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MULTILAYER FERTILIZATION TECHNIQUE SCRUTINIZATION IN COTTON CROP

NIKHIL BHENDE
Poornima University, Sitapura, Jaipur, Rajasthan

Dr. DEVESH KUMAR
Poornima University Sitapura, Jaipur, Rajasthan

Dr. JAYANT PUROHIT
Poornima University, Sitapura, Jaipur, Rajasthan

Dr. PRASHANT MAHESHWARY
J. D. College of Engineering & Management Nagpur, Maharashtra

Abstract:
The current agricultural practices require a sustainable, economic and environmental approach, but yields are poor for many agricultural commodities. The irrigation infrastructure is still weak and there is still a lack of high quality and advanced agricultural mechanization. In general, the framework does not contribute to an appropriate forum and regulation for agriculture. One of the major problems in cotton was discovered in the Vidarbha area of Maharashtra state, where traditional fertilization methods result in fertilizer waste in various forms and require a great deal of human effort. A novel Multilayered Fertilization Technique is proposed, where fertilizer is placed at three deep and three points of soil during the plant growth phases of the nursery, vegetation, mid-season and late season. An experimental investigation has been conducted to research the conduct of a plant using multi-layer fertilization techniques.
Keywords: traditional fertilization, multilayer fertilization, cotton crop, absorption, agricultural mechanism.

1. INTRODUCTION

Since the Green Revolution, industrial agriculture has characterized many parts of the world by intensification of agricultural production and corresponding increases in farm size. The rapid technological advances in the breeding of conventional crops, genetically engineered crops, use of fertilizers and pesticides allowed for an increase in productivity. This transformation has led to considerable production and operating quality improvement at farm level. Among crop protection methods focused at pests, neonicotinoid (NST) and genetically modified plant products expressing insecticide characteristics have been embraced on the international stage, particularly in field crops.(i.e., maize, cotton, soybean).

Cotton is the universe's fifth largest fiber plant [1]. Cotton is a marketable cash crop that provides global fiber, oil and animal feed. The population is increasingly demanding food and fiber, but there are challenges to crop production due to climate change. Intensified crops are essential, but water supplies are limited to generate more foods, fiber, and

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feed. Cotton, although regarded to be a drought resistant crop, has a negative impact upon its productivity due to drought stress and nutrient scarceness, resulting in lower growth and functional, enzymatic and molecular developments [2].

The use of water nutrient at a proper cotton crop growth time will increase productivity and production of cotton. However, several water-nutrient management strategies may contribute to the creation of an unbalanced organism, such as competition of root and aerial plants, and thus growth of vegetative bodies surpasses the development of reproductive organs, which reduces water production and yield [3]. Moreover, greater accumulation of dry matter above the ground can drive cotton yield, in particular in reproductive organs [4].

Cotton roots are highly water or nutrient stress-sensitive while water-nutrient modes or rates may control the morphological characteristic of the root. Sufficient water or N application will enhance the water roots and the N area added to the soil, increasing water absorption and N absorption leading to higher photo-synthesis accumulation [5]. The vigor of the cotton root ensures water-N and root vigor absorption in the layers of the 40–120 cm of the soil. Water or N tension also influences physiological characteristics of the root (nitrate reductase, radical force and hormonal changes), which lead to reduced N absorption. It is necessary for increased leaf photosynthetic capacity to promote vertical root distribution [6-7].

Potassium (K), which presents an especially fundamental role in the fiber production, it is an essential nutrient for the growth and progress of cotton [8]. Deficiency of potassium leads to reduced quality of fiber and reduced yields. If K is confined during active fiber development, the fiber turgor pressure decreases and the cell elongation decreases and fibers become shorter at maturity [9]. Anything that limits root growth, such as disease, damage to insects, nematodes, root powdering, poor drainage, soil or compacta, decreases the absorption of nutrients and can cause K deficiency to increase. Potassium cotton demands can be met by applying K to the pre-planted soil and/or K sidedress applications in the mid-season [10].

Phosphorus (P) for the creation and development of cellular biomollecules such as adenosin triphosphate (ATP), nuclear acids, and proteins is an integral part in a variety of herbal metabalic processes [11]. This macronutrient has a considerable biological function but its low availability of cotton, maize, rice, soybeans and wheat in the soil (estimated at 0,1 percent) in 5,7 million acres of land worldwide is strongly limited. The macronutrient plays the crucial role for the early phase of the growth, manufacture of biomass and final yield of cotton cultivation, making it one of the most important and sensitively growing P fiber crops [12]. In particular, cotton plant deficiency is responsible for sluggish shooting and flower buds, dark green leaves, necrosis of floral buds, and the yellowing of senescent leaves [13].

The NPK application timing was hypothesized to affect cotton relays growth, return and economic benefits.

In an agricultural environment, IoT instruments provide valuable facts on a wide range

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of physical parameters to improve cultivation customs [14]. In modern wireless communications IoT is one of the most innovative technologies [15-16]. The fundamental principle is that a number of physical things or objects communicate to be linked to the internet using special address schemes. In various vertical markets, IoT technology can be used, including manufacturing, transport, healthcare, cars, intelligent homes and farming [17]

By incorporating many primary emerging technologies into a new and exciting age in agricultural and food production, so-called Agri-Food 4.0. The agricultural sector is changing. IoT, Smart Sensor Technology, Remote Sensing, UAV, Low Power Wide Area Networks (LPWAN) and Wireless Sensor Networks (WSN) are among the main components. In data collection, study, assessment and application technology, these smart farming modernizations could be classified [18-19].

In comparison with traditional farm machine use in the agricultural sector, automation in agricultural appliances and devices has raised agricultural production. During the agricultural production system various types of high-quality sensors have revolutionized the use of IoT technology and a massive link Internet. These automation techniques have reduced production costs and increased crop yields [20].

Considering the possible benefits and future efficiency of IoT in smart farming, proposed work suggested a model that promotes large-scale analytic and data processing, real-time data collection from cotton crops and a highly personalized on-line platform. It can analyze and forecast data streams for farmers to take efficient decisions about rapidly reactive environment changes and suddenly unpredictable events in the field. It integrates sensory data with web services to anticipate climate change to predict irrigation and fertilization viability of crops.

2. LITERATURE SURVEY

Mentsiev et al [21] In the field of efficient use of irrigation water, fertilizer, fungicide and disease prevention in several cultivars, different types of quality effective sensor have been installed. This technique has enhanced farm yields and reduced production costs. In agricultural farms, the use of IoT technology has helped the farmer to use mobile apps and high-speed Internet connections. These systems provide all information possible by comparing the data collected from the farm with standard charts which have already been stored in a data base for a farmer during crop management accurately.

Khan et al [22] Smart farming focused on semantic web ontologies using an IoT-based model that uses real-time stream processing, interpretation, and reasoning in the domain of cotton crops. It will provide real-time results, allowing the cultivator to make more informed decisions about upcoming events. Examining the rise of IoT in agriculture through smart agriculture, which involves the integration of high-speed networks and the combination of heterogeneous technologies, as well as semantic ontologies from various sources. The proposed model integrates open-data, semantic technologies, and linked data to achieve interoperability among sensors, processes, data sources, fields as

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entities, and web-based services.

