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# Soil Nutrients Detecting Device using IOT Technology

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***Abstract:*** India is a land of agriculture.18% of India's GDP is through agriculture. 61.5% of India's population is involved in agriculture. But the farmers are not receiving resources which aremust for the crops to grow. Soil contain nutrients for the growth of plants, 6 of them are required in large quantities for any plant grow. Many farmers across India are attaining awareness on smart farming. This method of smart farming gives the ability to get high yieldin a small area of land.

Nutrients are nothing but elements in the periodic table. Recent study says 17 nutrients are required, maybe in small or large quantities. Therefore, a requirement in nutrient analysis isrequired. The present circumstance is that farmers must travel very far for testing or use testing kits which are one-off. Through this project we try to achieve testing of soil using near infrared spectroscopy.

***Index Terms*** – IOT, Nutrients.

## I INTRODUCTION: AGRICULTURE IN INDIA

Agriculture and allied sector forms the bedrock of Indian economy as it engages more than50% of the workforce and contributes about 17% to the country's Gross Value Added (GVA)

In the current situation if agriculturists adopt technology, it could maximize their produce. In other countries the technology is far more advanced. Farmers in India lack knowledge ofAgricultural technologies.

Moreover, land through generations get divided as ancestral privileges. Due to this optimumyield cannot be provided. For this purpose, community farming is implemented in other countries.

### *Internet of Things*

Internet of Things (IoT) is widely used in connecting devices and collecting data information. Internet of Things is used with IoT frameworks to handle and interact with dataand information. In the system users can register their sensors, create streams of data and process information. IoT are applicable in various methodologies of agriculture. Applications of IoT are Smart Cities, Smart Environment, Smart Water, Smart Metering, Security and Emergency, Industrial Control, Smart Agriculture, Home Automation Health etc. 'Internet of Things' is based on device which is capable of analysing the sensed information and then transmitting it to the user.

### Basic nutrient requirement

Nutrients are nothing but elements in the periodic table. Recent study says 17 nutrients are required, maybe in small or large quantities. Therefore, a requirement in nutrient analysis isrequired. In the present circumstance farmers need to travel very far for testing or use testingkits which are one-off. Through this project we aim to test the soil using near infrared spectroscopy.

### Smart Agriculture

Smart agriculture is a revolution in the agriculture industry that helps to guide actions required to modify and reorient agricultural systems to effectively support the developmentand guarantee food security during an ever-changing climate. This method involves technology in agriculture. Using IoT along with sensors gives the ability to have data at ourgrasp.

**Near Infrared spectroscopy**

Near-infrared spectroscopy (NIRS) is a spectroscopic method that uses the near-infrared region of the electromagnetic spectrum (from 780nm to 2500nm). Typical applications include medical and physiological diagnostics and research. Near infrared spectroscopy is based on molecular overtone and combination vibrations. Such transition are forbidden by the selection rules of quantum mechanics.

Photodiodesensor

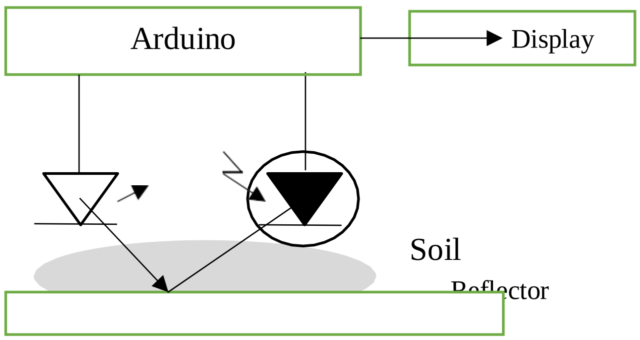



Fig 1 Soil Nutrient Sensor

The above figure is the block diagram of the sensor used to analyze the nutrients present inthe soil. The table 1 gives the data required to decide the color of LED to be used in thesensor with respect to wavelength.

