DEVELOPMENT OF GPS BASED VARIABLE RATE FERTILIZER SPREADER

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CERTIFICATION

I hereby undertake that this research is an original one and no part of this thesis falls under plagiarism, If found otherwise at any stage, I will be responsible for the consequences.

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Certified that the contents and form of thesis entitled **"[Development of GPS Based Variable Rate Fertilizer Spreader]"** has been found satisfactory for requirements of the degree.

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Ser. No	Student Name	ARID No.	I	II	III	Total
			Problem Identification & Objectives	Methodology	Work Plan and VIVA	
			(3)	(3)	(3)	(9)
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			I	II	III	IV	V	VI	VII	VIII	15
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Literature Review	Methodology	Analysis & Conclusions	Technical Writing	Innovation	Practical Application	Formatting/ Organization	Originality

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Abstract

Precision agriculture techniques have gained significant attention in recent years, as they offer the potential to optimize crop yields while minimizing environmental impact. The aim of this work is to design and develop a GPS-based variable rate fertilizer spreader for precision agriculture applications. This research focus on improving the efficiency and accuracy of fertilizer application by incorporating GPS technology into the existing fertilizer spreading equipment. The proposed system utilizes a combination of GPS and sensor technologies to map the field and assess the nutrient requirements of different areas. By integrating these data, the system calculates and adjusts the fertilizer application rates in real-time, allowing for precise application tailored to the specific needs of different areas within the field. The traditional approach of uniformly spreading fertilizers cross an entire field often leads overuse in certain areas and underutilization in others, researching in suboptimal crop growth and potential environmental damage. This work proposes a solution to this problem by implementing a variable rate fertilizer spreader that intelligently spread fertilizer applications rates based on management zone of field. This study involves the replacement of the tractor's Power Take off (PTO) shaft with a Direct Current (DC) motor, along with the integration of Global Positioning System (GPS) technology and a microcontroller. This integration facilitates the creation of a controlled environment for the spreader assembly, enabling efficient fertilizer spreading. Additionally, a mobile application has been developed to generate prescription maps for enhanced functionality. The performance of the system was evaluated through field trials in various agricultural settings. The trials focused on measuring the accuracy of fertilizer application, analyzing the impact on crop growth and yield, and assessing the economic benefits of adopting the technology. The results demonstrated that the GPS-based variable rate fertilizer spreader effectively optimized fertilizer application, resulting in improved crop performance and reduced input costs. The findings of this thesis have implications for farmers, agronomists, and agricultural machinery manufacturers, as they offer insights into the potential benefits and challenges associated with implementing GPS-based variable rate technology in fertilizer spreading operations. Furthermore, this research encourages the adoption of precision agriculture practices, contributing to sustainable and environmentally conscious agricultural practices in the future.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Precision agriculture, also known as precision farming or site-specific farming, is a modern farming approach that utilizes advanced technologies and data analysis techniques to optimize agricultural practices. It involves the use of precision farming tools and systems to collect, analyze, and apply precise data about the variability within agricultural fields. This data-driven approach enables farmers to make informed decisions and take targeted actions, resulting in increased efficiency, improved productivity, and reduced environmental impacts. At the core of precision agriculture is the concept of treating each area of a field as a unique entity with its specific characteristics and requirements. Traditional farming practices often involve treating the entire field uniformly, regardless of its inherent variability. In contrast, precision agriculture recognizes that different areas of a field may have varying soil types, nutrient levels, moisture content, and other factors that influence crop growth and yield.

To implement precision agriculture, farmers utilize a range of technologies and tools. These include global positioning systems (GPS), geographic information systems (GIS), sensors, and data analytics software. GPS and GIS technologies provide accurate and precise spatial information, enabling farmers to precisely map and monitor their fields. Precision agriculture also encompasses variable rate technology (VRT), which enables farmers to apply inputs, such as fertilizers, pesticides, and water, at varying rates based on the specific needs of different areas within a field.

VRT systems utilize the collected data, such as soil nutrient levels or crop health information, to adjust application rates in real-time. This ensures that crops receive the right number of inputs at the right time and in the right place, maximizing resource efficiency and minimizing environmental impacts. The benefits of precision agriculture are numerous. Firstly, it enables farmers to achieve higher crop yields and improved quality by tailoring inputs and management practices to the specific needs of different areas within a field. By optimizing the use of fertilizers, pesticides, and water, precision agriculture reduces input costs and minimizes waste. This not only improves farm profitability but also reduces the environmental impact of agriculture, such as water pollution and greenhouse gas emissions. Precision agriculture also enhances sustainability by promoting soil health and reducing soil erosion. By precisely managing inputs and monitoring soil moisture levels, farmers can prevent over-irrigation, conserve water resources, and maintain optimal soil moisture conditions. This helps in preserving water quality and reducing the risk of nutrient runoff into nearby water bodies. Precision agriculture represents a paradigm shift in farming practices, leveraging technology, data, and analytics to optimize agricultural operations. By considering the variability within fields and applying inputs precisely, farmers can achieve higher yields, reduce costs, minimize environmental impacts, and promote sustainable agriculture. As technology continues to advance, precision agriculture is expected to play an increasingly vital role in feeding the growing global population while minimizing the strain on natural resources.

Variable Rate Technology (VRT) is a key component of precision agriculture that allows farmers to optimize input application rates based on the specific needs of different areas within a field. VRT enables farmers to vary the application rates of inputs such as fertilizers, pesticides, and irrigation water, according to the variability of soil conditions, crop requirements, and other factors. Traditionally, farmers applied inputs uniformly across an entire field, assuming that each area had similar nutrient requirements or pest pressure. However, this one-size-fits-all approach often led to over-application or under-application of inputs, resulting in inefficient resource utilization, decreased yields, and negative environmental impacts.

A variable rate fertilizer spreader is a type of agricultural equipment used for spreading fertilizers onto fields or crops. Unlike traditional spreaders that apply a fixed rate of fertilizer across the entire area, a variable rate fertilizer spreader allows for precise application of fertilizer based on specific field conditions and crop requirements. The key feature of a variable rate fertilizer spreader is its ability to adjust the rate of fertilizer application in real-time as the equipment moves across the field. This adjustment is typically done through advanced technology such as GPS (Global Positioning System) and electronic controllers. The spreader receives data from various sources, including soil nutrient analysis, crop yield goals, and satellite imagery, to determine the optimal fertilizer application rates for different sections of the field. By using variable rate technology, farmers can achieve more precise fertilizer distribution, tailored to the specific needs of different areas within a field. This can result in several benefits, including improved crop yields, reduced input costs by avoiding over-application of fertilizers, minimized environmental impact by reducing nutrient runoff, and better resource management. A variable rate fertilizer spreader is a modern agricultural tool that helps optimize fertilizer usage by providing targeted and variable application rates based on site-specific conditions, ultimately enhancing productivity and sustainability in farming practices.