Lin et al [23] the paper establishes the basis for a long-term and short-term IoT irrigation and fertilization scheme. The paradigm provides for the creation of an integer linear programming model for the allocation of limited resources between multiple crops to maximize economic profit and environmental benefits. The next goal is to solve the optimization model by a hybrid genetic algorithm. The results confirmed the possibility of sustainable irrigation and fertilization management in precision agriculture by providing economic and environmental advantage over Empirical models by the optimization model.

Panda et al [24] Organic farming has emerged as a viable choice for rural India that not only addresses quality and durability issues, but also provides a viable livelihood option. To overcome the problems faced by organic farmers and allow them to achieve social and economic development for sustainable agriculture, the government's initiative to assist informal farmers through various means to encourage sustainable farmers is needed. as well as serious warnings. In comparison to the NPK fertilizer therapy, the growth of yellow pimples by the healing of organic manure. Different forms of organic manure for animal products, soil properties, application requirements, nutritional requirements of the plant, and environmental and hygiene conditions around the premises must all be taken into account before applying organic fertilizers. The study found that organic fertilizers derived from livestock and sawdust products not only aided yellow poplar growth but also improved soil quality. As a result, in seedling development systems, organic manure should be seen as an alternative to chemical fertilizers.

Jing et al [25] The N-efficient cotton cultivars CRI 69 and ZZM 1017 have a high capacity to absorb nitrogen and pass it to reproductive organs. As a result, they produced more biomass and boll weight, both of which were favorable for the formation of production, especially at low N rates. As a result, it chooses N-efficient cultivars to increase the NUE and reduce the N input while still ensuring a yield. More significantly, breeding high NUtE and NUpE cultivars will lower production costs while also reducing environmental impact.

Aisham et al [26] Fertigation is a method that involves injecting soil amendments, fertilizers, and other water-soluble chemicals into an irrigation system to combine fertilization with irrigation. In Malaysia, the manual technique is used to mix the fertilizer solution and manually take the EC and pH of the solution readings. The goal of this project is to create a fertigation system that can combine many types of fertilizer and construct a system that can blend fertilizer concentration and pH value using an Arduino system and a PID. The use of an automated system can make it easier for farmers to create fertilizer solutions before applying them to their crops. Fertilizer mixing was also more precise and efficient. Using an Arduino Uno as a controller, this device can combine two types of fertilizer.

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Fereidoon et al [27] Agriculture is one of the environmental/economic sectors that might be negatively impacted by climate change, particularly in water-scarce countries such as the Middle East. SWAT-LINGO-MODSIM-PSO (SLMP) is a sophisticated coupled simulation-optimization method that was designed to determine the future optimal crop production area for maximizing of economic advantages in five irrigation-fed agricultural plains in southwest Iran. The Karkheh River Basin (KRB) is a large water reservoir in the south of the nation that supplies the majority of the country's water. On the basis of observed river stream flow along the Karkheh major river, the SWAT-hydrological model was constructed and calibrated/validated. The statistical metrics demonstrate that actual and modelled stream flows are in good agreement. Using observed time series of wheat crop yields as calibration targets and standard SWAT-crop parameters for other crops, the calibrated SWAT-model was then utilized to estimate yearly crop yields as a function of water availability. There are good correlations between simulated and observed crop yields.

Hussain et al [28] Cotton is a drought-tolerant crop, but it works best when water is plentiful. Many cotton-growing regions are running out of water for irrigation. There are a variety of irrigation scheduling methods available, with the basic goal of supplying water according to the needs of the plant. A few essential strategies for maintaining irrigation scheduling in cotton are the water balance approach, predicting crop water usage, and sensor-based scheduling. Cotton is a complex crop with byproducts that can be utilized for household or commercial purposes in addition to their healthy or individual applications. Cotton's major products include sticks, fibers, seed, and oil, all of which are beneficial to humans. The scientists believe that using this silver line thread might save lives in future climate change scenarios by preventing high temperatures, skin dryness, and respiratory illnesses.

3. MULTILAYERED FERTILIZATION TECHNIQUE

Maharashtra is the first state in India in terms of cotton cultivation area. Despite the fact, that cotton is grown across most of the country, India's cotton production is among the lowest in the world. This is attributable not only to the growing costs of crops, fertilizer, and labor but also to various wastes. Yields are deteriorating in quality, and soil fertility is declining as it becomes increasingly resistant to chemical fertilizers and pesticides. Other issues that farmers face include unequal and depleting water supplies, inadequate irrigation facilities, a lack of trendy technology in cultivation techniques, market price fluctuations, and a host of other issues that have resulted in an uncontrollable debt for farmers, leading to suicides. As a result, the problems are addressed using a novel multilayered fertilization method. In the early stages of cotton seed sowing, fertilizers will be added at different levels of the soil. Fertilizer may be required at the nursery, vegetative, mid-season, and late-season periods of plant development by using multi-depth fertilization. By distributing fertilizer through several layers of soil, the crop would be able to absorb nutrients more quickly and expand to maximum potential. The fertilizer is placed in 3 depths and 3 points during nursery, vegetational, mid-season and latter

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season of plant development, as needed, with multi-faceted fertilization technique. Putting the fertilizer in the soil would help the plant absorb nutrients in the early stages and reduce their waste in full growth.

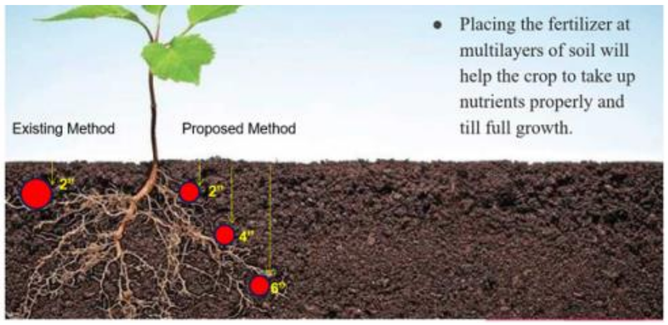

Figure 1:sample image of proposed technique

Step 1: Pots (planters)

Two pots with 15-inch-deep,15-inch-diameter-opening-diameter is considered. In one pot, traditional fertilization is used, and in the other, multilayered fertilization is used at three separate depths of 2 inches, 4 inches, and 6 inches.

