

## DESIGN AND DEVELOPMENT OF AN AUTOMATED FERTILIZER AND SEED VENDING MACHINE FOR AGRICULTURAL APPLICATIONS

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**Abstract**—Fertilizer is an essential component used to provide necessary nutrients to the soil or plant tissues for plant growth. It can be derived from both natural and synthetic sources and is widely used for growing all types of crops. The amount of fertilizer needed depends on the soil's fertility, measured through a soil test, and the specific crop being grown. However, a minimum of 50 kg fertiliser bag has to be purchased by farmers even for a small requirement during farming. In India, there are three generations of seeds recognized by the Seeds Programme: breeder, foundation, and certified seeds. The quality of seeds contributes to about twenty to twenty-five per cent of productivity. Therefore, it is crucial to provide farmers with high-quality seeds for optimal crop yield. The presented machine is an Automated Fertilizer and Seed Vending Machine that dispenses the required amount of fertilizer and seeds, making them easily accessible to the general public in places like Krishi Vigyan Kendra, Agricultural Produce Market etc. The machine has been customised to cater for the need of farmers with both fertiliser and cultivation seed packets that can be easily dispensed using RFID technology. The obtained results for dispensing time is found satisfactory on par with real time machine and the error rate is between 1-2 % for the actual and dispensed quantity.

**Keywords**— *Agriculture, Dispense, Fertilizer, Seed, Vending*

### I. INTRODUCTION

Fertilizer is a fundamental component that is utilized to provide essential nutrients for plant growth, and it is applied to either the soil or plant tissues. There are numerous types of fertilizer, including those derived from natural and synthetic sources. Fertilizers are extensively employed for cultivating all kinds of crops, with the amount used depending on the soil's fertility, typically measured through soil testing and the specific crop being grown [1]. The amount of fertilizer needed for crops is influenced by various factors such as soil type, nutrient levels, previous crops, expected growing season length, and crop variety [2][3]. The fertilizer needs of crops are largely influenced by the soil test results for specific nutrients, soil organic

matter levels, and the desired yield, among other factors. Additionally, seed is the most crucial input for agricultural production. Indeed, it is the most cost-effective method of boosting agricultural output and efficiency. In India, there are Krishi Vigyan Kendra, village outlets, which provide the required seeds and fertilisers for the farmers. Farmers in India depend primarily on rain for agriculture. Therefore, they sow seeds in the month of June or July, during this time there will be a huge queue in front of Krishi Kendra's. Usually, the seeds and fertilizers are available in 25 Kg or 50 Kg packets they serve the farmers who have large farming lands.

For the farmers with small lands and the people who grow vegetables or fruits on house rooftops, they need fewer fertilizers, maybe of 1Kg to 10 Kg and seeds of 50gm – 300gm. To serve these small land farmers there is a need for small quantity seeds and fertilizer dispensers. These issues can be addressed with the help of automated vending machines that can dispense a variety of seeds and fertilizers in smaller quantities as needed. And it can avoid the burden of standing in long queues in Krishi outlets. Automated vending machines are now being used for dispensing products such as snacks, beverages, cigarettes and lottery tickets, after inserting money, a credit card, or a specially designed card [4]. The present work describes the design and development of an automatic fertilizer vending machine for the distribution of fertilizers of capacity ranging from 1kg-10kg and a vending machine for the distribution of seeds of 50g-200g. The automated vending machine can help farmers to get good-quality seeds and their harvests can rise dramatically. Farmers can buy seeds for crop cultivation according to their requirements after testing their soil for that particular seed.

An automated vending machine is a type of self-service machine that can distribute a range of items, including snacks, drinks, newspapers, tickets, and electronics, to customers without the need for human intervention. These machines accept payment in the form of coins, bills, or credit/debit cards, and customers can choose their desired product by pressing a button or touching a screen after payment. Once the product is selected, the machine automatically dispenses it to the customer. Sivasubramanian et al. suggested a fruit vending system that would deliver fruits to the customers based on their preferences. camera image and classification algorithms are used to identify the preferred fruit of customers. This system includes a raspberry pi microprocessor with several in-out peripherals such as a keypad, LCD, load cell and motors [6].

