagram of the seed depth control system illustrates the sequential steps and processes involved in the system's functioning.

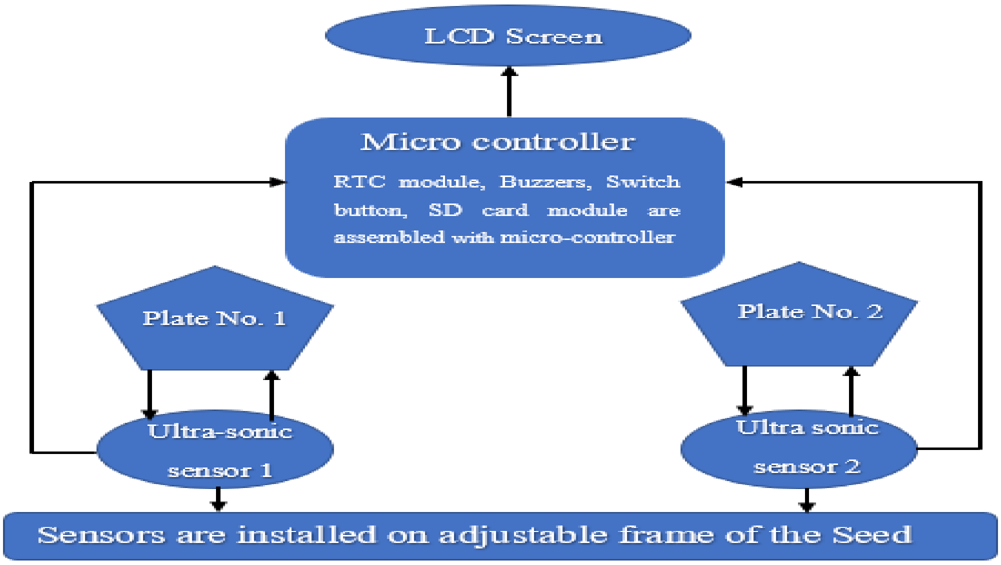

Figure 3.1: Flow diagram of the proposed real time monitoring mechanism

Figure 3.2: Prototype model for seed depth control system

Figure 3.3: Real time seed depth control mechanism mounting on tractor

During this phase, the microcontroller was integrated with the designed electronic circuit, and the entire system was installed on a tractor-propelled conventional seed drill. The seed depth control system was specifically mounted onto the tractor-propelled conventional seed drill. To ensure accurate measurements, metal plates were employed as reference points for the sensors. Ultrasonic waves, emitted by the transmitter, would encounter these metal plates and reflect back. Both the ultrasonic sensors and metal plates were installed on the tractor and conventional seed drill, positioned in a manner that allowed direct contact between them. The metal plates, extending to a length of 8 meters, were set perpendicular to the sensors at a height of 6 meters.

The tines of the conventional seed drill were placed on the soil surface, and the system was switched on. The LCD displayed the sensor reading as the "Reference value" corresponding to the metal plate. A comparison was made between two height difference readings: one manually measured from the sensor to the metal plates and the other obtained from the sensor. If both values matched, the sowing process could commence. However, if there was a disparity, the height difference was adjusted to rectify the error. The system regarded the depth of the seed drill tines as the depth of seed placement. The spot where the seed drill tines penetrated the soil indicated the point of seed sowing. The system measured this depth from the metal plate to the seed placement, referred to as the "Main value," and calculated the difference between the "Main value" and the "Reference value." This difference was then displayed on the LCD as the "Seed depth." Additionally, there was a switch that needed to be turned on when storing the seed depth data. The data was saved in an SD card that had already been inserted into the system.