The utilization of GPS-based variable rate fertilizer application exemplifies the latest technological advancements in the field of precision agriculture. This cutting-edge approach ensures the precise distribution of fertilizer to specific areas within the field that exhibit soil deficiencies in vital nutrients such as potassium, nitrogen, and phosphorus. By accurately targeting nutrient-deficient soil, this technology significantly enhances crop yield when compared to conventional manual fertilization methods. Moreover, this method proves to be highly effective, yielding improved results, while simultaneously reducing the time required for application. The GPS-based variable rate fertilizer spreader comprises several essential components for its operation. Primarily, the PTO (power take-off) shaft of the implement is replaced with a 200-watt DC motor. This process occurs through multiple stages. The DC motor is connected to the shaft of the fertilizer spreader, receiving signals from the microcontroller. The microcontroller, in turn, initially obtains the signal from the GPS and then provides the signal to the motor using the IBT2 Motor Shield. To facilitate this operation, a combination of various tools is necessary, including a GPS receiver, microcontroller, Bluetooth, IBT2 motor shield, a mobile app, a 12-volt battery, and a variable rate resistor. The proposed variable rate fertilization process can be carried out in three different modes:

1.2 MANUAL MODE

In this mode, the rate of fertilizer dispensing is altered by adjusting the resistance of the variable rate resistor. The resistor transfers the signals to the microcontroller, thereby changing the speed of the motor attached to the assemble shaft, consequently, the speed of fertilizer dispensing.

1.3 TRACTOR SPEED SYNCHRONIZATION

In the speed sync method, the microcontroller receives signals from the GPS and defines the initial and final points for fertilization. The IBT Motor Shield calculates the distance between these two points and the distance covered within a given unit of time. The mobile app, integrated with Bluetooth, displays the working speed of the tractor on its screen. As the speed of the tractor increases, the dispensing rate of the fertilizer also increases, and vice versa.

1.4 PRESCRIPTION MAP

In the third mode, the prescription map is configured on the mobile application, which is connected to the system via Bluetooth. This map is designed to outline a circular region, defining various parameters such as the radius and center point of the circle, achieved through the utilization of the Haversine formula. Once the map is generated, it is transmitted to the microcontroller. The GPS then identifies the specific field where the fertilizer needs to be spread. Consequently, only the designated areas outlined in the prescription map are covered during the fertilization process, while those areas where the nutrient levels are already sufficient are excluded from the dispensing process.

The GPS-based variable rate fertilizer spreader is a sophisticated system that utilizes components such as a GPS receiver, microcontroller, Bluetooth, IBT2 motor shield, mobile app, 12-volt battery, and a variable rate resistor. It offers three modes of operation: manual mode, speed sync, and prescription map, each serving different purposes to enable precise and efficient fertilization.

CHAPTER 2

LITERATURE REVIEW

Arnold W Schuman explained in his research work a Fertilizer spreader capable of variable rate application are increasingly important for enhancing nutrient management in horticultural crops because they improve placement and increase nutrient uptake efficiency. Matching applied fertilizer to fertilizer requirements represents a significant input cost saving for the grower and a reduction in potential pollutant loading to ground and surface water. Variable rate fertilization (VRF) is a precision agriculture technology made possible by embedded high-speed computers, accurate Global Positioning System (GPS) receivers, Geographic Information Systems (GIS), remote sensing, yield or soil maps, actuators, and electronic sensors capable of measuring and even forecasting crop properties in real time. For tree crops like Florida citrus (*Citrus* spp.), the most important function of the VRF spreader is to detect and avoid fertilizing spaces of the orchard not occupied by trees. Treeless spaces are becoming more common in Florida as diseases such as citrus greening and canker cause the removal of thousands of trees every year. VRF works best under those conditions. Because VRF exploits crop and soil variability, it has no value in a perfectly uniform field. VRF enables smaller trees including resets to be fertilized at lower, most appropriate rates, thus minimizing any excess application. This article examines the existing knowledge on using precision agriculture and variable rate technology to keep water and nutrients in the root zone of horticultural crops, thus facilitating maximum uptake efficiency (Schumann 2010).

Hassan S Chattha did a research work on “Variable rate spreader for real time spot application of granulate fertilizer in wild blueberry “ , the commercial variable rate (VR) fertilizer spreader can change fertilizer rates in different management zones using global positioning system (GPS) guided prescription maps. The VR fertilizer spreader allows the independent control only on half of the fertilizer boom (3.66 m; 6 nozzles). This existing VR fertilizer spreader fertilizes unevenly distributed small sized bare spots/weed patches which are less than half boom length in wild blueberry fields. Therefore, the existing VR fertilizer spreader was modified to control each pair of nozzles for spot-application of fertilizer only in plant areas. The automated sensing and control system consisting of 6 eye colour cameras, solenoid valves, pneumatic cylinders, programmable logic controller (PLC), 8-channel VR controller (VRC) interfaced to a pocket PC (PPC) using wireless Bluetooth radio with Windows Mobile® and a custom software was developed. The eye colour cameras were mounted on a separate boom in front of the tractor at a height of 1.2 m. The modified VR spreader was capable of using prescription maps and automated sensing and control system simultaneously to detect foliage/bare spots in real-time to avoid fertilization in bare spots/weed patches. The ACCU-RATE controller calibration and response time calculations were performed prior to field experiment. The results of calibration tests for the ACCU-RATE controller suggested <5% deviation when compared with the manually measured application rate. The results of response time revealed that the maximum of 2.38 s and 2.25 s were taken to dispense clay filler and fertilizer respectively, after detection of the target. In order to assess the real-time performance accuracy of modified variable rate granular (MVRG) fertilizer spreader grass and wild blueberry fields were selected. Artificial bare spots were made using orange coloured tarps in the selected grass field and equal numbers of weighed rat catchers were placed on artificial bare spots and grass. The MVRG fertilizer spreader was operated on VR mode (detection and no application in artificial bare spots) and the rat catchers were collected and re-weighed. The same procedure was repeated for uniform (UN) application mode of the system (application on both grass and artificial bare spots). This test was repeated for wild blueberry field to detect bare spots and plants for spot-application of fertilizer only in plant areas. The results of paired *t*-tests showed significant difference (P-value < 0.0001) between VR and UN treatments when the clay filler weight collected from bare spots were compared for both fields. The results showed non-significant difference (P-value > 0.05) between VR and UN treatments in grass/plant areas. These results suggested that the MVRG fertilizer spreader was efficient and accurate for spot-application of fertilizer to increase farm profitability and reduce environmental risks (Chattha et al. 2014).