Figure 2: Pots filled with Black Sandy Loamy Soil

Figure 2 shows the pots filled with black sandy loamy soil used for the experiments. Here pot 1 is used for traditional method and pot 2 is used for proposed method

Step 2: Soil Sampling and Test

Soil must be chosen for experimentation and contrast with conventional service. The Waddhamna Village, TahasilHingna, Nagpur Region, Farmland area has therefore been selected. The soil condition must be known and hence, its sample must be checked in the District Soil Survey Laboratory, Nagpur, for both quality and quantity of the pots. Items to remember are as follows:

Here, black loamy soil is selected for the soil test .Black loam soil is a fertile soil made

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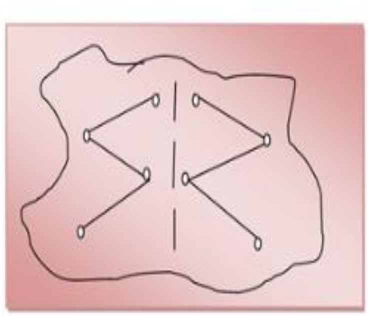
up of sand, clay, and organic matter that has decayed. Loam soils are richer in minerals and humus than sandy soils, have greater irrigation and drainage than silty soils, and are less difficult to till than clay soils. Loams are dusty, sticky, and readily absorb water. Since several soil clumps, gravel, roots, and excess debris have been collected, this substance is simple to deal with. This screened substance can be used for a number of purposes depending on the natural intrinsic soil properties of the topsoil. Black loam can be used for a lot of things, from filling in low spots to topping off the lawn.

- Soil samples to be taken after plant harvest and at least 3 months after application of fertilizer. Sandy Loamy Black Soil is soil type.

Figure 3: Actual picture of the site for soil sampling

Figure 3 shows the agricultural area for research. The whole field area is 90 m2. The entire surface is divided into two halves and as shown in figure 4 the points are labelled in zigzag.



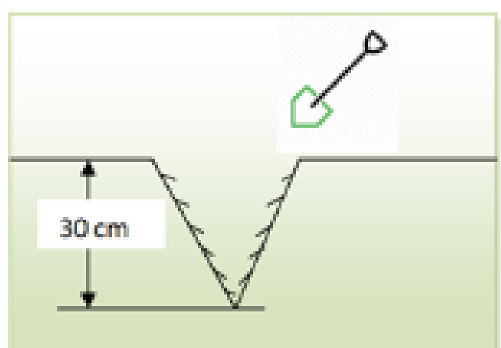


Figure 4: Farm area division **Figure 5: V-shaped pit for sampling**

The V-shaped pit is shown in Figure 5 at the marked ground points. It retains a depth of 30 cm and fully removes the floor within the trap. The soil for testing is

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collected in a sampling bag from the inner boundary of the pit. For all the land-marked points, the procedure is repeated.

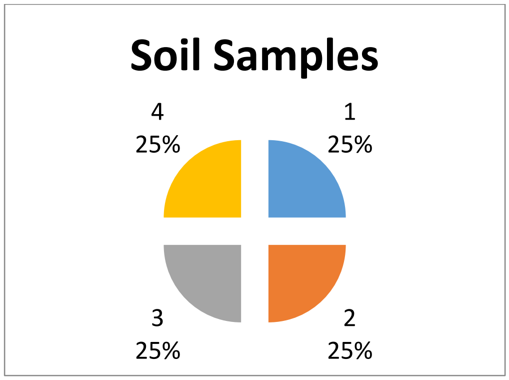

Figure 6: Soil Distribution

The soil sample collected is then collected in one position and then divided into 4 parts, as shown in figure 6. Then two pieces were discarded and two remaining pieces were combined thoroughly.

TABLE 1

SOIL TESTING RESULT

Sr. No.	Property	Reading from Control Land	Recommended	Remark
1	pH (pH value)	8.6	6.5-7.5	High Alkaline
2	EC (mS/cm)	0.04	0-1	Normal
3	Organic Carbon (%)	0.33	0.4-0.6	Low
4	Phosphorous (kg/ha)	8.77	14-21	Low
5	Potassium (kg/ha)	253.48	150-200	High

From Table 1 Soil has a high alkaline pH value of 8.6. The conductivity is natural at 0.04 ms/cm. The percentage of organic carbon is 0.33 lower than recommended. Phosphorus is 8.77 kg/ha which is also below the recommended level. The value of potassium exceeds the recommended value.

Step 3: Cotton Seed and Fertilizer Selection

Bollgard II BT Cotton seed were selected for the experimentation and sowed in both the pots. Di Ammonium Phosphate and Urea mixed fertilizer were used.

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3.1.1 Bollgard II BT Cotton seed

Bollgard insect-protected cotton was introduced commercially in the United States in 1996 and has since been widely embraced by farmers due to its effectiveness in preventing lepidopteran insect pests such as tobacco budworms, pink bollworms, and cotton bollworms from feeding on and damaging the crop.

Figure 7a: shows image of Cotton Seed Ammonium Phosphate

Figure 7b: shows image of Di

Figure 7c: shows image of Urea

Figure 7 shows the images of cotton seed, Di Ammonium Phosphate and Urea used in the experiment.

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Step 4: IoT Devices used in the proposed method

a) DS18B20 Temperature Sensor

The DS18B20 is a maximally integrated 1-wire programmable temperature sensor. It is also used in rough conditions like chemical solutions, mines or soil etc. for temperature measurement. The sensor constriction is robust and can be bought with a waterproof option that facilitates the installation. With good precision of ±5°C, it can calculate large temperatures between -55 °C and +125 °C. Circuit diagram of DS18B20 temperature sensor is shown in figure 8. Every sensor has a unique address and only needs a pin of the MCU to pass data, so it can be a very good option for temperature measurement at several points without compromises on many of the microcontroller digital pins.

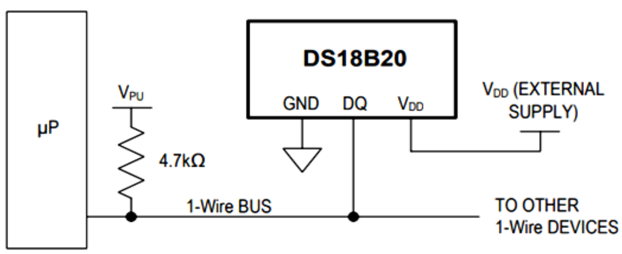

Figure 8: Circuit Diagram of DS18B20 Temperature Sensor

The sensor uses the 1-Wire communication system. Only a data pin with a pull up resistor is required and the other 2 pins for power as shown in figure 9. It is a function of the data pin. The pull-up resistor is used when the bus is not in operation to hold the line in high order. The sensor-measured temperature value is stored within the sensor in a two-byte register. These data can be read by sending a sequence of data using the 1-wire process. In order to read the values there are two types of commands, one being a ROM and one being a function command. In the following data sheet, you can enter the value of each ROM memory along with the series.

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Figure 9: DS18B20 Temperature Sensor

Application of DS18B20 Temperature Sensor

- The heat energy or even the coldness produced by an object or device are measured by Temperature sensors
- The sensor measures the quantity of heat energy or even cold that an object or device generates
- Range: -55 to 125°C (-67°F to +257°F) Utile temperatures Resolution from 9 to 12 bit. Only one digital pin is required for communication using 1-Wire interface-

a) Soil Humidity Sensor or DF Robot Moisture Sensor

The amount of humidity in the soil surrounding can be read by the soil moisture sensor. It is an excellent place to track a city garden or the water level of plant. It must have component for an IOT garden / agriculture.