## II. LITERATURE SURVEY

The vending machine is set up to gather detailed information about customers, such as time-based records of customer interactions with the vending machine during a Vend transaction. Customer menu choices, brand information connected to payment or product selections made by customers, and promotions or displays that prompt feedback from customers are all logged for analysis to learn more about how well customers respond to sales and promotions. The Tamil Nadu Agricultural University's (TNAU) has recently installed seed vending machine for farmers and enthusiastic home gardeners. [1][3][8] Presents AI-ML techniques in Vending machine to classify and sort products, transmit information using LORA technology and integrate IoT feature in the machine.

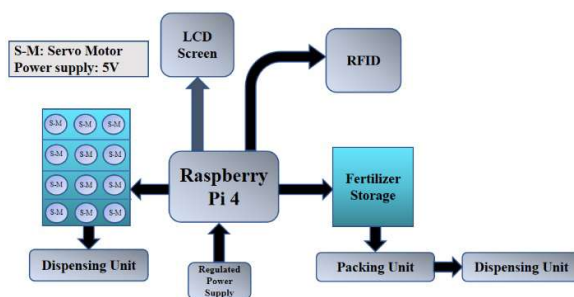
[6] had shown a network of integrated vending machines powered by the IoT that serves as a platform to market daily groceries to neighbouring homes.[7] described the development of a vending machine that distributes smart, personalized safety equipment such as face masks, hand gloves, clothing suits, respirators, shields, helmets, and sanitizers. The machine uses contactless dispensing technology to provide desired items and monitors inventory levels in real time. Vaisakh et al. has developed a functional prototype of an automated distribution system for three essential commodities - rice, wheat, and kerosene, which has been successfully verified. This proposed system can be readily implemented in the current ration shops, resulting in reduced labour requirements for product distribution [9].

To authorize users, RFID technology is employed to scan them before use. Further, sanitary pads is dispensed using this method[5]. The article [4] details a cloud-based vending machine based on the Internet of Things (IoT) that can be accessed via contactless payment. The aim of this service is to provide users with an affordable and easy-to-use vending experience. The article [8] illustrates a dispenser machine that can dispense or vend different types of groceries. There are several varieties of automatic vending machines are reported in the literature for different applications as described in [9][10][11][12][13]. The primary goal of our present work is to design and develop an automatic vending machine that can dispense seeds and fertilizers for farmers who have smaller farmlands, and require a small number of seeds and fertilizers.

Based on the Literature Survey, it was observed that the fertiliser quantity for less than 50kg was not available. Further, an integrated machine that can cater to the demand of farmers 24/7 at Krishi Vigyaan Kendras or Wholesale market was not available, Hence, the objective to design a low-cost Vending Machine to help farmers is proposed. The machine provides the fertilisers less than 50Kg and Packaged seeds for farmers with smaller lands. To dispense fertilizers and seeds 24/7.

### III. PROPOSED METHODOLOGY

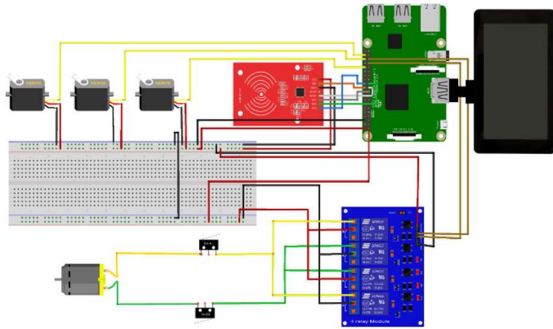
The primary goal of this work is to provide fertilizer and seed of the required quantity through an automatic Vending Machine to small land farmers. The proposed automated vendingmachine block diagram is shown in Figure 1.



