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REVIEW ARTICLE

SEEDING AND FERTILIZATION USING AN AUTOMATED ROBOT

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ABSTRACT

Robotics is one of the fastest growing engineering fields of today. Millions of dollars are spent every year on the developments of robots to be used in all sorts of field. The use of robots is more common today than ever before and it is no longer exclusively used by the heavy production industries. Robots are designed to remove the human factor from labor intensive and/or dangerous work. In modern farming applications, so many different types of automation techniques are used for easy and staff less operations that includes the important functions like seeding and spraying fertilizers. The system uses so many automatic methods, which require very less labor. The project intends to develop a prototype of an autonomous agricultural robot that includes an automated guidance system, and has applications in different stages of horticulture. A general concept for a field crops robotic machine is to selectively harvest or easily weed the desired prototype. Future trends must be pursued in order to make robots a viable option for all agricultural operations such as to plough the field, saw the seeds, plant saplings, weed the weeds, water the plants, and spray insecticides and pesticides. Microcontroller P89V51RD2 is used to intelligently monitor the robot. Keil uVision4 software provides an integrated development environment to develop a program to do the same.

INTRODUCTION

Many of the tasks associated with horticulture, such as picking, pruning, pest and weed control, are repetitive and arduous and there is a problem in getting and retaining labor to do them. Such tasks seem ideally suited to robots and, in countries where labor costs are high, there is an economic incentive to use automation as a solution to the problem. However, while robots are commonly used for repetitive tasks in industry they have not been successful in horticulture. The industrial environment is clean, well-lit, dry and uniform while the horticultural environment is extremely variable in terms of weather, terrain and light. The components, which are manipulated in industrial settings, are Uniform, un-obscured, stationary and robust whilst those in horticulture are generally very variable in terms of shape, color and size, hidden amongst foliage, moving (for example, in the wind) and are soft and easily damaged during handling.

The key problem areas associated with horticultural robotics are:

- Path finding- navigation both within the rows of an orchard and in order to get to the orchard.
- Mapping- keeping track of where the robotic task has already been completed and where it remains to be done.
- The design of the mechanical agent or arm of the robot, which will perform the task of spraying, and could later be developed for tasks like pruning, pollinating, picking etc.
- Building a chassis, which is cost effective, can handle rough terrain, sloping ground, muddy soil and rain.
- Obstacle avoidance: technique for recognition of obstacles such as people, poles, wires, stumps and rocks so that the robot can navigate safely around these.
- Swarm behavior management- to allow multiple robots to function together in one area under remote control without interfering with each other.
- Overall cost- most of the horticultural tasks, such as seeding and fertilizing, only last for a few months of the year and it is not cost effective to use a robot for such a short period. Ideally, robots should be capable of performing many different operations, such as fertilizing followed by picking of the fruits, bud count followed by pollination followed by fruit count, in order to extend the useful work period of the robot and ensure a reasonable payback time on the robot

This machine consists of a simple electro-mechanical system supported on a chassis, driven by dc motors. User interface portals will help the user to input the type of operation to be performed (fertilizing/seeding operations), and to input other information, like the dimensions of the field. Apparatus to plough the field, seeding tray, and mechanical arms for closing the dug pits are also provided. Special spraying mechanism for spraying water and fertilizers is also mounted on the chassis. The microcontroller 8051 forms the brain of this machine and controls all the operations mentioned above. Both small and large landholders can implement this prototype machine.

MECHANICAL SYSTEM DESCRIPTION

The machine set up contains six important parts:

A. Pit digging unit

Digging of the pits is one of the foremost tasks in agriculture. The machine designed here uses a metallic spatula specially designed in the shape of a digger to do the digging. Special arrangement including a screw and a hinge are provided in order to make the spatula mobile.

B. Seeding unit

Seeds are placed in a seeding tray. The program enables a user to use different types of seeds (3 types of seeds could be selected in this prototype). Timed output signals from the microcontroller are provided to the electromechanical switch, which in turn opens and closes the flap that covers the seeding hole, in the seeding tray.