Immersion Gold is used to shield the nickel from oxidation by the modern Soil Moisture Sensor. Electroless Nickel immersion gold (ENIG) has a number of benefits compared to more conventional (and cheaper) surface platelets such as HASL (solder), including excellent surface planarity, good resistance to oxidation, and usability for untreatable contact surfs such as membrane switches and contact points.

The two probes in this soil moisture arduino sensor pass current through the soil, and the resistance is then read to determine the moisture level. More water allows the soil to conduct electricity more efficiently (with less resistance), whereas dry soil does not (more resistance). This sensor can be used to remind to water indoor plants or to keep track of the moisture in the garden soil.

A Gravity Interface has been adapted to allow plug & play to make using this sensor easier. The Arduino IO expansion shield is ideal for connecting this sound sensor to Arduino. Since this sensor runs on 3.3V, it's compatible with Raspberry Pi, Intel Edison, and Joule and curie.

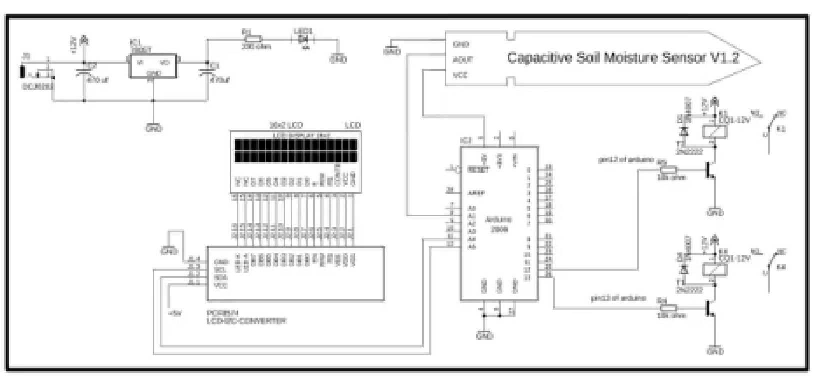

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Figure 10: Circuit Diagram for Soil Humidity Sensor

From figure 10, The LCD pins are wired to all 16 pins of the PCF8574 driver module. You can transform any 162 LCD into an i2c enabled LCD using these connections. The VCC pin is connected to the Arduino's 5 volts, the SDA pin is connected to Analog pin A4 on the Arduino, the SCL pin is connected to Analog pin A5 on the Arduino, and the GND pin is connected to the Arduino's field. It can monitor the 162 LCD with just two pins A4 and A5.The controlled power supply based on the LM7805 voltage regulator is shown in the top left corner. This controlled power supply is optional, but it is recommended. If it is planned to add more electronic components later, then use this power supply to power those components, keeping the Arduino board from being overloaded.

A two-channel relay module can be seen on the right side. The Water pump is controlled by a relay connected to the Arduino's pin number 12, while the Buzzer is controlled by a relay connected to the Arduino's pin number 13.

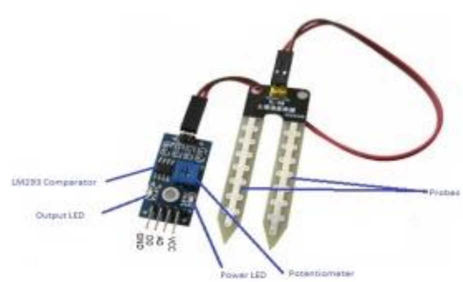

Figure 11: Soil Humidity Sensor

Application of Soil Humidity Sensor

- Soil moisture sensors determine the amount of water in the root region.
- Soil moisture sensors track crop growth, rainfall, and environmental testing, among other things.
- Soil moisture sensors track crop growth, rainfall, and environmental testing, among other things. Voltage range: 3.3 to 5.5 VDC
- Voltage range: 1.2 to 2.5V
- PH2.0-3P PH2 0-3P.

a) DF Robot PH Sensor

DFRobot analog pH meter with a simple and functional "Gravity" connector and a slew of features, developed specifically for Arduino controllers. Instantaneous attachment to Arduino probe for pH measurements at 0.1pH (25 °C). This great accuracy range and

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low cost make this a great tool for biorobotics and other projects for most hobbyists! It includes a Power Indicator LED, a BNC connector, and a PH2.0 sensor interface. To use it, simply add the pH sensor to the BND connector and insert the PH2.0 interface into any Arduino controller's analog input port. You can easily obtain the pH value if the device is pre-programmed.

This product significantly enhances the accuracy and user interface as an improved version of pH meter V1. The onboard voltage regulator chip can handle a large voltage range of 3.3 to 5.5V, making it compatible with both 5V and 3.3V main control boards. The hardware-filtered output signal has a low jitter. The software library uses a two-point calibration system, which allows it to automatically distinguish two standard buffer solutions (4.0 and 7.0), making it extremely easy and convenient.

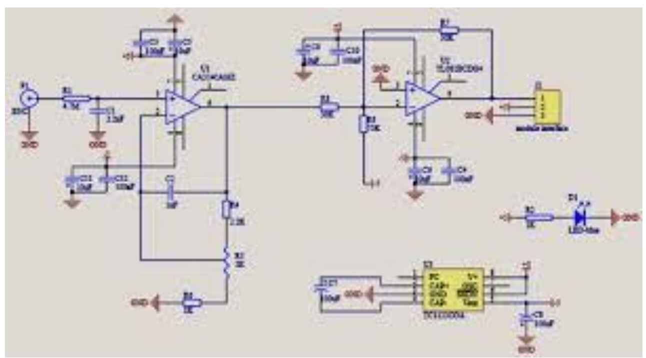

Figure 12: Circuit Diagram for DF Robot PH meter

The analog pH-meter module circuit is shown in Figure 12. The output voltage was calculated by multiplying the input voltage by the sensor state. The Arduino Uno microcontroller was also used to process the pH module's induced voltage. The pH sensor output signal of 0.059 V/pH entering the Zelio was signal-conditioned by the microcontroller. There was a coding command that translated the pH value to voltage and allowed the Zelio to read it.

Figure 13: DF Robot PH Sensor

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Application of DF Robot PH Sensor

- The pH of soil will affect how well crops grow.
- Determining the pH of rainwater and irrigation water.
- foliar and hydroponic fertilizer measurements
- DF Robot analog pH meter, which is designed specifically for Arduino controllers and includes a simple and functional "Gravity" connector as well as a slew of other features. The pH of soil will affect how well the crops grow.
- Determining the pH of rainwater and irrigation water

a) NPK Sensor RS485

The soil nitrogen, phosphorus, and potassium three-in-one fertility sensor can be used to detect the content of nitrogen, phosphorus, and potassium in the soil, as well as to determine the fertility of the soil by sensing the content of nitrogen, phosphorus, and potassium in the soil, allowing for a more comprehensive assessment of the soil condition. Long-term electrolysis resistance, corrosion resistance, vacuum potting, and complete waterproofness are all features of this material.