**Table 1 Wavelength for nutrient identification**

| Nutrient | Absorption wavelength (nm) | LED Type | Wavelength (nm) |
|---|---|---|---|
| Nitrogen (N) | 438-490 | LED 1 | 460-485 |
| Phosphorous (P) | 528-579 | LED 2 | 500-574 |
| Potassium (K) | 605-650 | LED 3 | 635-660 |

The Table 2 is the data of 6 samples taken for reference and analyzed using the sensor.Thisis compared with Table.3 where chemical is used i.e, the conventional method, gives an idea of sensor's accuracy.

**Table 2 Sample analysis**

| Soil Sample | Nutrient content |
|---|---|
| Sample 1 | High Nitrogen |
| Sample 2 | High Phosphorus |
| Sample 3 | High Potassium |
| Sample 4 | Low Nutrient |
| Sample 5 | Low Nutrient |
| Sample 6 | Low Nutrient |

**Table 3 Sample analysis through chemical method**

| Sample | Nitrogen (N) | Phosphorous (P) | Potassium (K) |
|---|---|---|---|
| 1 | High | Medium | Low |
| 2 | Low | High | Low |
| 3 | Low | Low | High |
| 4 | Low | Low | Low |
| 5 | Low | Low | Low |
| 6 | Low | Low | Low |

## II.LITERATURE REVIEW

Whether variable–rate nutrient application is planned or not, sampling the soil in an organized pattern is a good management practice was stated in website of the **mosaic company**. It helps ensure adequate representation of the entire field. Most agronomistsrecommend sampling on a pattern so that each sample represents about 2 ½ acres (one hectare) or less. At least one sample per acre is preferred, especially in areas receiving 25" or more of annual rainfall and in irrigated fields.

The rapid development of new technologies and the changing landscape of the online world(e.g., Internet of Things (IoT), Internet of All, cloud-based solutions) provide a unique opportunity for developing automated and robotic systems for urban farming, agriculture, and forestry was stated by **Yiannis Ampatzidis et al.** Technological advances in machine vision, global positioning systems, laser technologies, actuators, and mechatronics have enabled the development and implementation of robotic systems and intelligent technologies for precision agriculture.Herein, we present and review robotic applications on plant pathology and management, and emerging agricultural technologies for intra-urbanagriculture. Greenhouse advanced management systems and technologies have been greatlydeveloped in the last years, integrating IoT and WSN (Wireless Sensor Network). Machinelearning, machine vision, and AI (Artificial Intelligence) have been utilized and applied in agriculture for automated and robotic farming. Intelligence technologies, using machine vision/learning, have been developed not only for planting, irrigation, weeding (to some extent), pruning, and harvesting, but also for plant disease detection and identification. However, plant disease detection still represents an intriguing challenge, for both abiotic and biotic stress.

## III. PROBLEM DEFINITION

Agriculture is the main occupation of our Indian Economy. Indian agriculture sectoraccounts for 18 per cent of India's gross domestic product (GDP) and provides employmentto 50 per cent of India's workforce.

The main problem faced by Indian farmers are water supply, pest control and productivity per land. Land used by farmers are family holdings, land is divided through generations. Due to this land is divided into smaller plots. It is difficult to get high yield in small area ofland.

Instead of farmers going to co-operative society for suggestions, we can bring suggestions to them by using robots which can analyze the soil for water content and nutrients. This canhelp provide optimum condition for better growth of plants.

Robots with the ability to sense the land area, take data are saved in the cloud storage or memory. This data must be plotted into a graph for the user to read. Necessary actions for the detected values must be taken in order to achieve the objective.

Smart farming is the future of agriculture. It is a farming management concept using moderntechnology to increase the quantity and quality of agricultural products.

Through this project work an approach is being worked out to model and estimate a robot to test soil for nutrient and moisture, which will help in the better growth of crops. The modelling of the robot helps us to predict the optimum growth of crops in a land.