Figure 3.4: Position of the sensor on a conventional drill

4

Figure 3.5: Installing Seed Depth Monitoring System

Figure 3.6: Positions and distance b/w sensor and metal plate

Figure 3.7: Manually measuring distance b/w sensor and plate for comparison with sensor reading

3.2 EXPERIMENTAL PROCEDURE

The designated area, measuring 87,120 square feet or 2 acres, divided into fields for the purpose of testing the tillage and seed depth monitoring system and the conventional drill. The field was further subdivided into ten rows for groundnut cultivation. The tillage and seeding depth monitoring system underwent testing, and various parameters were monitored and measured, including seeding depth with and without the control system on the conventional seed drill, germination rates, and yields. Since both fields shared the same dimensions, a single layout plan was used for both crops. After harvesting the previous crop (groundnut sown in April), the layout plan was implemented. During groundnut sowing, the total area was divided into ten equal rows to ensure more precise data collection. The experimental field layout plan depicted the groundnut layout in blue, labeled as R1 to R10.

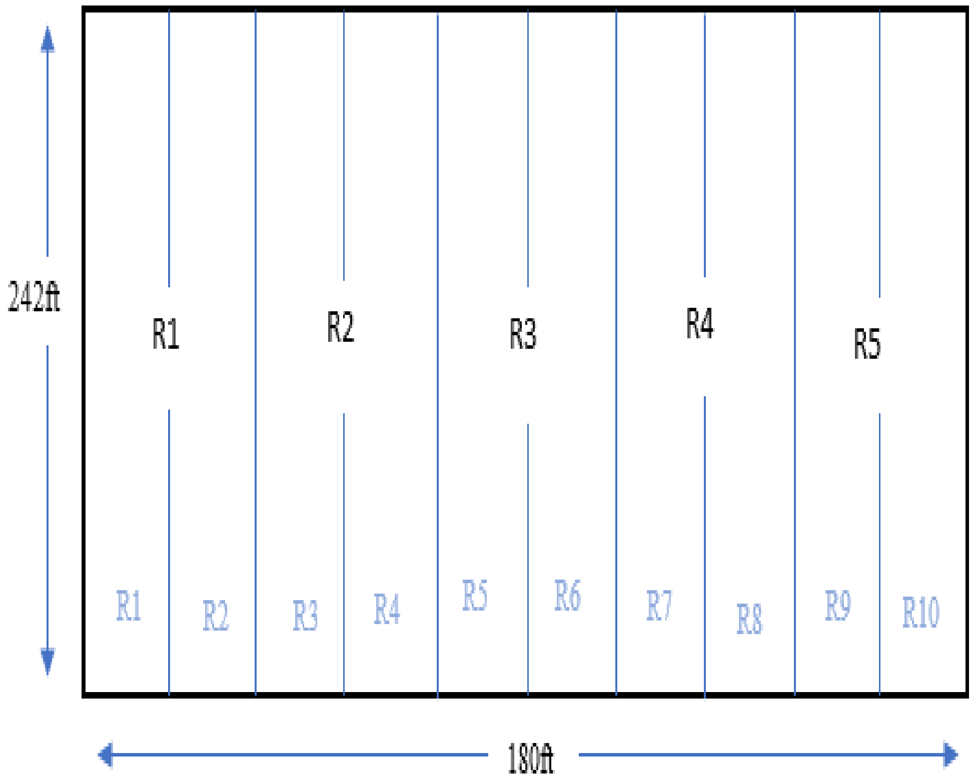

Figure 3.8: Fields layout plan with tillage and seeding depth monitoring system and with conventional seed drill

3.3 METHOD TO FIND GERMINATION RATE

It is simple to find out the germination rate (GR). The following points shows the procedure to find out the germination rate as following:

1. Make a steel frame of 1 m^2 area.
2. Place this steel frame over the standing root of the plants
3. Count how many plant populations are there in the frame.
4. Places the frame at different locations and count the no. of plant populations.