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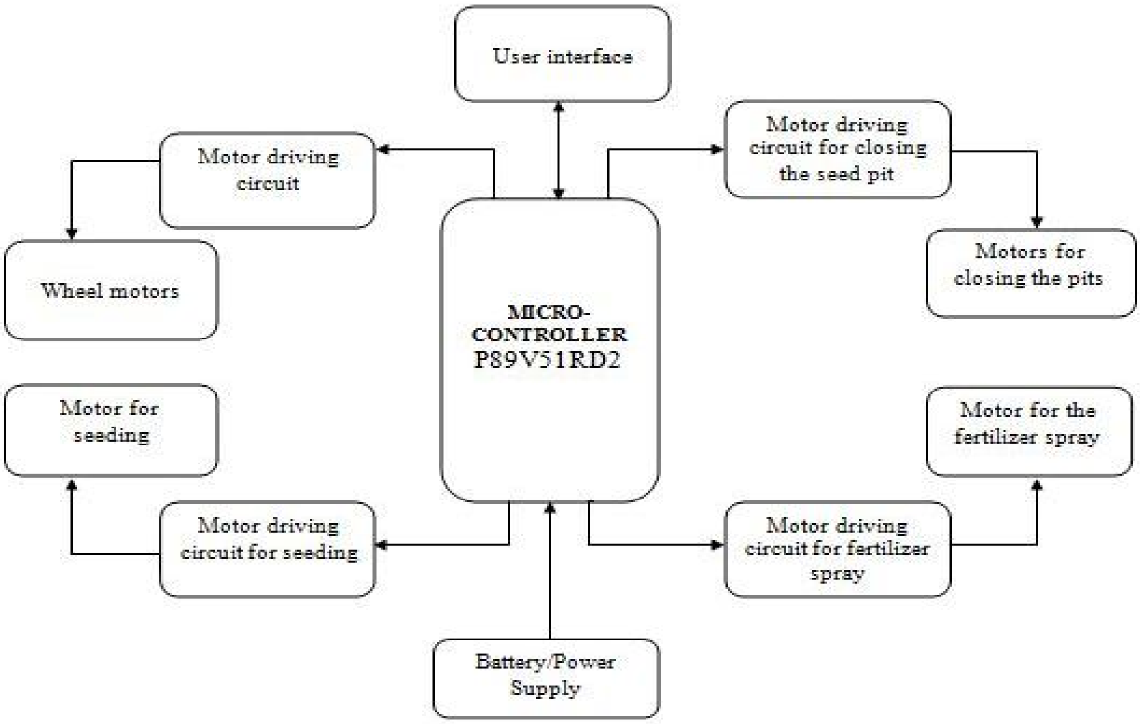

Fig.1. Block diagram representation an automated seeding and fertilization robot

C. Seed pits closing unit

Once the seeds are sown, the soil is replaced on the pits using two horizontal flaps. The flaps are connected to two gear motors, which are controlled by the micro controller. The gear motors at any given instance of time, turn in opposite directions. And this mechanism thus helps in closing the dug pits.

D. System mobility control unit

The gear motors are used for driving the entire machine. The motors are connected to the hind wheels and can offer independent motion with respect to each other. For a straight motion path, both the motors move in uniform speeds in the same direction. But when the machine has to execute alternate left and right turns, it makes use of a simple robotic principle, where one motor runs in direction opposite to the other for making 90° or 180° turns.

E. Fertilizing unit

Fertilizing is done after the dug pits are closed. A custom size motor can modulate the spraying radius based on the power supply provided to it. The sprayer can work in 3 levels, namely, below spray nozzle level, spray nozzle level and above spray nozzle level.

F. Power supply unit

Power control unit consists of a lead acid battery with specifications of 12V/4.5 AH. It weighs 2.6 Kg approx, and constitutes around 28% of the total unit weight. A low weight power supply unit can be proposed for better system performance.

HARDWARE DESCRIPTION

A. Microcontroller P89V51RD2

8051 based fully static 24 MHZ CMOS controller with
•32 I/O lines
• 2 timers/counters
•6 interrupts/2 priority levels

- UART
- Three level program memory lock
- 4 Kbytes flash memory
- 128 bytes on-chip RAM

B. Interfacing

- Port P0 is used to control the gear motors.
  - o P0.0 to P0.3 is used to control the wheel motors.
  - o P0.4 to P0.7 is used to control the motors associated with closing the pits.
- Port P1 is connected to the LCD display
- P2.0 of port P2 is used to control the electromechanical switch used for seeding.
- P2.1 and P2.2 are the 2 LCD control pins.
- P2.3 and P2.4 are connected to the IR sensor.
- P2.5 is used for fertilizing.
- Port P3 is connected to the hex keypad.