(Kim et al. 2008) made research on “Fertilizer application performance of a variable-rate pneumatic granular applicator for rice production”. The research paper provides an overview of the recent advancements in variable rate fertilizer spreaders. Smith examines various technological innovations and highlights their potential benefits, such as improved nutrient distribution, reduced environmental impact, and increased cost-efficiency. The author also discusses the challenges associated with variable rate application, including accurate sensor technology and software development.

Sindir discusses “Economic Analysis of Variable Rate Fertilizer Spreaders”. His study explores the economic implications of adopting variable rate fertilizer spreaders on wheat farms in the Midwest. The research examines the cost-effectiveness of variable rate technology by analyzing input savings, yield improvements, and return on investment. The author's findings shed light on the financial benefits associated with variable rate application, encouraging farmers to consider its adoption (Sindir and Tekin 2002).

Hasan Mirzakhaninafchi did a research work on “Performance Assessment of a Sensor-Based Variable-Rate Real-Time Fertilizer Applicator for Rice Crop”. This research was conducted for the evaluation of variable rate plantation of the rice crop. The purpose of the research was to get the maximum crop yield and to make it environment friendly by reducing the cost rate. There were three replications were conducted, each of which was divided into four plots. System field performance was assessed at different levels of nitrogen with a dispensing rate of 75, 125, 175, 225 kg ha−1, growth stages (tillering, panicle initiation, heading), and heights of the sensor from the crop canopy was 40, 60, 80, 100 cm. Fertilizer rate was at minimum 12.59 kg ha−1 at 10 rpm of drive-shaft rotational speed and at maximum 50.41 kg ha−1 at 40 rpm. The system response time was within the range of 3.53 to 4.93 s, with overall error ranging between 0.83% to 4.92%. (Mirzakhaninafchi et al. 2022).

S Sai Mohan did a research work on “GPS and Sensor Based Technologies in Variable Rate Fertilizer Application “explaining the importance of VRFA system importance in the field of Mechatronics and precision. The traditional method of fertilization which results in much fertilizer utilization is replaced with GPS based variable rate fertilizer spreader and this system was effective, cost efficient and showed a quick response to target application rates with a little time lag. (Mohan 2021).

CHAPTER 3

PROBLEM STATEMENT & OBJECTIVES

3.1 PROBLEM STATEMENT:

The current fertilizer spreading methods in agriculture rely on manual estimation and uniform distribution, leading to inefficient use of fertilizers and suboptimal crop growth. There is a need for an improved system that combines manual fertilization techniques with GPS-based variable rate fertilizer spreaders to optimize fertilizer application and enhance crop productivity.

The utilization of manual fertilization instead of variable rate technology fertilizer can give rise to several issues, some of which are outline below:

3.1.1 Inaccurate Manual Estimation

Manual estimation of fertilizer requirements for different areas of a field is prone to human error and often leads to over or under application of fertilizers, resulting in reduced crop yields and increased costs.

3.1.2 Uniform Distribution

Traditional fertilizer spreaders apply fertilizers uniformly across the entire field, neglecting the spatial variability of soil nutrient levels. This leads to inefficient use of fertilizers and fails to address the specific nutrient requirements of different areas within the field.

3.1.3 Lack of Real-time Data

Current manual fertilization methods do not utilize real-time data about soil conditions, crop growth, and nutrient levels. This limits the ability to make informed decisions about fertilizer application rates and timing, resulting in suboptimal crop growth.

3.1.4 Time and Labor Intensive

Manual fertilization is a labor-intensive process that requires skilled personnel to estimate and distribute fertilizers. This can be time-consuming and impractical for large-scale farming operations.

3.1.5 Cost Inefficiencies

Inefficient fertilizer application leads to increased costs due to wastage and reduced crop yields. There is a need for a more precise and cost-effective approach to fertilizer application that maximizes the return on investment.

3.2 OBJECTIVES:

The objective of the proposed solution is to integrate manual fertilization techniques with GPS-based variable rate fertilizer spreaders, incorporating the following components:

3.2.1 Cost Efficiency

The aim is to establish a cost-efficient fertilization process by utilizing GPS-mounted variable rate fertilizer spreaders. This approach minimizes costs by preventing over-spreading of fertilizers, ensuring that they are only applied where necessary. In comparison, manual spreading techniques result in greater fertilizer usage due to losses within the field.

3.2.2 Spot-Specific

The objective is to develop or modify existing fertilizer spreaders to enable variable rate application based on GPS coordinates and real-time data. This will facilitate precise and targeted fertilizer distribution, catering to the specific needs of different areas within the field.

3.2.3 Precise Spreading

Through the utilization of GPS-based technology, the solution aims to achieve precise fertilization. This means that fertilizers will only be dispensed in areas where the soil lacks sufficient crop nutrients. Consequently, areas of the soil that are already nutrient-rich will not become overly saturated, avoiding excessive crop growth.

3.2.4 Environmentally Friendly

The solution aims to promote an environmentally friendly approach through the implementation of variable rate technology. By avoiding excessive fertilization in unnecessary areas, it prevents the unnecessary contamination of additional land. This approach ensures proper crop growth without hindering or promoting overpopulation.

3.2.5 Time Saving

The proposed solution aims to save time by performing fertilization tasks accurately and precisely. By eliminating over-dispensing, the process becomes more efficient, reducing the time required for fertilization activities.

CHAPTER 4

MATERIALS & METHODS

4.1 MATERIALS:

4.1.1 Microcontroller

The project utilized the Arduino Mega 2560 microcontroller, a versatile board built upon the ATmega2560 microcontroller. With a comprehensive set of features, it includes 54 digital input/output pins, of which 15 can function as PWM outputs. Additionally, it incorporates 16 analog inputs, 4 UARTs for hardware serial communication, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. These components collectively provide all the necessary support for the microcontroller's operation. In the system, the Arduino Mega 2560 receives signals from the GPS module, which is mounted atop the implement and connected through an antenna. Subsequently, the microcontroller Processes these signals and transmits commands to the IBT2 Motor Shield for further processing.