**Fig 1.** Block Diagram of Proposed Seed and Fertilizer Vending Machine

The circuit diagram of the module is shown in Figure 2, where Raspberry pi is the main processor which controls all the equipment [12]. The display is connected to the processor for the customer to interface with the vending machine. The machine consists of two parts. First is

the seed section with a particular seed with a fixed gram of 100gm, 200gm, and 300gm packets. Second is the fertilizer with a specific amount of 1Kg, 2Kg and 5Kg.



**Fig 2.** Circuit Diagram of Proposed Seed and Fertilizer Vending Machine

#### IV. HARDWARE AND SOFTWARE DESCRIPTION

**TABLE 1.** HARDWARE AND SOFTWARE COMPONENTS USED

Sl. No	Hardware Components Used	
	Component name	Features
1	Raspberry-Pi 4	RAM: 2GB CPU: ARM v8 GPIO header: Raspberry Pi standard 40 pin
2	7-inch LCD Display	Resolution: 800 x 480 Power Supply: 5V
3	Servo Motor	360° Continuous Rotation
4	DC Motor	3V
5	Relay Module	Input: 5V Output: 10A, 250V AC
6	Power Supply	5V

The proposed automated vending machine is implemented with the hardware devices listed in Table 1.

##### A. RASPBERRY PI4

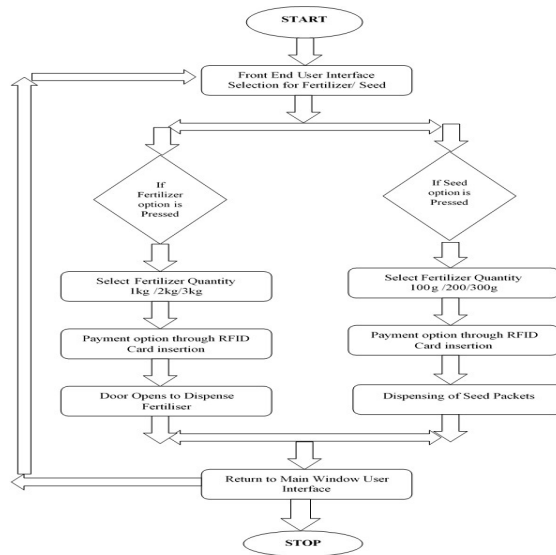
The Raspberry Pi 4 is equipped with a Broadcom BCM2711 SoC (System-on-Chip) that has a quad-core ARM Cortex-A72 CPU operating at 1.5 GHz. It can support up to 8 GB of RAM and has numerous connectivity options such as dual-band 802.11ac wireless, Gigabit Ethernet, and Bluetooth 5.0. Additionally, it has two micro-HDMI ports that can output up to 4K resolution, two USB 3.0 ports, two USB 2.0 ports, and a 40-pin GPIO header that allows users to connect various peripherals and sensors. It is compatible with a range of operating systems, including the Raspberry Pi OS, Ubuntu, and other Linux distributions.

## **B. SERVO MOTOR, RFID and LCD DISPLAY**

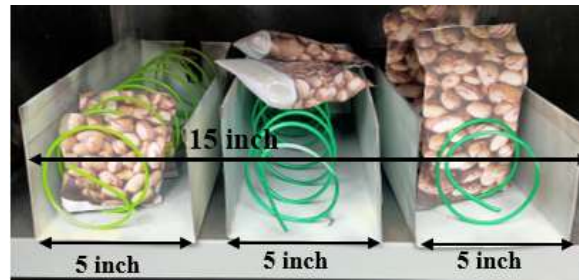
A servo motor is a type of motor that is designed to provide precise control of position, speed, and acceleration. Servo motors are commonly used in applications such as robotics, industrial automation, and aerospace, where precise and accurate control is required. They are available in a variety of sizes and can generate high torque at low speeds. A servo motor with a weight of 55 grams, operating voltage of 4.8 - 7.2V, stall torque @4.8V, 9.4 Kg-cm and stall torque @6.6V, 11 Kg-cm, has been used in the proposed system. RFID is an acronym for Radio Frequency Identification, a technology that utilizes radio waves to retrieve and obtain data that's saved on a tiny tag or sticker that's affixed to an object. These RFID tags possess a compact integrated circuit and antenna, allowing them to transfer data wirelessly to an RFID scanner or reader. It is used in a Vending Machine to give the input for the amount of fertilizer or a seed required. LCD display with a display size of 7 inches, resolution 800x480, power supply range of 5 volts, support to Raspberry Pi, input interface HDMI, 2AV, and a touch panel of type capacitive. Raspberry Pi is programmed by simulating the program with python 2 or 3.