Average Germination Rate (%) = (Number of Seeds Germinated / Total Number Seeds in test) ×100

The designated area, measuring 87,120 square feet or 2 acres, was divided into two fields for the purpose of testing the tillage and seeding depth monitoring system and the conventional drill. The field was further subdivided ten rows for groundnut cultivation. The tillage and seeding depth monitoring system underwent testing, and various parameters were monitored and measured, including seeding depth with and without the control system on the conventional seed drill, germination rates, and yields. After harvesting the previous crop (groundnut sown in April), the layout plan was implemented. During groundnut sowing, the total area was divided into ten equal rows to ensure more precise data collection. The experimental field layout plan depicted the groundnut layout in blue, labeled as R1 to R10.

CHAPTER 4

RESULTS AND DISCUSSION

The results of the study demonstrated the effectiveness of the seed depth control system in maintaining optimal seeding depth compared to conventional drilling methods. The groundnut, the seed depth control system yielded an average cumulative germination rate of 14 plants/m2, whereas the conventional drill resulted in an average germination rate of 13 plants/m2.

The expected yield of groundnut with the depth control system was projected to be 730 kg/acre, whereas the conventional drill yielded an estimated 680 kg/acre.

The findings of this study highlight the importance of proper seed placement and its impact on germination rates and crop yields. The tillage and seeding depth monitoring system proved to be superior in maintaining the desired seeding depth, resulting in higher germination rates and increased crop yields compared to the conventional drill.

The improved germination rates observed with the tillage and seeding depth monitoring system can be attributed to the accurate placement of seeds at the recommended depth. Proper seed depth ensures that the seeds receive optimal moisture, nutrients, and contact with the soil, leading to better germination and subsequent crop growth.

The higher yields achieved with the tillage and seeding depth monitoring system can be attributed to the improved germination rates and uniformity in seed distribution. When seeds are sown at the recommended depth, they have a higher chance of successful germination and establishment, leading to healthier and more productive crops.

In contrast, the conventional drilling methods exhibited variations in seed placement depth, resulting in lower germination rates and reduced crop yields. Inconsistent seed placement can lead to uneven emergence and growth, resulting in reduced plant density and overall productivity.

The results of this study emphasize the significance of adopting modern technologies, such as tillage and seeding depth monitoring system, to optimize crop production. By ensuring precise seed placement and maintaining the recommended seeding depth, farmers can achieve higher germination rates, healthier crops, and increased yields.

Furthermore, the implementation of tillage and seeding depth monitoring system has the potential to enhance the profitability and sustainability of small farmers in Pakistan. By improving crop yields, farmers can increase their revenue and contribute to the country's overall agricultural productivity.

It is important to note that while this study focused on seed placement and its impact on germination rates and yields, there may be other factors that can influence crop production, such as soil quality, irrigation, and pest management. Further research is recommended to explore these factors and their interactions with seed depth control systems for a more comprehensive understanding of their effects on crop performance.

Overall, the findings of this study underscore the importance of precise seed placement and the potential benefits of implementing advanced technologies, such as tillage and seeding depth monitoring system, to enhance crop yields and improve the livelihoods of small farmers in Pakistan.

4.1 GROUNDNUT SOWING

The graph in fig: 4.3 shows that trend of the graph fluctuates by represent the seed depth placement during groundnut sowing by using conventional seed drill. The maximum value recorded was 9 cm deep. The minimum value noted is 1cm deep in the soil that is too shallow, which was harm by birds and rats. The desired seeding depth for uniform groundnut germination was in between 3 to 7 cm. The red line is representing the maximum upper limit and yellow line shows the minimum lower limit for seed sowing. All rows as shown in figure 5 reveals that 72 % readings were in the desired depth and the remaining were either too deep or too shallow in the soil. The seeding depth recorded out of desired range was 13 % and too shallow was 10 %. All the rows show notable inconsistency in seed placement. The row 1, and row 2, shows 11.5 % seeds above the red line and 7.6 % seeds was below the yellow line. In row 3 and row 7, 7.6 % cross the max. limit and 11.5 % behind the yellow line. In row 9 and row 10, only one seeds was placed too shallow in each row and, 9.5 %, 17.6 % seeds was above the red line. The row 4, 5, 6, and 7 have lots of variations in seeding depth as seeds placed too deep were 11.5 %, 15 %, 23 %, and 16 % and those which were too shallow 15 %, 15 %, 11.5%, and 4 % respectively. Main reason to this inconsistency was the undulated land, and unskilled operator which was regularly driving tractor-mounted seed drill without considering proper seeds placement as per desired range.