**Objectives of the proposed work**

- To create a 3D-Model of SOIL NUTRIENT TESTING ROBOT(SNTR).
- To select suitable sensors for testing (Moisture and Nutrients) soil.
- To select required motors, controllers, other equipment.

## COMPONENTS USED

### Arduino UNO R3

The Arduino UNO R3 is frequently used microcontroller board in the family of an Arduino.This is the latest third version of an Arduino board and released in the year 2011. The mainadvantage of this board is if we make a mistake we can change the microcontroller on the board. The main features of this board mainly include, it is available in DIP (dual-inline- package), detachable and ATmega328 microcontroller. The programming of this board caneasily be loaded by using an Arduino computer program. This board has huge support fromthe Arduino community, which will make a very simple way to start working in embeddedelectronics, and many more applications. Please refer the link to know about Arduino – Basics, and Design

**What is Arduino Uno R3?**

Arduino Uno R3 is one kind of ATmega328P based microcontroller board. It includes the whole thing required to hold up the microcontroller; just attach it to a PC with the help of aUSB cable, and give the supply using AC-DC adapter or a battery to get started. The term Uno means "one" in the language of "Italian" and was selected for marking the release of Arduino's IDE 1.0 software. The R3 Arduino Uno is the 3rd as well as most recent modification of the Arduino Uno. Arduino board and IDE software are the reference versions of Arduino and currently progressed to new releases. The Uno-board is the primaryin a sequence of USB-Arduino boards, & the reference model designed for the Arduino platform.

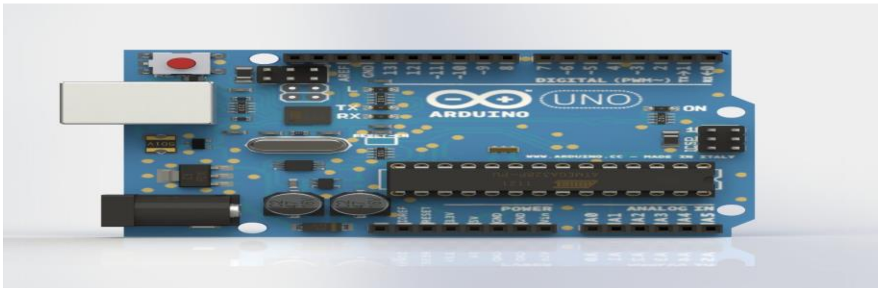


Fig 2 Arduino UNO R3

**Arduino Uno R3 Specifications**

The Arduino Uno R3 board includes the following specifications.

- It is an ATmega328P based Microcontroller
- The Operating Voltage of the Arduino is 5V
- The recommended input voltage ranges from 7V to 12V
- The i/p voltage (limit) is 6V to 20V
- Digital input and output pins-14
- Digital input & output pins (PWM)-6
- Analog i/p pins are 6
- DC Current for each I/O Pin is 20 mA
- DC Current used for 3.3V Pin is 50 mA

**Arduino Uno R3 Pin Diagram**

The Arduino Uno R3 pin diagram is shown below. It comprises 14-digit I/O pins. From these pins, 6-pins can be utilized like PWM outputs. This board includes 14 digitalinput/output pins, Analog inputs-6, a USB connection, quartz crystal-16 MHz, a power jack,a USB connection, resonator-16Mhz, a power jack, an ICSP header an RST button.

Fig 3 Power Supply

**Power Supply**

The power supply of the Arduino can be done with the help of an exterior power supplyotherwise USB connection. The exterior power supply (6 to 20 volts) mainly includes a battery or an AC to DC adapter. The connection of an adapter can be done by plugging a center-positive plug (2.1mm) into the power jack on the board. The battery terminals can beplaced in the pins of Vin as well as GND. The power pins of an Arduino board include the following.

Vin: The input voltage or Vin to the Arduino while it is using an exterior power supply opposite to volts from the connection of USB or else RPS (regulated power supply). By using this pin, one can supply the voltage.