## **C. PROCESS**

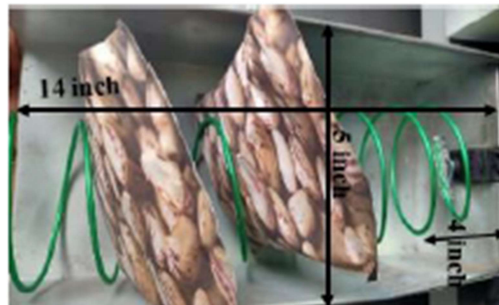
Raspberry pi is programmed using the python tkinter program. In the Tkinter program, we can create buttons for the selection of seeds and fertilizer according to the required weight. Such that it is called GUI (Graphical User Interface). In the seed and fertilizer part, there is an option called quantity selection which can be used to dispense seeds and fertilizers of different quantities. The proposed method's flow diagram is depicted in Figure 3. If the vending machine is empty then it will display a message that "It's Empty", and the alert message will be mailed automatically to the owner as it is integrated with IoT [13]. In the seed part, a spring coil is used which rotates in an anticlockwise direction for a period of time and is attached to the servo motor [10]. When the processor gives a signal to the servo motor it will start to rotate in an anticlockwise direction in the way to dispense the seed packet in order wise. The compartment with a spring design is shown in Figures 4 and 5. In the fertilizer part, a tank will be installed with an open and close valve or it can be considered as a door. In the action of opening and closing, there will be a period of timing with respect to a specific amount of fertilizer. Then it will be collected by the customer.



**Fig 3.** Flow Diagram of Proposed Seed and Fertilizer Vending Machine



**Fig 4.** Seed spring design (Front View)

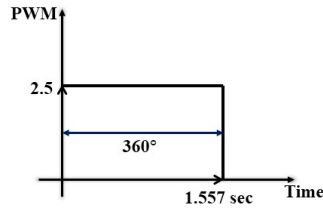


**Fig 5.** Seed spring design (Top View)

## V. DESIGN CALCULATIONS

### A. DESIGN CALCULATIONS OF SEED VENDING MACHINE

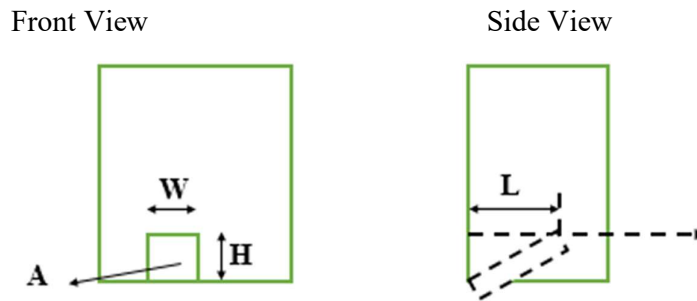
In the servo motor, there are 3 terminals, 2 terminals for Power supply and one for PWM Signals. Considered Duty Cycle = 2.5 and Period of time = 1.557 sec. The PWM vs time plot is shown below in Figure 6.



**Fig 6.** PWM v/s time

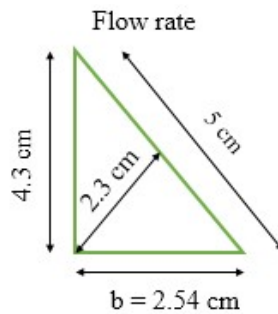
**B. FERTILIZER STORAGE TANK**

It consists of an overall weight of 1.45 Kg in the Demo Storage tank structure design is shown in Figure 7. The dimensions include L x B x H= 16cmx10cmx18cm.