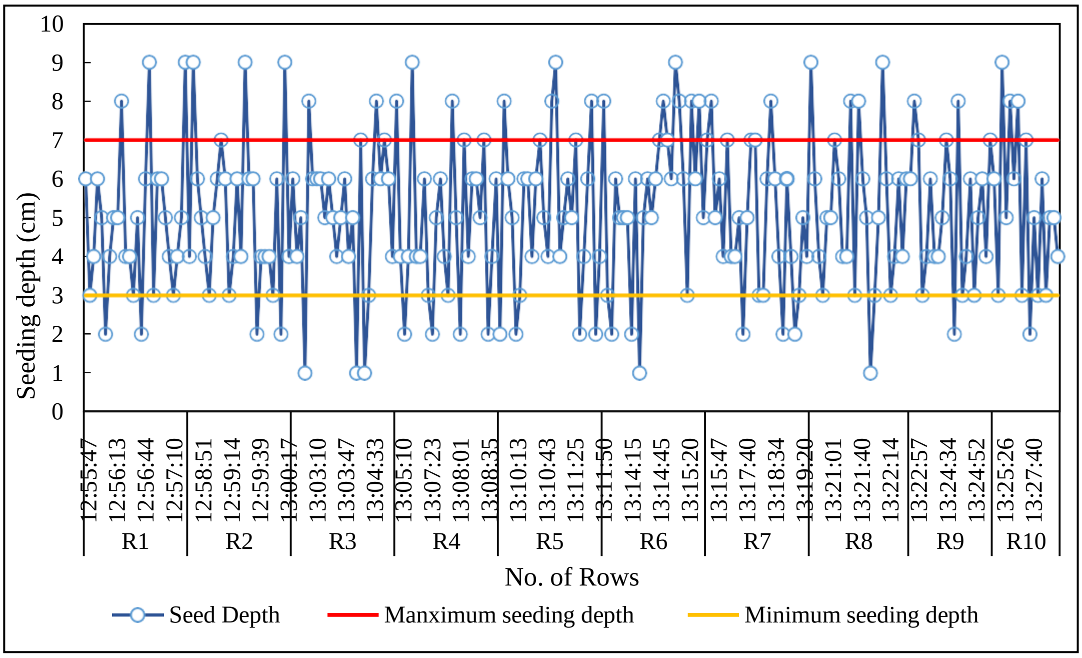

Figure 4.1: Seeding depth during groundnut sowing at field with conventional drill

4.2 GERMINATION RATE OF GROUNDNUT:

The Fig: 4.8 indicates the trends for the germination rate of groundnut after sowing from day 7 to days 25. Average germination rate of 20 samples was 60.53 % by the seed depth control system. The maximum germination rate of groundnut was recorded as 72.72% and having 16 no. of plants/m2. The minimum germination rate was 45.45 % having 10 no. of plants/m2. The average no. of plants/m2 were 13.31 and average germination rate of groundnut with conventional seed planter was 55.57 %. The maximum GR of the sample 16, and 21, having 68.18 %, and plants population were 15. The samples which have minimum GR are 1, 5, 13, 18, having 45.45 % GR, and 10 no. of plants. In conventional seed planter average no. of plants were recorded as 12.22.