C. Driver circuits

1) *Motor driving circuit using IC l293*

Gear motor cannot be connected to the microcontroller directly because of its low current output. An external driver is used which increases the current output and drives the motor.

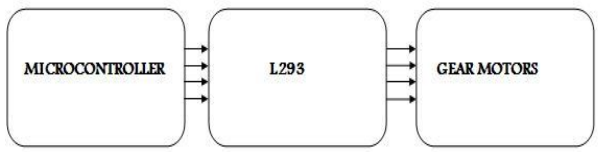

Fig.2. Block diagram for implementation using l293

The motor driving circuit using IC L293 is implemented with the help of 4 resistors of value 4.7 K Ω and 3.3 K Ω on each side.

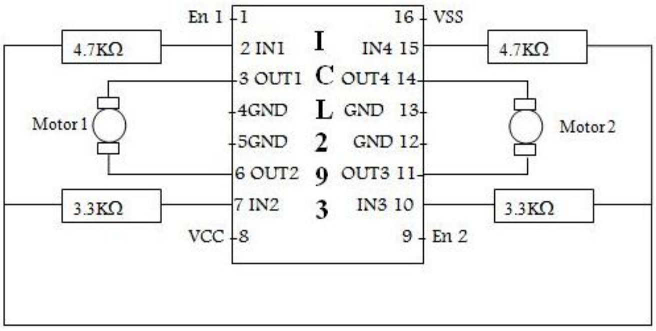

Fig.3. Motor driving circuit IC L293

2) *Driving IC for seeding (ULN 2803)*

The electromagnetic switch cannot be connected to the microcontroller directly because of its low current output. An external driver is used which increases the current output and hence for efficient working of the switch. The switch is connected to the pin number 11 of the ULN 2803

3) *Infra red object detector*

The receiver block uses an infrared sensor module, which is commonly used in color television, for sensing the IR signals reflected from obstacles. The sensor module shown incorporates a detector diode, and SMD IC which consists a band pass filter, an amplifier and a demodulator on a small PCB placed inside a small tin cube enclosure to get rid of unwanted electromagnetic interference.
The two IR receiver modules are connected to pin 2.3 and 2.4 of 8051 micro-controller to service the signal of the presence of obstacle. The pins of port 2 are polled continuously for the presence of obstacle. The circuit diagram of IR receiver is shown in Fig.4.

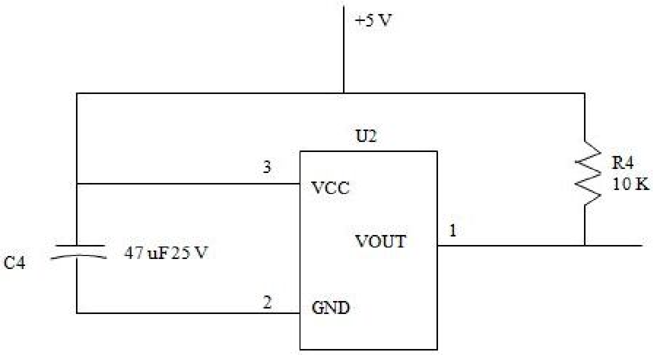

Fig.4. IR receiver circuit

4) *Liquid crystal display*

A liquid crystal display (LCD) is a thin, flat device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filter, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other. For an 8-bit data bus, the display requires a +5V supply plus 11 I/O lines. For a 4-bit data bus it only requires the supply lines plus 7 extra lines. When the LCD display is not enabled, data lines are tri-state and they do not interfere with the operation of the micro-controller. Data can be placed at any location on the LCD. For 16x2 LCD, the address locations are given in Fig.5.

First line	80	81	82	83	84	85	86	through	8F
Second line	C0	C1	C2	C3	C4	C5	C6	through	CF

Fig.5. Address locations for 2x16 lines LCD

Enable (E)

This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from the R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly.

Read/Write (R/W)

This line determines the direction of data between the LCD and micro-controller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.