**Fig 7.** Tank design

**C. FLOW RATE OF FERTILIZER**



**Fig 8.** Flow Rate dimension

The flow rate dimension is shown in Figure 8, whose dimensions include

$$A = 5.46 \text{ m}^2$$

$$\text{Volume} = L \times W \times H \tag{1}$$

Where,

V = volume of the required area to flow

$$\text{Volume} = L \times W \times H$$

$$= A \times H$$

$$W = 2.54 \text{ cm}$$

$$H = 2.54 \text{ cm}$$

$$\begin{aligned}
 V &= 0.5 \times 2.54 \times 5.46 \times 2.54 \\
 &= 17.61 \text{ c m}^3 \\
 V &= 0.1761 \text{ m}^3
 \end{aligned}$$

#### **D. TIME TAKEN**

For 1 kg fertilizer, the flow is 25.3 sec.

$$Q = V/t \quad (2)$$

Where, Q= flow rate

$$\begin{aligned}
 Q &= \frac{V}{t} \\
 Q &= \frac{0.1761}{25.3}
 \end{aligned}$$

$$Q = 0.006960 \text{ m}^3/\text{s}$$

For 2Kg fertilizer is 51.1 sec.

$$\begin{aligned}
 Q &= \frac{V}{t} \\
 Q &= \frac{0.1761}{51.1}
 \end{aligned}$$

$$Q = 0.00344 \text{ m}^3/\text{s}$$

## **VI. RESULTS AND DISCUSSION**

This section discusses the evolution of the design, the problem faced and the complete unit. The seed vending concept is designed with the spring method, by taking 3 meters of wire and 1.5-inch pipe. By holding the pipe and placing a wire in the starting of the pipe and rolling till the end in a tight position. In Fertilizer Vending, a tank is made to store the fertilizer and dispense it at periodic times. In fertilizer tank design the inside chamber tank is made in slope design. The slope in the tank will be made to flow in the required rectangle area square. The controlling of the fertilizer flow rate will be done by a door. It can be called a valve for fertilizer. The door is connected to a 3V dc motor. Here Urea is used as fertilizer. A closed storage tank in steel metal reinforcement is used to make the storage tank. It should be taken care that the tank must not get rusted from keeping urea for a long time period Further, the tank chamber should be on a very clear slope for full flow in an easy way. The design is made to avoid air penetration from the atmosphere.

In order to get fertilizer, insert an RFID as an alternative to the money insertion type design. Here the card can be customized to a Below Income group family card holder to get the required number of fertilizers/seeds. Hence the rates are displayed are below:

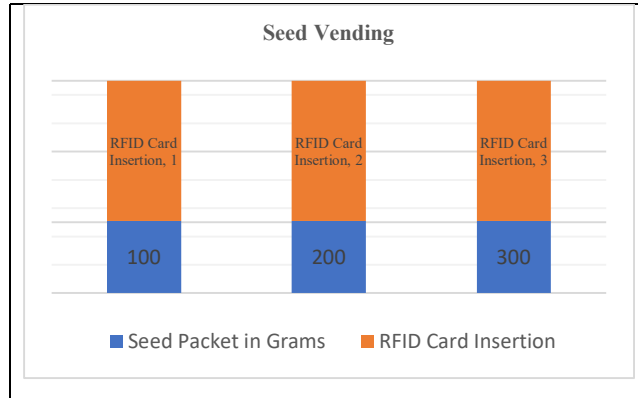
- i. For 1Kg: `10 (it is equal to placing RFID 1 time on the reader)
- ii. For 2Kg: `20 (it is equal to placing RFID 2 times on the reader)
- iii. For 5Kg: `50(it is equal to placing RFID for 5 time on reader)



In the above representation placing RFID is an indication of inserting money. Then the equation is shown below:

$$N \times 10 = \text{the total amount} \quad (3)$$

Where N = number of placing RFID



**Fig 9.** Seed Vending result

The graphical results of the proposed design are shown in Figure 9 and 10. While Figure 9 shows seed packets in grams dispensed for RFID card insertion, Figure 10 shows, the accuracy of dispensing which is at 98-99% with an error rate of 1-2%. Figure 11 shows the final model design of the proposed model and Figures 12 and 13 depict the real-world image of the regional language and quantity selection interface available in the developed system.