In soil nitrogen, phosphorus, and potassium detection, precision agriculture, forestry, soil science, geological exploration, plant cultivation, and other areas, the sensor is widely used.

This Soil NPK Sensor comes with high-quality stainless steel probes that are totally rust-proof, electrolytic-resistant, salt-resistant, and alkali-resistant. As a result, this Soil NPK Sensor is appropriate for any kind of soil. Its ability to detect alkaline soil, acid soil, substrate soil, seedling bed soil, and coconut bran soil is another function I like. Furthermore, this Soil NPK Sensor is waterproof and dustproof to ensure that components continue to function normally for a long time.

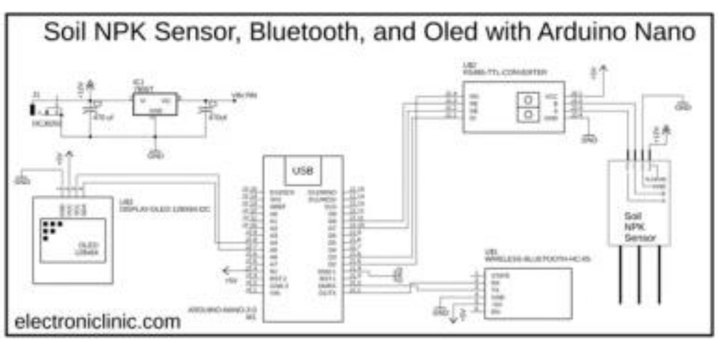

Figure 14: Circuit Diagram of NPK Sensor RS485

From figure 14, A 12V power supply for the Soil NPK Sensor because it supports a wide range of input voltages. Can power the NPK sensor and the Arduino board with a single 12V power supply this way. The NPK sensor's Black and Blue wires are attached to the

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RS485 TTL converter's B and A pins. The VCC and GND pins are attached to the Arduino's 5V and GND pins, respectively. The Arduino's D2 and D3 pins are wired to the RO and DI pins. The D8 and D7 pins are used to link the RE and DE pins, respectively. The RX and TX pins of the HC-05 Bluetooth module are linked to the Arduino's TX and RX pins, and the Power supply pins are connected to the Arduino's 5 volt and Gnd.

The SDA and SCL pins of the SSD1306 I2C enabled OLED display module are connected to the A4 and A5 pins of the Arduino Nano board, while the VCC and GND pins are connected to the 5v and GND pins of the Arduino Nano board.

Figure 15: NPK Sensor RS485

Application of NPK Sensor RS485

- It is used to quantify and detect the presence of nitrogen (N), phosphorus (P), and potassium (K) in soil, as well as to apply extra amounts of these nutrients to improve soil fertility.
- Measurement Accuracy: +-2 percent Fs • Measurement Range: 0-1999 mg/kg
- 1 mg/kg (mg/l) resolution
- Working temperature: 5-450 degrees Celsius

a) ESP32 Wi-Fi Module

ESP32 is a single 2.4 GHz Wi-Fi and Bluetooth combo chip manufactured in TSMC's ultra-low-power 40 nm process. It's designed to provide the best power and RF output in a wide range of applications and power scenarios, demonstrating robustness, flexibility, and reliability. Generic Low-power IoT Sensor Hubs, Generic Low-power IoT Data Loggers, and Mesh Network are examples of applications.

It's made for smartphone and wearable electronics, as well as Internet of Things (IoT) applications. It has many of the cutting-edge low-power chip features, such as fine-grained clock gating, multiple power modes, and dynamic power scaling. The power amplifier's performance can also be adjusted, allowing for the best possible trade-off between communication range, data rate, and power consumption.

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Figure 16: ESP32 Wi-Fi Module

Application of ESP32 Wi-Fi Module

• It's a system-on-a-chip microcontroller with built-in Wi-Fi and dual-mode Bluetooth.

• CPU: Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, running at 160 or 240 MHz and capable of 600 DMIPS output. Coprocessor with ultra-low power consumption (ULP).

Other Supporting Devices: Connecting wires, Zero PCB, AC Supply wire, Adapter, Enclosure, Push Buttons, etc

4. RESULT AND DISCUSSION

This section includes a concise summary of the proposed work's implementation results, performance analysis, and comparative strategies.

4.1. Experimental setup

The following framework specification was used to implement this work in Ubuntu in the python 3.7 working platform, and the simulation results are discussed below.

Platform	: Python 3.7
OS	: Ubuntu
Processor	: Intel Core i5
RAM	: 8GB RAM
User Interference	: LabView

Both pots are filled with 100 gm cow dung manure and Black Sandy Loamy Soil from Wadhammna Village in Nagpur. At the same time, cotton seed is sown. DS18B20 temperature sensor, DF Robot moisture sensor SEN0193, and RS 485 NPK sensor inserted 2 inches away from the seed at the recommended depth. The pH value of both pots was almost the same, so the DF Robot pH Sensor SEN0161 was used to calculate it. A 12 V, 500 mA power supply is provided. With WiFi ESP 32, all IoT devices are linked to the microcontroller. LabVIEW software is used to interface with hardware configuration and data measurement for user interaction.

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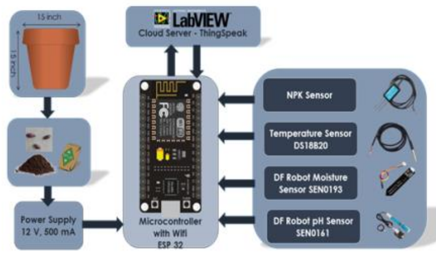

Figure 17: Experimental Setup

Figure 17 shows the experimental setup of LabView software. Lab VIEW provides a graphical programming approach that allows users to simulate and track humidity, temperature, and NPK from the soil at any time using the Things Speak mobile application.

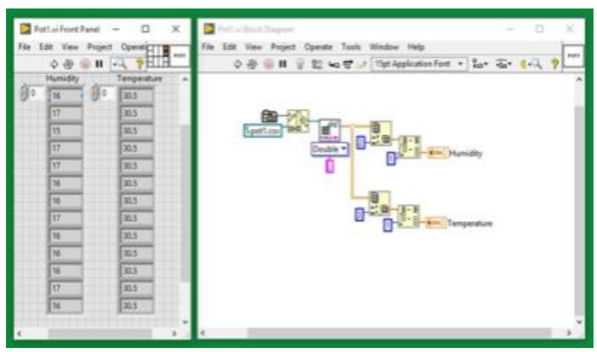

Figure 18: Example of LabVIEW Graphical Programming used for fetching data of Moisture (humidity) and Temperature for POT 1.

Figure 18 shows the Example of LabVIEW Graphical Programming used for fetching data of Moisture (humidity) and Temperature for POT 1.