5Volts: The RPS can be used to give the power supply to the microcontroller as well as components which are used on the Arduino board. This can approach from the input voltagethrough a regulator.

**Arduino Uno R3 Programming**

The programming of an Arduino Uno R3 can be done using IDE software. The microcontroller on the board will come with pre-burned by a boot loader that permits to upload fresh code without using an exterior hardware programmer.

- The communication of this can be done using a protocol like STK500.
- We can also upload the program in the microcontroller by avoiding the boot loaderusing the header like the In-Circuit Serial Programming.

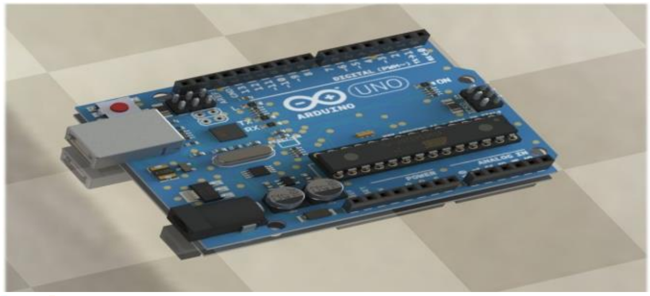


Fig 4 Ardunio Uno R3

**NodeMCU**

**NodeMCU** is a low-cost open source IoT platform. It initially included firmware which runson the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which was based on the ESP-12 module. Later, support for the ESP32, 32-bit MCU was added.

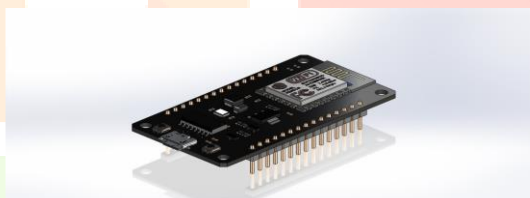


Fig 5 - Node MCU

**Pins**

NodeMCU provides access to the GPIO (General Purpose Input/Output) and a pin mapping table is part of the API documentation.

Table 2 Pin mapping

| I/O index | ESP8266 pin |
|---|---|
| 0 | GPIO16 |
| 1 | GPIO5 |
| 2 | GPIO4 |
| 3 | GPIO0 |
| 4 | GPIO2 |

**L293D Motor Driver – Arduino**

**Introduction**

The Motor Driver is a module for motors that allows you to control the working speed anddirection of two motors simultaneously. This Motor Driver is designed and developed basedon L293D IC.

L293D is a 16 Pin Motor Driver IC. This is designed to provide bidirectional drive currentsat voltages from 5 V to 36 V.

**Hardware required**

**Table 3 Hardware requirement**

| Sl.No. | Item | Quantity |
|---|---|---|
| 1 | Arduino UNO | 1 |
| 2 | Motor Driver | 1 |
| 3 | DC Motor | 2 |
| 4 | Female to Male Jumper wire | 8 |
| 5 | AA Battery | 6 |

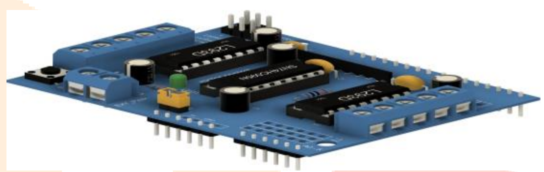


Fig 6 – Motor Driver

**Working Mechanism**

Rotation of motor depends on Enable Pins. When Enable 1/2 is HIGH , motor connected toleft part of IC will rotate according to following manner:

**Table 4 - Enable pin details**

| **Input 1** | **Input 2** | **Result** |
|---|---|---|
| 0 | 0 | Stop |
| 0 | 1 | Anti-Clockwise |
| 1 | 0 | Clockwise |
| 1 | 1 | Stop |

**DHT11 Sensor and Its Working**

Humidity is the measure of water vapour present in the air. The level of humidity in air affects various physical, chemical and biological processes. In industrial applications, humidity can affect the business cost of the products, health and safety of the employees. So, in semiconductor industries and control system industries measurement of humidity is very important. Humidity measurement determines the amount of moisture present in the gas that can be a mixture of water vapour, nitrogen, argon or pure gas etc… Humidity sensors are of two types based on their measurement units. They are a relative humidity sensor and Absolute humidity sensor. DHT11 is a digital temperature and humidity sensor.