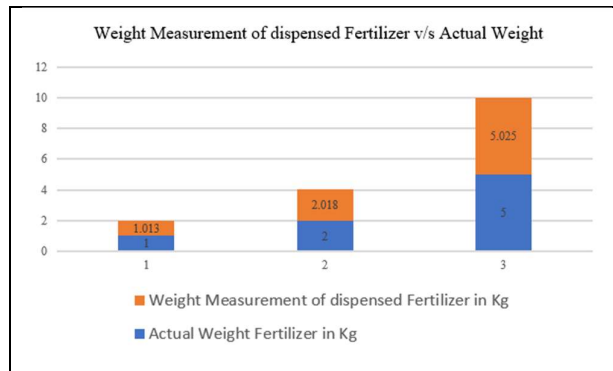
**TABLE 2.** FERTILISER & SEED VENDING RESULT

Sl. No	Fertilizer Vending		Seed Vending	
	Fertilizer Quantity in Kg	Time taken to dispense in Sec	Seed Quantity in grams (Ready Packet)	Time taken to dispense in Sec
1	1	25.3	100	12-15
2	2	51.1	200	15-20
3	3	126.8	200	20-25

Table 2 shows the time taken for fertilizer dispensing on the placement of the RFID card and entering the required quantity.

The Comparison of the dispensing time of seed vending machine is found to be 90-95% accurate on par with real time vending machine (Reference:Seed Vending Machine SC-500-

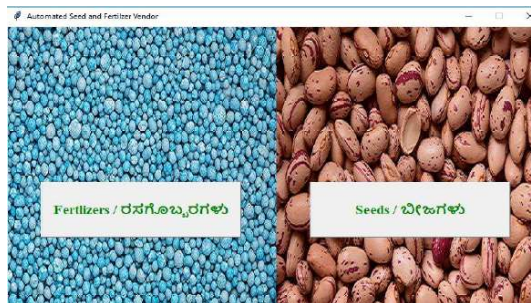
24) which takes about 10-15seconds. Further, it depends on the user operation speed. Fertiliser vending machine is under stages of development and practical comparison can be introduced at this period of time.



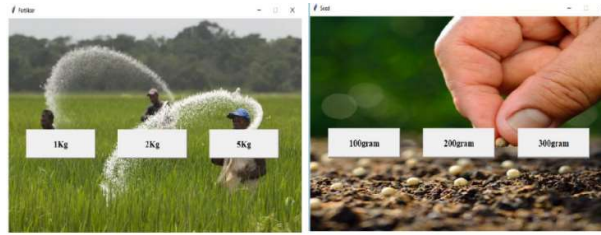
**Fig 10.** Result Analysis of the Dispensed Quantity



**Fig 11.** Final Model Design (Front View)



**Fig 12.** Regional language User Interface



**Fig 14.** Quantity Selection Interface

## VII. CONCLUSION

The model encapsulates a single Vending Machine which dispenses both Seeds and fertilizer (Urea). Vegetable/Fruit seeds of range 50gram-200gram and fertilizer of required quantity in Kg is customized. In this way, The Fertilizer and Seeds will be available 24x7 and will be available in small quantities. The machine is customized in a regional language User a friendly interface to help farmers with the vending machines technology. The benefit is that it can be installed in rural villages, Krishi Vigyan Kendra, fertilizer outlets, and Kiosks near remote places. As an improvement in design, Payment without cash, including Credit Cards, Square, and even apps like Venmo Telemetry devices that alert the vending company on real-time sales data can be introduced. Inner storage tank temperature monitoring is essential as fertilizers need a controlled environment. In the future work, this can be improved using related sensors integration with IoT monitoring facility.

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