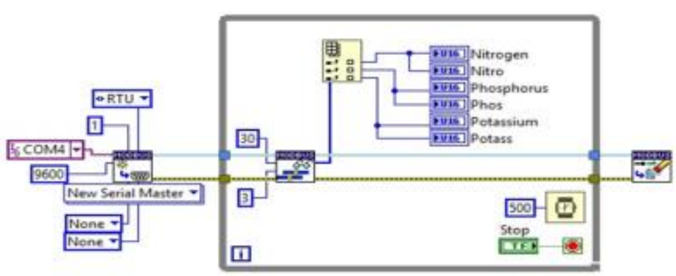

Figure 19: Modbus in LabVIEW

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Figure 19 shows the Modbus in LabVIEW.Modbus is a system that measures temperature and humidity and communicates the results to a computer.

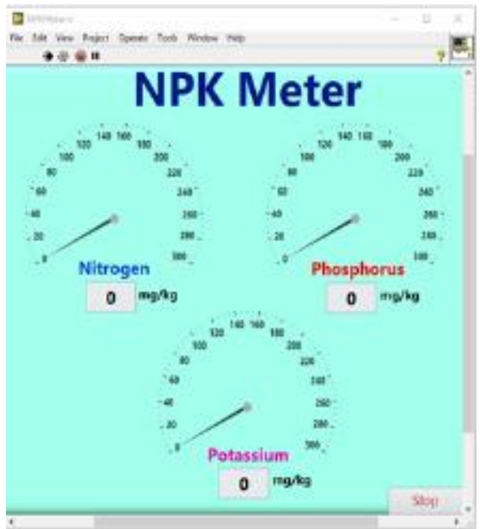

Figure 20: Example of LabVIEW Graphical Programming used for fetching data of NPK for POT 1.

Figure 20 shows the Example of LabVIEW Graphical Programming used for fetching data of NPK for POT 1.

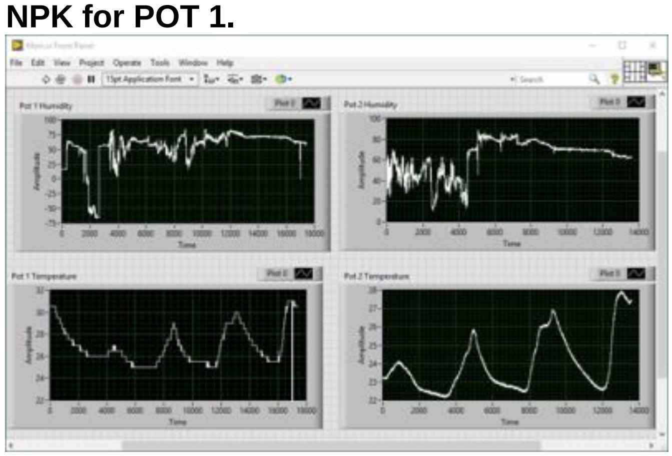

Figure 21: Live data as seen on Front Panel of LabVIEW software.

Figure 21 shows the Live data as seen on Front Panel of LabVIEW software. Thing Speak is a cloud-based IoT analytics application that enables users to aggregate, visualize, and analyze live data streams. Sensors can submit data to ThingSpeak from computers, allowing for real-time visualization of data.

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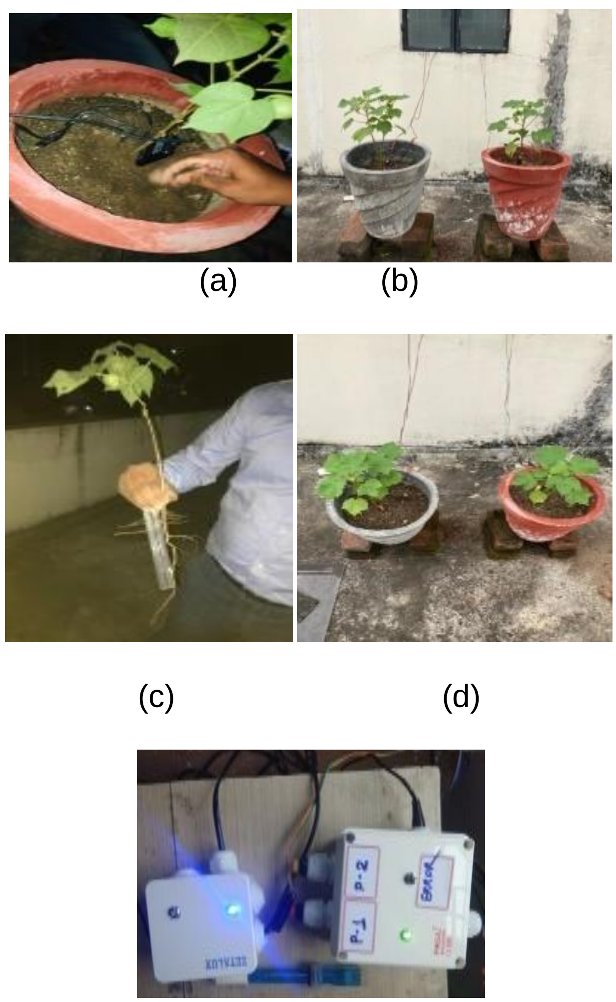
Figure 22: Thing Speak Live Data Monitoring through Server.



(a) (b)

(c) (d)

(e)

Figure 23: Actual Experimentation pictures using IoT devices for Cotton plants.

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Figure 23 shows the Actual Experimentation pictures using IoT devices for Cotton plants. Temperature, moisture, N, P, and K data were collected every hour from October 21st to November 24th, 2020. After that, the data was analyzed using Python Language tools. Import data sets, Clean and prepare data for analysis, Manipulate pandas Data Frame, and Summarize data with Stats models, a Python module that allows users to explore data, estimate statistical models, and perform statistical tests.

4.2 Statistical Analysis using Python

- In this review, the Central Limit Theorem is used for statistical analysis. The sampling distribution is said to be normally distributed.
- Z – The central limit theorem is used to measure the score. The z-score is a statistical transformation that expresses how much a given value deviates from the mean of a normal distribution in terms of standard deviations; z-scores are especially useful when comparing observations from different populations and distributions with different means, standard deviations, or both.
- For hypothesis validation, the P value is used, which is characterized as the likelihood of an alternative or more extreme outcome if the null hypothesis is true.

Scenario 1: Before Addition of Fertilizers
Observation Date: 21/10/2020 to 1/11/2020

Hypothesis Formulation:
Three Soil parameters are measured as a part of this experiment, namely,

- Nitrogen content of soil
- Phosphorous content of soil
- Potassium content of soil

Null hypothesis: Before the addition of fertilizers, the average content of N, P, and K in both populations is the same.
Alternative hypothesis: Before the addition of fertilizers, the average content of N, P, and K in both populations is different.