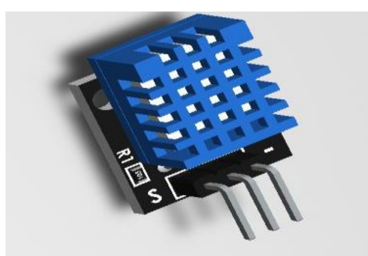


**Fig 7 - Humidity Sensor**

**Working Principle of DHT11 Sensor**

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs withthe change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.

For measuring temperature this sensor uses a Negative Temperature coefficient thermistor,which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made upof semiconductor ceramics or polymers.

The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy.Humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz .i.e. it gives one reading for every second. DHT11 is small in size with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5mA.

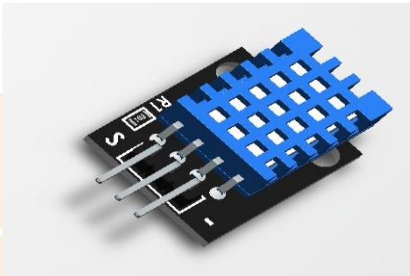


**Fig 8- Humidity Sensor**

**Micro Servo motor SG90**

**Introduction**

It is tiny and lightweight with high output power. This servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but smaller. You can use any servo code, hardware or library to control these servos. It comes with a 3 horns (arms) and hardware.

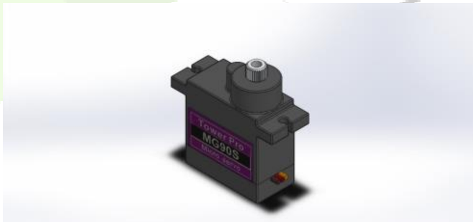


**Fig 9 - Servo Motor**

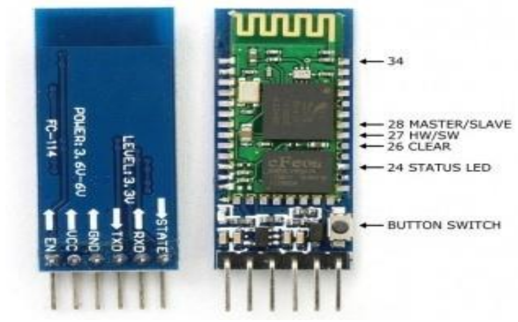



**Fig 10- Servo Switch**

**HC05 BLUETOOTH MODULE**

**Introduction**

**HC–05 module** is an easy to use **Bluetooth SPP (Serial Port Protocol) module**, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be usedin a Master or Slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is fully qualified **Bluetooth V2.0+EDR (Enhanced DataRate)** 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses **CSR Blue core 04**-External single chip Bluetooth system with CMOS technology and withAFH (Adaptive Frequency Hopping Feature).

**Bluetooth Module HC-05**

The Bluetooth module HC-05 is a MASTER/SLAVE module. By default the factory settingis SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS.The slave modules cannot initiate a connection to another Bluetooth device,but can accept connections. Master module can initiate a connection to other devices.

**Hardware Features**

- Typical -80dBm sensitivity.
- Up to +4dBm RF transmit power.
- 3.3 to 5 V I/O.
- PIO(Programmable Input/Output) control.
- UART interface with programmable baud rate.
- With integrated antenna.
- With edge connector.

**Software Features**

- Slave default Baud rate: 9600, Data bits:8, Stop bit:1,Parity:No parity.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PINCODE:"1234" as default.
-

**WORKING OF THE PROJECT**

The device when powered on boots and goes into command mode/Controller mode and waits for the user to connect it through Bluetooth.