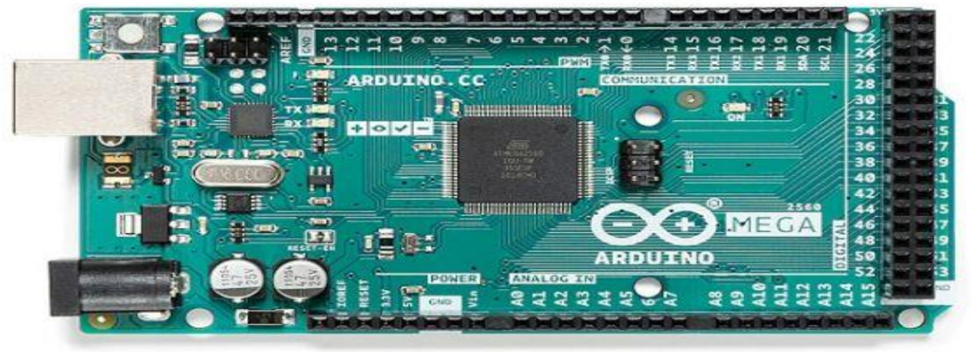


Fig 4.1: Microcontroller Mega 2560

4.1.2 Bluetooth Module HC05

The HC-05 is a Bluetooth module specifically engineered for facilitating transparent wireless serial communication. Its primary purpose is to serve as a pre-configured slave Bluetooth device. Once paired with a master Bluetooth device, such as a PC, smartphone, or tablet, the module seamlessly operates in the background, transparent to the end-user. In our specific application, we integrate the HC-05 module with the mobile app of our project. The app allows users to input the desired coordinates of the location where work needs to be performed. The Bluetooth module acts as the intermediary, transmitting this coordinate information to the microcontroller. The microcontroller then utilizes this precise location data to facilitate accurate and targeted fertilization applications. Overall, the HC-05 Bluetooth module plays a crucial role in enabling wireless communication between the mobile app and the microcontroller, ensuring seamless data transfer for precise and effective fertilization operations.

Fig 4.2: HC-05 Bluetooth Module

4.1.3 GPS Module NEO 6M

The NEO-6M GPS module represents a resilient GPS receiver equipped with an integrated ceramic antenna measuring 25 x 25 x 4mm, which greatly enhances its capacity to search and acquire satellite signals. Within our project, we have employed this module to facilitate the transmission of signals to the microcontroller in the form of analog signals. The GPS module effectively captures signals from satellites and delivers real-time data to the controller for subsequent processing. Notably, this module incorporates a patch antenna with a sensitivity of -161 dB, enabling it to receive radio signals from GPS satellites. It can efficiently track up to 22 satellites across 50 channels while consuming a mere 45mA of current and operates within a voltage range of 2.7V to 3.6V. One of its notable features is its power-saving mode, which optimizes power consumption.

Fig 4.3: Neo 6m GPS Module

4.1.4 DC Motor 12 Volt

In the present project, a 12-volt DC motor was employed, possessing a power rating of 200 watts, capable of transferring current within the range of 4-8 amperes. The 12-volt DC motor, classified as a rotary motor, efficiently converts direct current into mechanical energy. The motor is strategically linked to the shaft of a fertilizer spreader via a gear chain mechanism. As the implement commences its movement, the motor propels the shaft, enabling the dispensation of seeds. The seeding rate can be precisely regulated by adjusting the motor's speed, rendering it a pivotal component in this operational setup. To operate, the motor draws current from a 12-volt battery source.

Fig 4.4: DC Motor 12 Volt

4.1.5 12 Volt Battery

In our project, we have implemented two 12-volt batteries with an internal resistance of 0.02 ohms each. These batteries play a crucial role in supplying a consistent and reliable power source. They are specifically designed to provide a steady current of 7 amperes per hour, ensuring efficient operation of the DC motor integrated within the fertilizer spreader. The powerful electrical output from these batteries enables smooth movement of the implement's shaft, facilitating the effective distribution of fertilizer. With their robust design and capability to deliver a constant current, these 12-volt batteries contribute significantly to the overall functionality and performance of the system.

Fig 4.5: 12 Volt Battery

4.1.6 Variable Resistor

The inclusion of a variable resistor with a resistance of 10 kilo ohm enhances the professional aspects of the project. This resistor serves the purpose of modifying the overall resistance within the circuit. Specifically, during speed sync mode, when it becomes necessary to fine-tune the dispensing rate of the spreader, the resistance of this resistor can be easily manipulated within a range of 2 kilo Ohms to 10 kilo Ohms. The adjustment of the resistor's knob directly influences its resistance, thereby causing fluctuations in the motor's speed. Consequently, these changes in speed have a direct impact on the rate at which seeds are dispensed per unit of time on a specific area of the land. This level of control and precision in seed dispensing ensures optimal distribution and efficient usage of resources in agricultural practices.