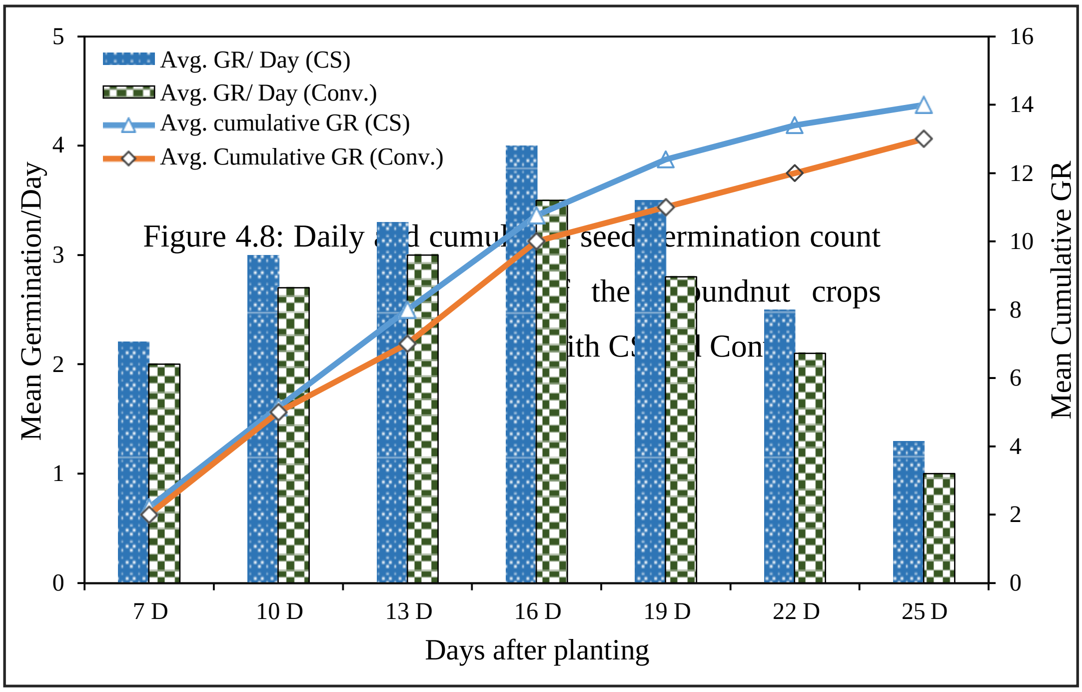

Figure 4.2: Daily and cumulative seed germination count of the Groundnut cropswith CS and Conv

- ❖ CS = Seed depth control system
- ❖ Conventional drill

As after 40 day of sowing for cross checking GR data was also collected. The average germination rate of 20 samples with depth control system was 61.63 %. The maximum germination rate of groundnut was 72.72% recorded when the no. of plants/m2 were 16, and minimum germination rate was 50.54 % when no. of plants/m2 were 11. The average no. of plants/m2 were 14. The average GR of groundnut with conventional seed planter was 55.84 %. The maximum GR of the sample 15, having 72.72 % of GR, and no. of plants were 16. The minimum GR samples are 2, 9, having 45.45 GR, and no. of plants were 10. In conventional seed planter average no. of plants were 12.72.

4.3 YIELD:

The expected production of groundnut with the seed depth control system will be 730 kg/acre and with a conventional seed planter 680 kg/acre.

SUMMARY

In Pakistan, small farmers often face challenges with the traditional broadcasting technique of sowing seeds, leading to unfavorable germination conditions, seed losses due to animals and rain, and lower crop yields. To address these issues, conventional drills were introduced for more precise seed placement. The effectiveness of conventional drills determines the uniformity of seed distribution, which is crucial for high and consistent seed emergence. Compared to broadcasting, drilling methods have shown to yield higher crop production. However, the automation of the seeding metering system is necessary for improved efficiency and cost-effectiveness.