Bluetooth connection can be made in controller mode or command mode. Controller modegives privilege to set commands to a particular key (memory provision) and arrows to guidedirection. Command mode can be used when we can remember the command required to be sent through the Bluetooth.

After achieving the connection we can send the commands as per our requirement. For easyremembrance the commands for movement and testing are set as below:

**Table 5 - Command list**

| REQUIREMENT | COMMAND |
|---|---|
| Forward | F |
| Backwards | B |
| Right | R |
| Left | L |
| Test the Soil | T |

## IV. RESULT AND DISCUSSION

Near infrared reflectance(NIR) spectroscopy(NIRS) is a physical non-destructive, rapid, reproducible and low-cost approach that characterizes materials according totheir reflectance in the wavelength range between 800 and 2500 nm. The analysis ofNIR spectra relies on calibration, which in general is a multivariate regression procedure that that expresses a given property, determined using a conventional method, as a function of absorbance at all or selected wavelengths of the NIR region.The calibration equation can then be used to predict that property on new samples from their NIR spectra only, the acquisition of which is time- and cost-effective

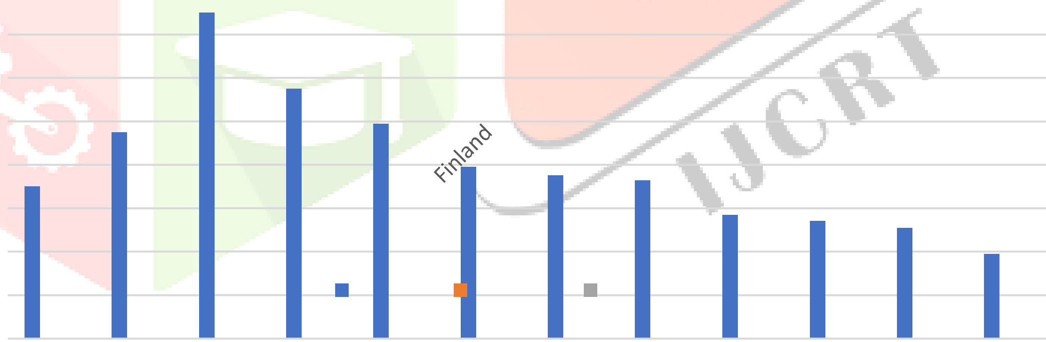
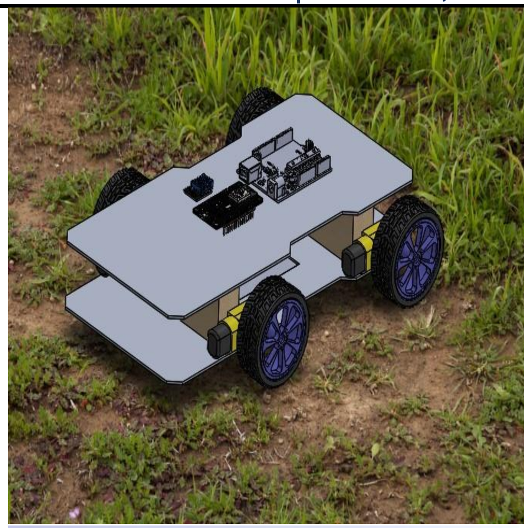