Register Select (RS)

With the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.

D. Logic status on control lines

- E - 0 Access to LCD disabled - 1 Access to LCD enabled
- R/W – 0 Writing data to LCD - 1 Reading data from LCD
- RS – 0 Instruction - 1 Character

E. Writing data to the LCD

Writing data to the LCD is done in several steps

- Set R/W bit to low
- Set RS bit to logic 0 or 1 (Instruction or character)
- Set data to data lines (If it is writing)
- Set E line to high
- Set E line to low

Software Description

Keil uVision4 software provides an integrated development environment to develop a program for the embedded system.

A.Microcontroller

A microcontroller helps in perfect synchronization of several inputs and their respective outputs, with real time considerations of different periods. It intelligently monitors all the operations. The microcontroller flow diagram for software implementation is described in flow diagrams (Fig .6. and Fig.7.)

Testing and Results

A. Procedure to determine the soil type & composition

- Spread soil on a newspaper to dry. Remove all rocks, trash, roots, etc. Crush lumps and clods.
- Finely pulverize the soil.
- Fill a tall, slender jar (like a quart canning jar) 1/4 full of soil.
- Add water until the just is 3/4 full
- Add a teaspoon of non-foaming dishwasher detergent.

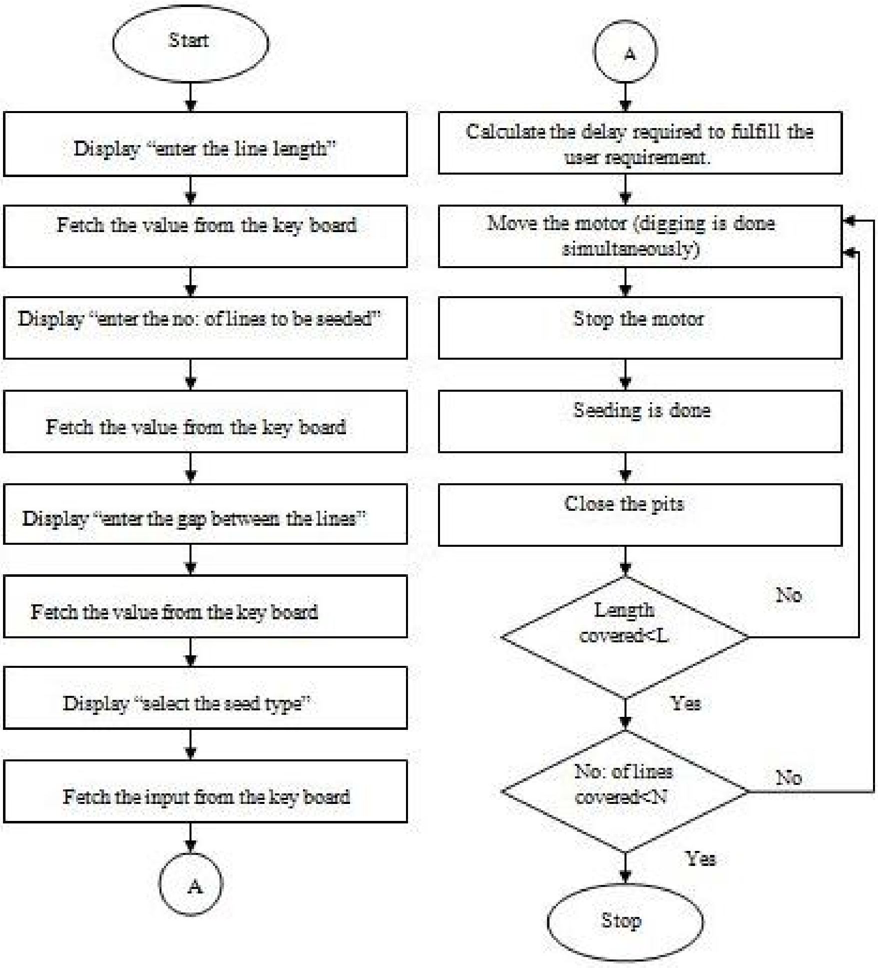

Fig.6. Flow diagram depecting seeding operation

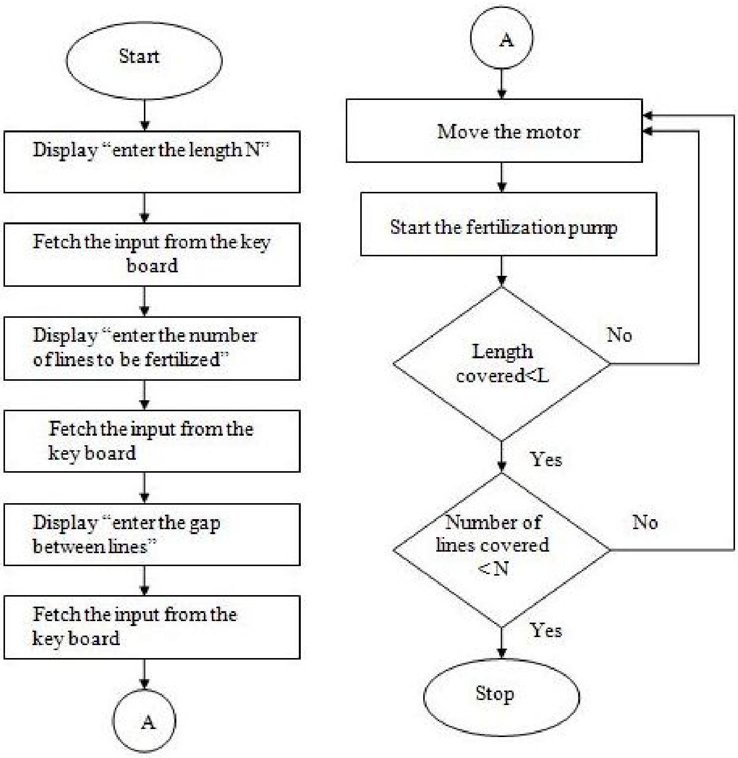

Fig.7. Flow diagram depicting fertilization operation

- Put on a tight fitting lid and shake hard for 10 to 15 minutes. This shaking breaks apart the soil aggregates and separates the soil into individual mineral particles.