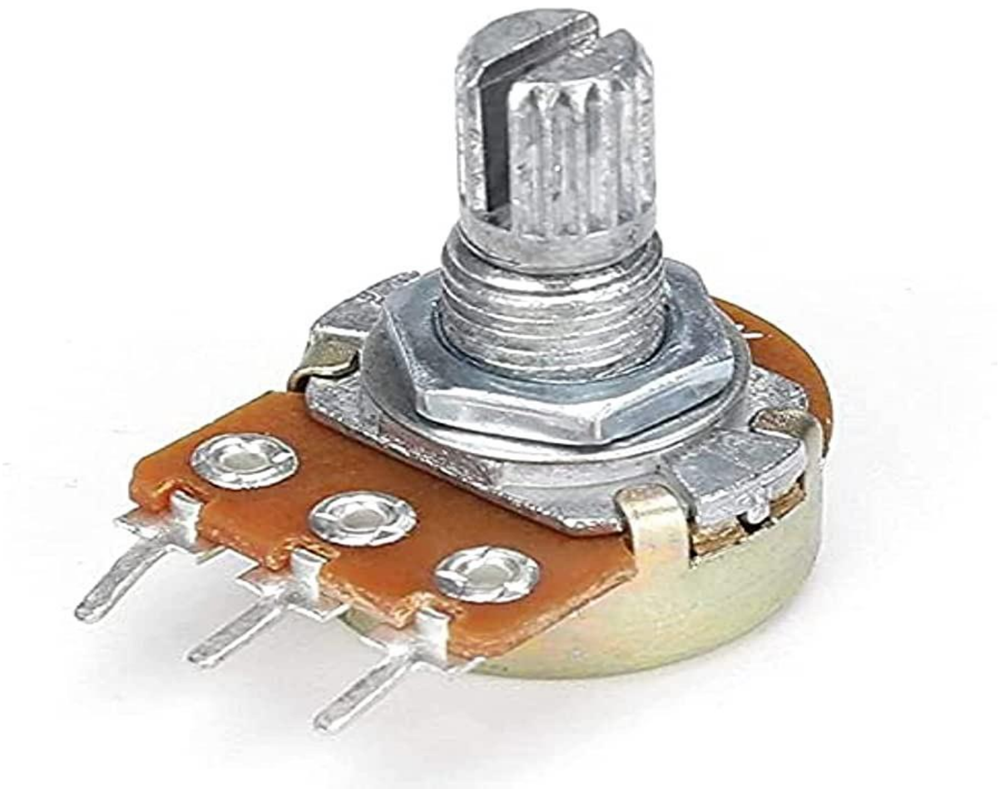


Fig 4.6: Variable Resistor

4.1.7 Motor CONTROL SHIELD IBT2

In the process of signal transformation towards a DC motor, a motor shield plays a crucial role by acting as a bridge between the microcontroller and the motor. Specifically designed for motor control applications, this motor shield serves as an interface that facilitates the seamless transfer of signals from the microcontroller to the DC motor, enabling precise control over motor speed and direction. The motor shield is an electronic module that integrates a set of components and circuitry, optimized for efficient motor control. Its primary function is to receive signals from the microcontroller and convert them into appropriate commands for the DC motor. By utilizing various integrated features, such as H-bridge circuitry, the motor shield effectively regulates the flow of current to the motor coils, enabling precise control over motor rotation. The integration of a motor shield in the signal transformation process brings several advantages. Firstly, it simplifies the overall motor control system by providing a standardized and convenient interface for connecting the microcontroller and the motor. This ensures compatibility and ease of integration, allowing developers to focus on higher-level functionalities rather than intricate hardware details. Furthermore, the motor shield enhances the reliability and safety of the system. It incorporates built-in protective mechanisms, such as overcurrent and over temperature protection, which safeguard both the motor and the microcontroller from potential damage due to excessive current or heat. These protective features help ensure the longevity and robustness of the motor control system, reducing the risk of component failures. In summary, the motor shield serves as a critical component in the signal transformation process for DC motor control. By acting as a bridge between the microcontroller and the motor, it enables the seamless transfer of signals, while providing advanced features for precise motor control and ensuring system reliability. Its integration simplifies the overall system design and enhances the efficiency and safety of motor control applications.

Fig 4.7: Motor Control Shield IBT2

4.2 WORKING:

One of the primary advantages associated with utilizing a GPS-based variable rate fertilizer spreader, as opposed to the uniform fertilization method, stems from its precise dispensing capabilities. This sophisticated system enables accurate control over the amount of fertilizer distributed within a given area, allowing operators to adjust the quantity according to specific requirements.

The integrated GPS fertilizer spreader functions through a defined procedure. Initially, the tractor's power take-off (PTO) is substituted with a DC motor, which is then integrated with a microcontroller and GPS to facilitate spot mechanism fertilization and variable rate dispensing via a gear chain mechanism. By rotating the shaft through the chain, the motor governs the dispensing rate of the fertilizer by varying its speed, facilitated by the motor shield connected to the microcontroller.

To enable GPS functionality, a GPS module is installed atop the system and connected to an antenna to receive signals from satellites. The system's circuitry incorporates several electronic components, including an Arduino Mega 2560 microcontroller, an HC05 Bluetooth module, a motor control shield, and an external variable resistance with a value of 10 kilo ohms, linked to the microcontroller. Two 12-volt batteries are connected to the motor shield to provide power to the motor. Additionally, a purpose-built mobile application acts as an interface to establish a Bluetooth connection with the system. A rechargeable cell with a power rating of 16 to 18 watts supplies the necessary current of 1-2 amperes to the microcontroller, motor shield, Bluetooth module, and GPS module. The microcontroller receives analog commands from the Bluetooth module via the mobile app, which are subsequently transmitted to the motor shield to regulate motor rotation by adjusting the power supply from the batteries.

The system offers three dispensing modes: manual, speed sync, and prescription map-based methods.