TABLE 2
STATISTICAL MEAN AND STANDARD DEVIATION DATA FOR POT 1 FROM 21ST OCT’2020 TO 1STNOV’2020 (BEFORE FERTILIZATION)

POT 1 Data Before Fertilization:

	Date	**Moisture**	**Temperature**	**N1**	**P1**	**K1**
count	282	282	282	282	282	282
unique	282	NaN	NaN	NaN	NaN	NaN

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top	2020-11-01 07:01:38	NaN	NaN	NaN	NaN	NaN
freq	1	NaN	NaN	NaN	NaN	NaN
mean	NaN	**79.489362**	**24.18794**	**11.16667**	**10.24114**	**27.62411**
std	NaN	**8.616889**	**20.54286**	**14.90052**	**13.67019**	**36.70117**
min	NaN	68	-127	0	0	0
25%	NaN	72	24.625	0	0	0
50%	NaN	75	27	0	0	0
75%	NaN	85	29	21	19.75	52.75
max	NaN	109	33	48	44	117

TABLE 3
STATISTICAL MEAN AND STANDARD DEVIATION DATA FOR POT 2 FROM 21ST OCT’2020 TO 1STNOV’2020 (BEFORE FERTILIZATION)

POT 2 Data Before Fertilization:						
	Date	**Moisture**	**Temperature**	**N2**	**P2**	**K2**
count	215	215	215	215	215	215
unique	215	NaN	NaN	NaN	NaN	NaN
top	2020-10-23 00:44:09	NaN	NaN	NaN	NaN	NaN
freq	1	NaN	NaN	NaN	NaN	NaN
mean	NaN	**36.9813**	**23.176**	**12.376**	**11.330**	**30.939**
std	NaN	**17.5179**	**10.695**	**10.154**	**9.2926**	**24.839**
min	NaN	13	-127	0	0	0
25%	NaN	23	21.7187	6	6	16
50%	NaN	34	23.812	10	9	24
75%	NaN	57	26	13	12	33
max	NaN	72	30.125	46	42	112

Hypothesis Testing for “N”: (before fertilization)
Null Hypothesis
Ho: µN1 = µN2
Alternate Hypothesis
Ha: µN1 ≠ µ

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TABLE 4
Z SCORE CALCULATION FOR N

Z Score Calculation		
	N1	N2
Mean (X)	11.16667	12.37674
Standard Deviation (S)	20.54286	10.15453
n	282	215

$$Z = \frac{(X_1 - X_2) - (\mu_{P1} - \mu_{P2})}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

$$Z = 0.81$$

$$P = 0.209 \quad or \quad 20.9\%$$

From table 4 As the value of P is 0.209 or 20.9 % and at a 5% significance level, cannot reject the null hypothesis and thus null hypothesis is accepted, i.e,

$Ho: \mu N1 = \mu N2$

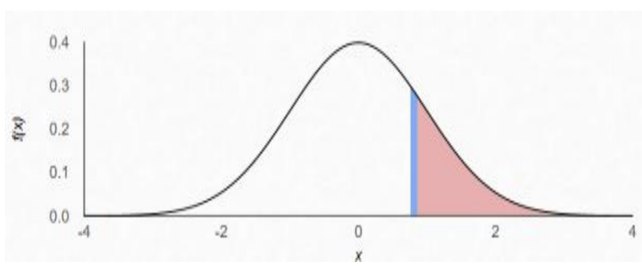

Figure 24: Standard Normal Distribution Curve with Z-value for N

Figure 24 shows the Standard Normal Distribution Curve with Z-value for N.

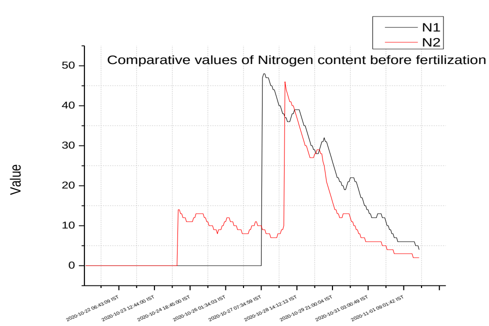

Figure 25: Comparative values of 'N' for Pot 1 and Pot 2 before fertilization

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Figure 25 shows how variation of N goes on reducing throughout the span when the NPK sensor is put on particular place under the soil in both the plants.

Hypothesis Testing for P: (before fertilization)

Null Hypothesis

Ho: µP1 = µP2

Alternate Hypothesis

Ha: µP1 ≠ µP2

TABLE 5
Z SCORE CALCULATION FOR 'P'

Z Score Calculation for P:		
	P1	P2
Mean (X)	10.24114	11.33023
Standard Deviation (S)	13.6709	9.292634
n	282	215

$$Z = \frac{(X_1 - X_2) - (\mu_{P1} - \mu_{P2})}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

$$Z = 1.027$$

$$P = 0.1538 \quad or \quad 15.38\%$$

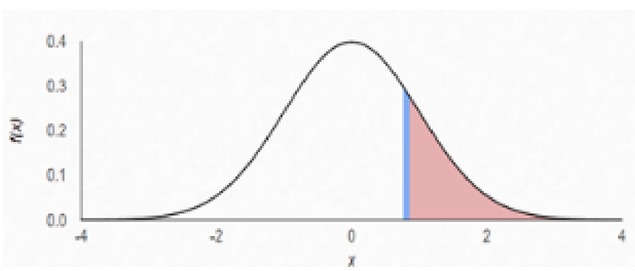

Figure 26: Standard Normal Distribution Curve with Z-value for P

From table 5 and figure 26 As the value of P is 0.1538 or 15.38 % and at a 5% significance level, could not reject the null hypothesis and thus null hypothesis is accepted, i.e,

Ho : µP1 = µP2

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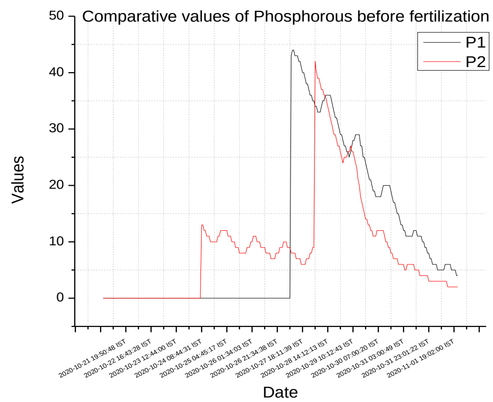

Figure 27: Comparative values of ‘P’ for Pot 1 and Pot 2 before fertilization

Figure 27 shows how variation of P goes on reducing throughout the span when the NPK sensor is put on particular place under the soil in both the plants.