To meet this need, a low-cost and easily accessible multifunctional technology system developed at the Farm Machinery Workshop, FAE&T, PMAS Arid Agriculture University Rawalpindi. The system aimed to achieve optimal seeding depth, improve crop germination, and enhance overall production. The technology utilized an electronic circuit connected to a microcontroller, along with additional components such as an RTC module for date and time, sensors (specifically ultrasonic sensors) to measure depth, buzzers for sound alarms, an LCD for visibility, an SD card module for data storage, and switch buttons for system control and data management. Metal plates were installed as reference points for the sensors, allowing the system to measure the depth accurately.

The tillage and seeding depth monitoring system was mounted on a tractor-propelled conventional seed drill, with sensors placed at appropriate positions on the drill's frame. The metal plates, spanning 8 meters in length and positioned perpendicular to the sensors at a height of 6 meters, provided reference values for depth measurement. By comparing the manually measured height difference between the sensor and metal plates with the sensor readings, the system adjusted the seeding depth accordingly. The depth of the drill tine determined the seed placement, and the system calculated the difference between the main value (sensor reading) and reference value (manually measured). This difference, referred to as the "Seed depth," was displayed on the LCD. Additionally, a switch allowed for the

storage of seeding depth data on the inserted SD card.

The implementation of the tillage and seed depth monitoring system effectively maintained the desired seeding depth, while conventional drills exhibited fluctuations. The groundnut average cumulative germination rate was 14 plants/m2 with the seed depth control system and 13 plants/m2 with the conventional drill. The expected yield of groundnut with the depth control system was projected to be 730 kg/acre, whereas it was estimated to be 680 kg/acre with the conventional drill.

Overall, the introduction of the tillage and seed depth monitoring system demonstrated its proficiency in maintaining accurate seeding depth and improving crop germination rates. In contrast, conventional drilling methods showed variations. The implementation of this technology has the potential to significantly enhance crop yields, providing a valuable tool for small farmers in Pakistan to increase their revenue and productivity.

CONCLUSIONS

In conclusion, one of the major challenges in Pakistan's agricultural sector is the inadequate seed depth and uneven distribution of seeds during sowing. Although conventional drills have been used to address these issues, they often fail to achieve the optimal seed depth required for successful germination. To overcome this problem, a study conducted at the Farm Machinery Workshop, FAE&T, PMAS AAUR, with the aim of designing and developing a tillage and seeding depth monitoring system for seed depth. The study also aimed to investigate the impact of seed placement on germination rates in different fields.

The results of the study showed that the tillage and seeding depth monitoring system effectively maintained the desired seeding depth, while the conventional drill exhibited variations, leading to inconsistencies in germination rates and crop yields for groundnut. On average, the cumulative germination rate of groundnut using the tillage and seeding depth monitoring system was 14 plants/m2, while it was 13 plants/m2 with the conventional drill. These differences in germination rates directly impacted the crop yields.

The yield of groundnut with the seeding depth monitoring system was projected to be 730 kg/acre, while it was estimated to be 680 kg/acre with the conventional drill. These findings highlight the significance of proper seed placement at the recommended depth in enhancing crop yields. Overall, the study emphasizes the importance of addressing seed depth issues and implementing effective measures to optimize crop yield, thus benefiting both farmers and the nation as a whole.

RECOMENDATIONS

Based on the design and fabrication of tillage and seeding depth monitoring system regarding seed placement and its impact on germination rates and yields, several recommendations can be made to improve the design.

1. Firstly, it is crucial to ensure that the land is properly prepared with crumbled soil structure before using the seeders and planters equipped with the control system. This will create an optimal environment for seed germination and growth.
2. To enhance the accuracy of the system, it is recommended to explore the implementation of hydraulic control systems instead of relying solely on operator intervention based on visual observations. By incorporating real-time data visualization and hydraulic control, the seeding depth can be more precisely controlled, leading to improved germination rates and ultimately higher crop yields.
3. It is also important to consider the potential influence of field residue or stubbles from previous crops on the performance of the sensor system. These remnants may introduce some variability to the sensor readings, and thus, their impact should be further investigated and mitigated to ensure consistent and reliable results.

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