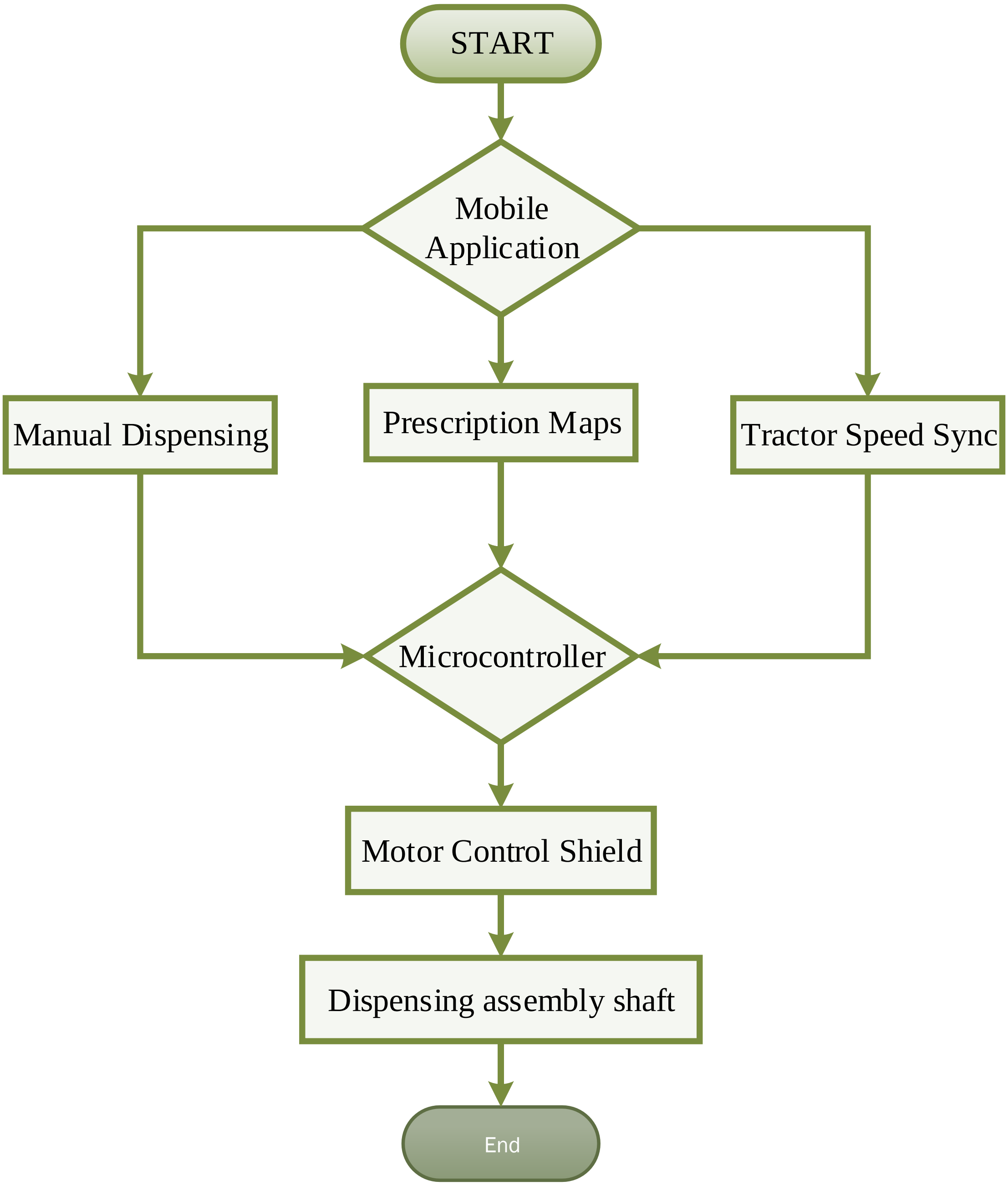


Fig 4.8: Flow Chart of Proposed Model

4.2.1 Coding

```
#include <SPI.h>
#include <Wire.h>
#include <TinyGPS++.h>
```

```
#include <RobojaxBTS7960.h>

#define Analog A0     // Output of potentiometer is connected to A0 pin
#define RPWM 2 // define pin 3 for RPWM pin (output)
#define R_EN 3 // define pin 2 for R_EN pin (input)
#define R_IS 4 // define pin 5 for R_IS pin (output)
#define LPWM 5 // define pin 6 for LPWM pin (output)
#define L_EN 6 // define pin 7 for L_EN pin (input)……………………………………….
………………………………………………………………………………………
void variable(){
//////////////////////////////////////////////////
//Serial.println("Manual Dispensing");
Serial1.println("Manual Dispensing");
int PresetValue = analogRead(Analog);
int Volt = map(PresetValue, 0, 1023, 0, 24);
  if (PresetValue<100)
  {
    motor.rotate(0,CCW);
    Serial1.println("0 Dispensing Rate");
   }
  else if (PresetValue<=300)
  {
    motor.rotate(35,CCW);
    Serial1.println("2.60 Dispencing Rate");
   }
void getGps(float& latitude, float& longitude)
{
 // Can take up to 60 seconds
 boolean newData = false;
 for (unsigned long start = millis(); millis() - start < 1000;){
   while (Serial2.available()){
    if (gps.encode(Serial2.read())){
      newData = true;
      break;
    }
```

```
    }
  }

  if (newData) //If newData is true
  {
    latitude = gps.location.lat();
    longitude = gps.location.lng();
    newData = false;
  }
}
```

4.2.2 Manual Mode

In the manual mode, the adjustment of the motor's rotation is achieved by manipulating the knob of the external resistor. This variation in resistance allows for the modification of the motor's revolutions per minute (RPM) and, as a result, controls the rotation of the spreader's shaft. By altering these parameters, the desired quantity of fertilizer can be precisely delivered to the soil.

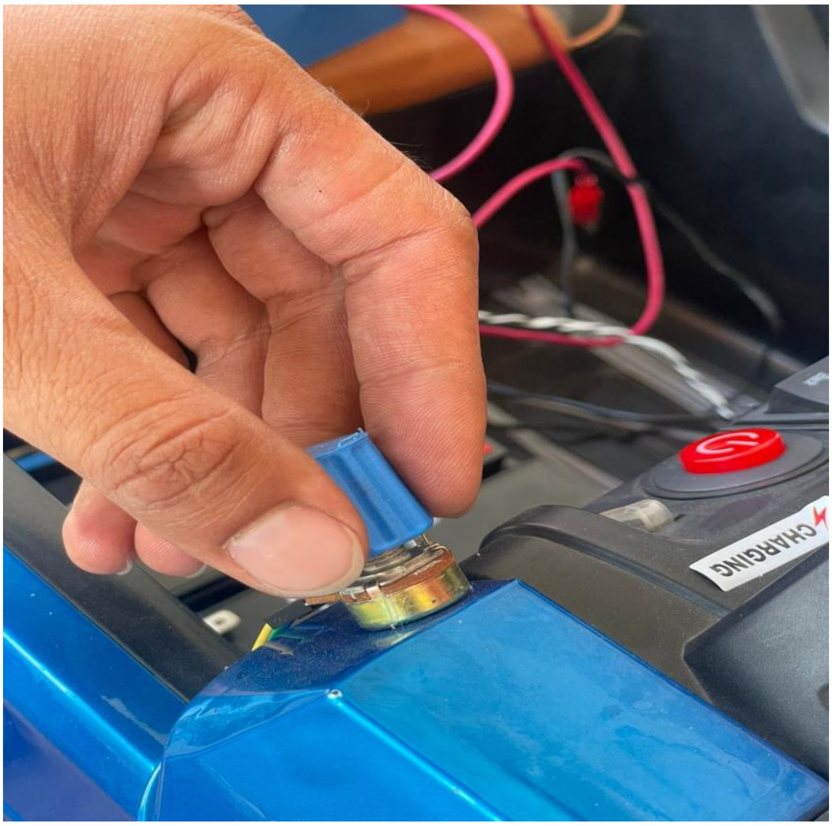


Fig 4.9: Manual Dispensing through Variable Resistor

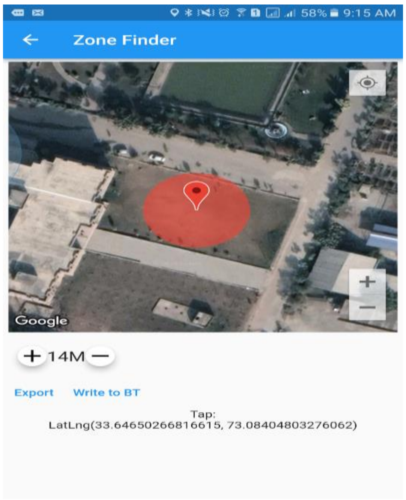
4.2.3 Tractor Speed Synchronization

The speed sync mode operates based on the integration of the GPS with the microcontroller. By defining the starting and ending points of the operation, the GPS calculates the distance covered by the implement and the corresponding time taken. Utilizing the speed formula, the real-time speed of the implement is then displayed on the mobile application. This information enables the adjustment of the dispensing rate by either increasing or decreasing the implement's speed. The speed formula is represented as follows:

$$(S = vt; v = s / t)$$

4.2.4 Prescription Map

The third mode, known as prescription map-based dispensing, encompasses the selection of a particular operational area through the mobile application by defining its coordinates. This involves specifying a circular region with a predetermined center point, represented by latitude and longitude, which is obtained from the mobile app utilizing the Google Application Programming Interface (API). To determine distances or locations on a spherical surface, the Haversian formula is applied to process this location information along with the defined radius. The Haversian formula enables calculations based on the coordinates of two points. Once the system enters the designated area, the dispensing process commences automatically. Upon exiting the selected area, the dispensing comes to a halt. Throughout all three dispensing methods, the microcontroller serves as a pivotal component, ensuring the smooth and efficient operation of the system.