- Set the jar where it will not be disturbed for 2-3 days.
- Soil particles will settle out according to size. After 1 minute, mark on the jar the depth of the sand.
- After 2 hours, mark on the jar the depth of the silt.
- When the water clears mark on the jar the clay level. This typically takes 1 to 3 days, but some soils may take weeks.
- Measure the thickness of the sand, silt, and clay layers.
  - Thickness of sand deposit ____
  - Thickness of silt deposit ____
  - Thickness of clay deposit ____
  - Thickness of gravel deposit ___
- Calculate the percentage of sand, silt, and clay.
  - [clay thickness] / total thickness] = ___ percent clay
  - [silt thickness] / total thickness] = ___ percent clay
  - [sand thickness] / [total thickness] = ___ percent sand
  - [gravel thickness] / [total thickness] = ___ percent gravel

Turn to the soil texture triangle and look up the soil texture class in Fig.8.

- It enables clean seeding pattern.
- The usage of DC battery enables the user to be free of constrains of ever rising electricity bills and the dependency on normal electricity.
- Simple and lightweight design makes the transportation of the apparatus easy.
- Minimal hardware usage helps in the easy maintenance of the system.

2. Limitations

- The machine takes considerably long duration of time while executing the right and left turns.
- Current model does not have provision for using an AC power source.
- The program makes use of time delay technique for determining the effective seeding distance between two consecutive seeds. This technique compromises the system accuracy for different type of terrains and soil types.