**Fig 11 - Comparison between countries on smart agriculture implementation**


The rapid development of new technologies and the changing landscaping of the online world (e.g., the Internet of Things (IoT), Internet of All, cloud-based solutions) provide a unique opportunity for developing automated and roboticsystems for urban farming, agriculture, and forestry. Technological advances in machine vision, global positioning systems (GPS), laser technologies, actuators, andmechatronics (embedded computers, micro-sensors, electrical motors, etc.)We were able to successfully create 3D-Model of the robot. Firstly, we tested with the helpof simulation and then came up with the final design. This design is very optimistic and efficient in terms of its size as well as the work done. With multiple tests being done on the prototype, we came to know the stresses acting on different parts of the robot and then came up with the final design. This robot comprises a nutrient sensor which works on the principle of infrared spectroscopy and each element in the periodic table has its own frequency. With this sensor the robot cantest the N,P and K in the soil. (N,P,K stands for Nitrogen, Potassium, Phosphorus). The soil has many other nutrients other than N,P and K. But the three main nutrients neededto be known in any soil to grow any sort of crop is N, P and K. This is the reason we focusedon these three nutrients and came up with this sensor. The robot is programmed and controlled using an arduino and it is the heart of this project where the program is loaded and the robot responds according to the program written. All the sensors and the motors are controlled using this device.Servo motors have been used because it has great accuracy and it can be used where we need accurate steps and that is the reason we opted for a servo. The force acting on the servowas calculated using formulas and this is one example, if you attach a string to the arm of the servowhile the arm is horizontal, 1 inch from the axis of rotation, then 25 oz-in means that the servo couldlift a 25 ounce weight with the string. Or, 12.5 ounces if the string is 2 inches from the axis of rotation, etc. Wifi module has also been implemented to make the robot be accessible remotely. The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack thatcan give any microcontroller access to your WiFi network. The ESP8266 is capable of eitherhosting an application or offloading all Wi-Fi networking functions from another application processor. So this robot can be connected using Wifi and can be controlled. Wifi is also being used to save the data on the cloud and for further use. All the test resultscarried out by the robot are sent to the cloud and the data can be retrieved anytime for further observation. A Bluetooth module is used to operate the robot remotely using a remote controller, wherethe farmers can stand in a shady area and manually menuer the robot across the field. First the farmer has to connect the remote controller to the inbuilt Bluetooth module and then he can control the movement of the robot. The movement of the servo also can be controlled using the remote controller. The farmer, using the controller, moves the robot to a desired location and he initiates the test. The robot then performs the test by taking a sample of the soil and then a beam of lightis sent and according to the spectrum obtained, the nutrients are tested. Once the sensor gives a value, It is sent to the cloud and saved. And also the robot has wheelswhich helps to move on the field and this test is carried out on flat land before the crop is grown. The results which we have got through various tests and observations have also beenverified in the soil testing. There are many upgrades to this robot. As this is the first prototype, we are planning for upgrades in future.The upgrades can be added to use wifi as a mode of control to the robot, where the farmer can control the robot using wifi if the bluetooth is not in range. We can also automate the process, where we can teach the robot the path and the robot will perform the same task repeatedly in an interval of time.



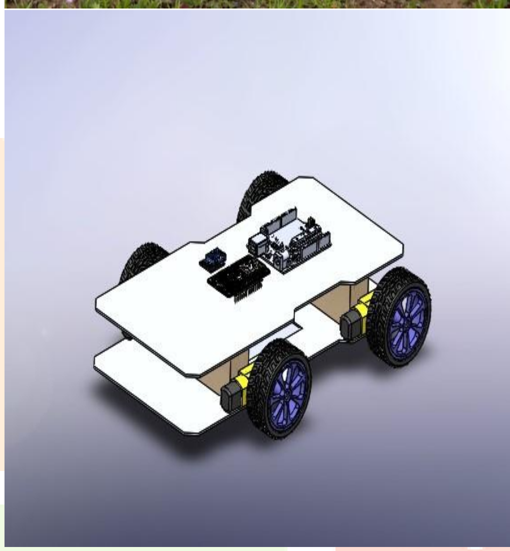


**Fig 11 - Soil test**

## V. CONCLUSION

Currently farmers choose crops on the basis of the trends of the last season. Technology canassist them in making right growing choices by carefully analyzing demand, pricing and fluctuations in weather conditions. This will create a better balance between supply and demand. Technology enabled farming tools can be a boon for small farms.

This project help farmers to test soil independently without long waits and requirement of authorities to do it for them.

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