Tap:
LatLng(33.64650266816615, 73.08404803276062)

Fig 4.10: Prescription Map

CHAPTER 5

RESULTS & DISCUSSION

5.1 CASE 1: MOTOR RPM VS DISPENCING RATE:

Comparison between the rotational speed of the motor (rpm) and the corresponding dispensing rate has been observed in the first scenario. The blue line represents the motor's rpm, while the orange line illustrates the dispensing rate in kg /min data obtained at various motor speeds. Initially, when the motor is in a stationary state, the dispensing rate value is also zero. Upon receiving current from the battery, the motor initiate’s movement, causing the connected shaft of the fertilizer spreader to rotate and subsequently initiating the dispensing process. As the rotational speed of the motor increases, there is a corresponding increase in the dispensing rate, as clearly depicted in the graph. It is evident that the rpm and dispensing rate exhibit a direct proportionality. For instance, an increase in the motor's rpm leads to an increase in the dispensing rate, while a decrease in the motor's speed results in a decrease in rpm as well.

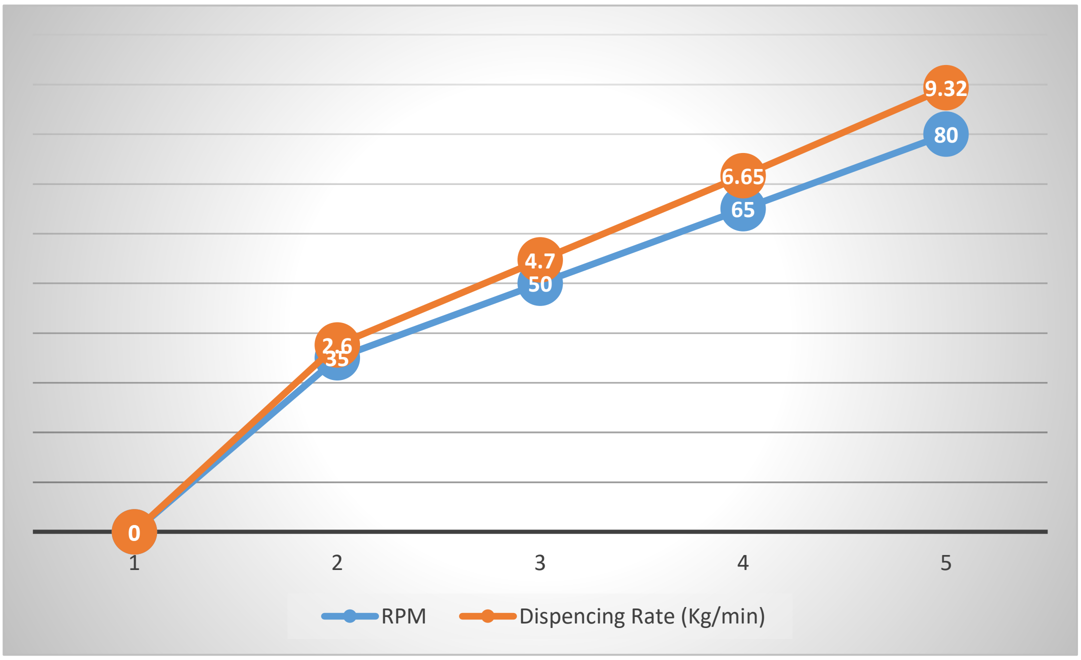


Fig 5.1: Motor rpm vs Dispensing Rate

5.2 CASE 2: TRACTOR SPEED VS DISPENCING RATE

The statistical analysis is presented, focusing on the correlation between the speed of the tractor and the corresponding dispensing rate in the second case. The blue line in the graph represents the tractor's speed measured in meters per second (m/s), while the orange line depicts the fertilizer dispensing rate measured in kilograms per minute (kg/min).At the initial stage when the tractor remains stationary, no dispensing of fertilizer occurs. However, once the tractor begins its operation and starts moving, the dispensing process is initiated accordingly. The rate at which the fertilizer is dispensed can be effectively regulated by adjusting the speed of the tractor. It is important to note that the tractor's speed exhibits a direct proportionality with the dispensing rate. In other words, as the tractor's speed increases, the dispensing rate of fertilizer also increases, and conversely, a decrease in tractor speed leads to a decrease in the dispensing rate. This relationship is clearly evident from the graph and highlights the control mechanism that the tractor speed exerts over the dispensing rate.