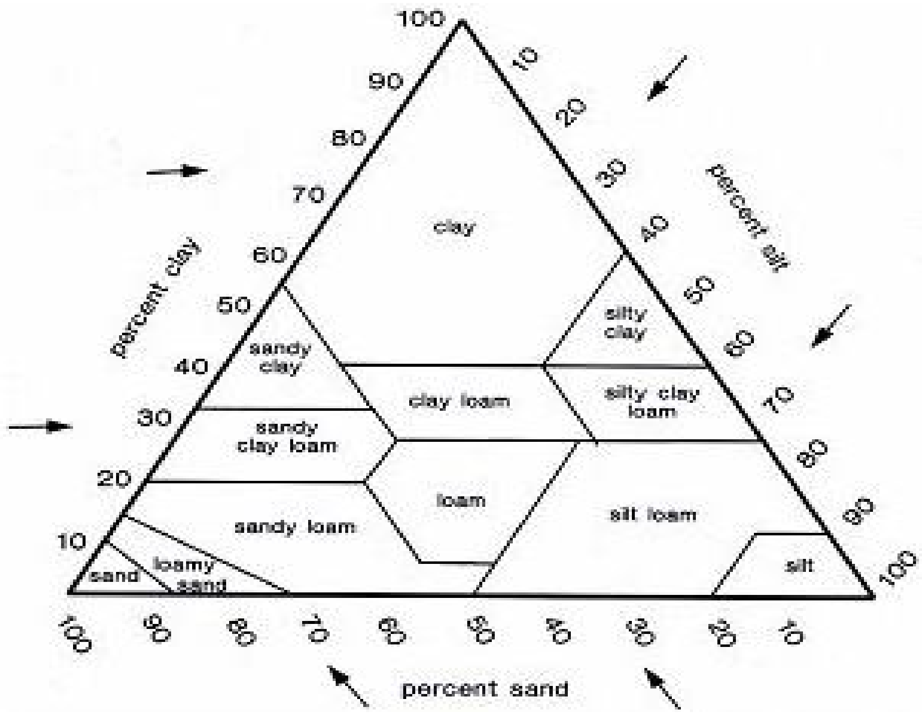

Fig.8. Soil texture triangle

- From the tests conducted, it is evidently noted that the apparatus works best for dry clayish (fine) soil. The seeding accuracy obtained is 94.827% as compared to seeding on a perfect flat surface. The machine moves at a speed of 55RPM compared to 58-60 RPMs` perfect flat surface.
- The seeding accuracy obtained for sandy (medium coarse) soil is 82.75% as compared to seeding on a perfect flat surface. The machine moves at a speed of 48-50RPM compared to 58-60 RPMs` perfect flat surface.
- The seeding accuracy obtained for very coarse soil is 72.41% as compared to seeding on a perfect flat surface. The machine moves at a speed of 40-45RPM compared to 58-60 RPMs` perfect flat surface.

1. Advantages

- The model Eliminates human intervention in some of the most labor-intensive parts of an agriculture procedure.
- The simplicity of the model enables even an illiterate user to use it with ease.

3. Application

- The prototype can be modified for any type of crop seed.
- It can also be modified in ways so that it could be used in different soil types and terrains.

4. Scope for future Improvement

- The model can be modified to fit in extra features, namely a mechanism for weeding, and planting the saplings.
- Hydraulics could be used so that the level of the digger could be adjusted automatically.
- Solar cells can replace the DC battery to reduce the recharging cost and improve the overall efficiency.
- Ultrasonic detectors could replace IR sensors for better performance.
- An optocoupler coupled with the wheel motors can help in improving the overall system accuracy when it comes to effective seeding distance between two consecutive seeds

Table 1. Tabular Colum Depicting the Relation between Different Seed Types, Distance between two Consecutive Seeds and the Delay Induced

SEED TYPE	DISTANCE BETWEEN TWO CONSECUTIVE SEEDS (T)	DELAY INDUCED	NO. OF REPETATIONS TO COVER LENGTH L (in feet)
A	15 cm	100	2*L
B	30 cm	200	L
C	45 cm	300	(2/3)*L

Table 2. Tabular column depicting test results

Serial number	Soil type	composition	Speed considerations	Accuracy
1	Fine soil	40% CLAY,30% SILT 20% SAND,10% GRAVEL	55 RPM	94.827%
2	Medium coarse soil	20% CLAY, 25% SILT 25% SAND, 30% GRAVEL	48 RPM	82.75%
3	Very coarse soil	10% CLAY, 15% SILT 30% SAND, 45% GRAVEL	42 RPM	72.41%

Conclusion

The project aimed at developing "SEEDING AND FERTILIZATION USING AUTOMATED ROBOT" is completed successfully. A machine assembled using the above-mentioned idea successfully seeds and fertilizes large areas of land without human intervention.The technology deployed in this work is an interface between aspects of robotics and artificial intelligence. India, being a nation with an agriculturist economy, would be greatly helped by such an invention that takes off an extra burden from the shoulders of small and large-scale farmers.

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