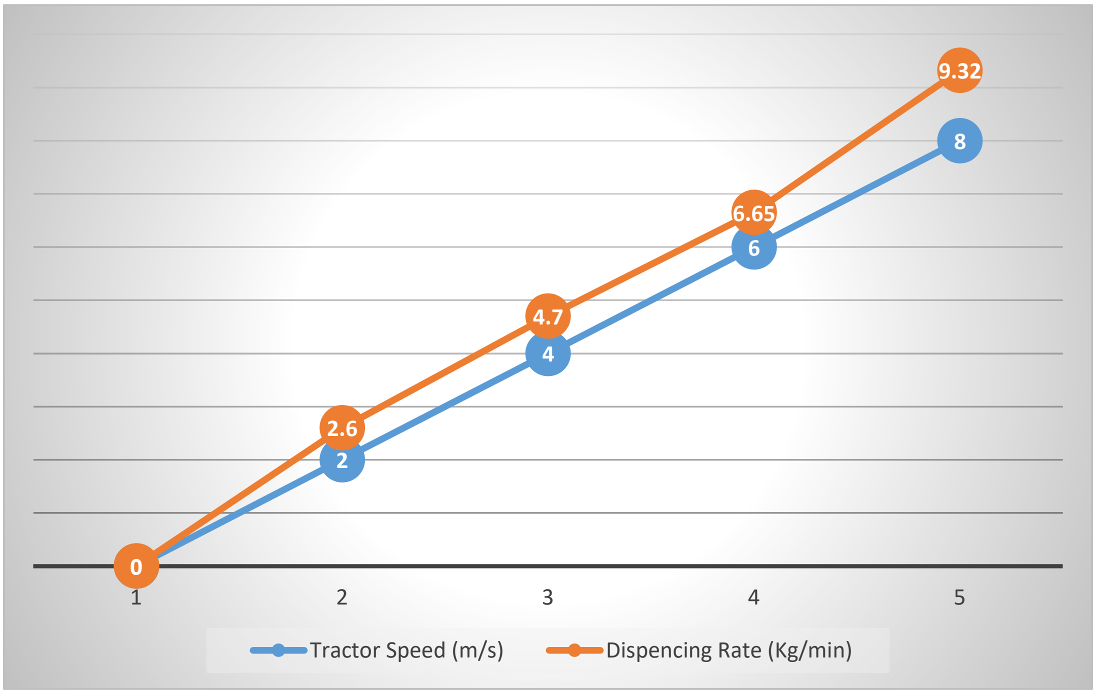


Fig 5.2: Tractor Speed vs Dispensing Rate

5.3 CASE 3: COMPARISON OF UNIFORM VS VARIABLE DISPENCING RATE

The dispensing rate of the proposed variable fertilizer spreader and the uniform fertilizer spreader is analyzed in the present scenario. The provided multiple bar graph, a comprehensive comparison is presented, analyzing the efficacy of uniform fertilizer dispensing against the dispensing achieved through a variable rate fertilizer spreader. The yellow bar represents the dispensing of fertilizer in kilograms per acre using variable rate technology (VRT), while the orange bar signifies the uniform dispensing of fertilizer in kilograms per acre. It is observed that a greater quantity of fertilizer is consumed when employing the uniform spreading method as opposed to the dispensing facilitated by the variable rate fertilizer spreader. The uniform spreading results in a higher utilization of fertilizer in comparison to variable rate technology. This observation highlights the potential benefits of implementing variable rate technology, as it allows for optimized fertilizer usage based on the specific requirements of different areas within a field, thereby reducing overall fertilizer consumption.

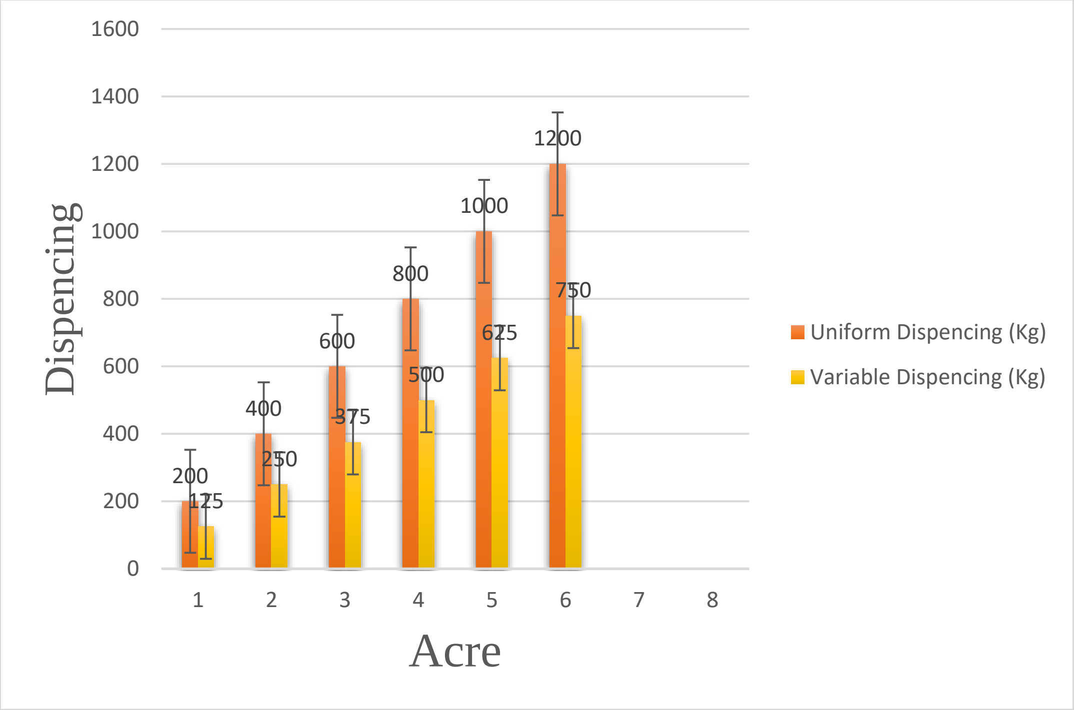


Fig 5.3: Comparison of Uniform Vs Variable Dispensing

CHAPTER 6

CONCLUSIONS AND FUTURE RECOMENDATION

6.1 CONCLUSIONS

In recent years, the agricultural industry has experienced a paradigm shift due to the innovation of GPS-based variable fertilizer spreaders and prescription mapping. These innovative tools have enabled farmers to achieve precise and targeted fertilizer application, resulting in improved crop yields, reduced environmental impact, and increased profitability. By leveraging GPS technology, farmers can now apply fertilizer with unprecedented accuracy, which has far-reaching implications for the entire agricultural sector. One of the most significant benefits of GPS-based variable fertilizer spreaders and prescription mapping is the ability to achieve precise fertilizer application. Traditional fertilizer application methods were often imprecise, resulting in uneven fertilizer distribution across fields. This imprecision was not only wasteful, but it also led to reduced crop yields and increased environmental impact. With GPS-based variable fertilizer spreaders, farmers can now apply fertilizer with pinpoint accuracy. Prescription mapping software allows farmers to create customized fertilizer application plans for each specific field, taking into account variables such as soil type, crop type, and topography. This level of precision ensures that crops receive the optimal amount of fertilizer, resulting in improved yields and reduced environmental impact. Another significant benefit of GPS-based variable fertilizer spreaders and prescription mapping is increased profitability. By optimizing fertilizer application, farmers can reduce their input costs while simultaneously improving yields. This increased efficiency translates into higher profits and a more sustainable agricultural industry. Additionally, by reducing environmental impact, farmers can avoid costly fines and penalties associated with non-compliance with environmental regulations.

6.2 FUTURE RECOMMENDATIONS

- System improvement through Keyhole Markup Language (KML) map integration for enhanced functionality.
- Future development to enable soil nutrient content analysis within the system.

- Designing a sophisticated system that adapts fertilizer spreading based on nutrients concentration in the field.

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