Hypothesis Testing for K: (before fertilization)

Null Hypothesis

Ho: µK1 = µK2

Alternate Hypothesis

Ha: µK1 ≠ µK2

TABLE 6

Z SCORE CALCULATION FOR ‘K’ (BEFORE FERTILIZATION)

Z Score Calculation for K		
	K1	K2
Mean (X)	27.62411	30.93954
Standard Deviation (S)	36.70117	24.83913
n	282	215

$$Z = \frac{(X_1 - X_2) - (\mu_{P1} - \mu_{P2})}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

$$Z = 1.12$$

$$P = 0.131 \quad or \quad 13.1\%$$

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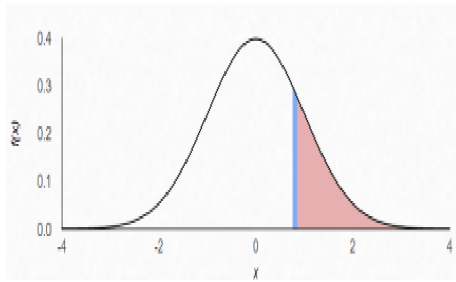

Figure 28: Standard Normal Distribution Curve with Z-value for K

From table 6 and figure 28 As the value of P is 0.1301 or 13.01 % and at a 5% significance level, cannot reject the null hypothesis and thus null hypothesis is accepted, i.e,

$$Ho : \mu P1 = \mu P2$$

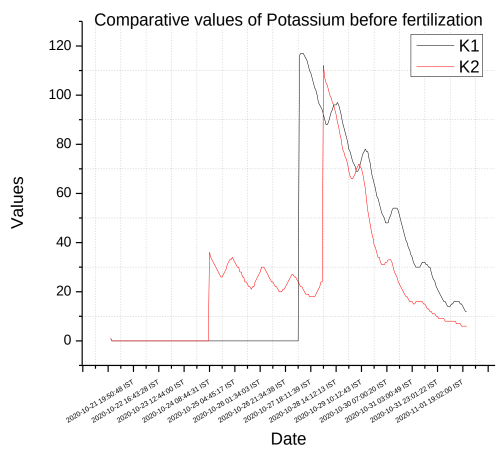

Figure 29: Comparative values of 'K' for Pot 1 and Pot 2 before fertilization

Figure 29 shows how variation of K goes on reducing throughout the span when the NPK sensor is put on particular place under the soil in both the plants.

Scenario 2: After Fertilization
Observation Date: 2nd Nov'2020 to 24th Nov'2020

In Pot 1, 30 gram of fertilizer was applied to the soil using the conventional method of digging a 2 inches deep pit and keeping it 2 inches away from the plant. Fertilization in Pot 2 is accomplished by digging three pits 2 inches away from the plant, each with a depth of 2 inches, 4 inches, and 6 inches and a weight of 10 grams each.

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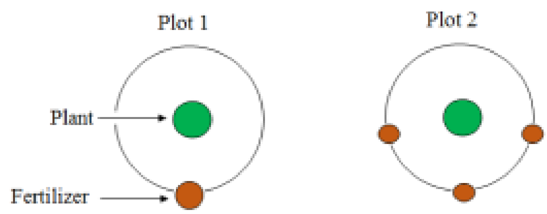

Figure 30: Pot 1 showing fertilizer performed at one place only while Pot 2 shows fertilization performed at different places

Figure 31: Existing Method applied to Pot1 and Proposed Method also called as Multilayered Fertilization technique applied to Pot2 under various depth as shown.

Hypothesis Formulation:

Three Soil parameters are measured as a part of this experiment, namely,

Nitrogen, Phosphorous & Potassium content of soil

Null hypothesis – Average content of N, P, K after the addition of fertilizers is same in both the populations

Alternate Hypothesis – Average content of N, P, K after the addition of fertilizers is different in both the populations.

One step further to suggest that the average contents of 1st type population would be more as compared to the 2nd type

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TABLE 7

STATISTICAL MEAN AND STANDARD DEVIATION DATA FOR POT 1 FROM 2 NOV'2020 TO 24 NOV'2020 (AFTER FERTILIZATION)

Pot 1 After Fertilizer:

	Date	**Moisture**	**Temperature**	**N1**	**P1**	**K1**
count	534	534	534	534	534	534
unique	534	NaN	NaN	NaN	NaN	NaN
top	2020-11-08 09:45:47 IST	NaN	NaN	NaN	NaN	NaN
freq	1	NaN	NaN	NaN	NaN	NaN
mean	NaN	**81.153558**	**19.51405**	**17.91011**	**16.40075**	**44.51498**
std	NaN	**6.195897**	**23.41027**	**11.48338**	**10.52579**	**28.06109**
min	NaN	72	-127	3	3	8
25%	NaN	77	20.5	8	7	20
50%	NaN	80	23.5	15.5	14	38.5
75%	NaN	83	25.5	27	24	66
max	NaN	103	31	48	44	119

TABLE 8

STATISTICAL MEAN AND STANDARD DEVIATION DATA FOR POT 2 FROM 2 NOV'2020 TO 24 NOV'2020 (AFTER FERTILIZATION)

Pot 2 After Fertilizer:

	Date	**Moisture**	**Temperature**	**N2**	**P2**	**K2**
count	531	531	531	531	531	531
unique	531	NaN	NaN	NaN	NaN	NaN
top	2020-11-21 23:06:25 IST	NaN	NaN	NaN	NaN	NaN
freq	1	NaN	NaN	NaN	NaN	NaN
mean	NaN	**44.27307**	**20.42961**	**12.45763**	**11.4275**	**31.21469**
std	NaN	**16.395202**	**3.421406**	**13.3699**	**12.24406**	**32.64288**
min	NaN	11	13.3125	1	1	2
25%	NaN	32	17.90625	2	1	4
50%	NaN	45	20.625	5	4	13
75%	NaN	57	22.875	24	22	59.5
max	NaN	75	28.6875	45	41	110

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Hypothesis Testing for N: (After fertilization)
Null Hypothesis
Ho: µN1 = µN2
Alternate Hypothesis
Ha: µN1> µN2

TABLE 9
Z SCORE CALCULATION FOR 'N' (AFTER FERTILIZATION)

Z Score Calculation for N:		
	N1	N2
Mean (X)	17.91011	12.45763
Standard Deviation (S)	11.48338	13.3699
n	534	531

$$Z = \frac{(X_1 - X_2) - (\mu_{P1} - \mu_{P2})}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

$$Z = 7.05$$

$$P = 0.000023$$

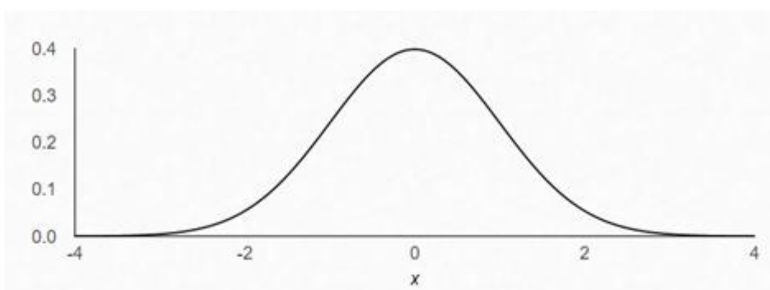

Figure 32: Standard Normal Distribution Curve with Z-value for N after fertilization

From table 9 and figure 32 As the value of P is 0.000023 and at a 5% significance level, have enough evidence to reject the null hypothesis and accept the alternative hypothesis,

Ho : µN1 > µN2

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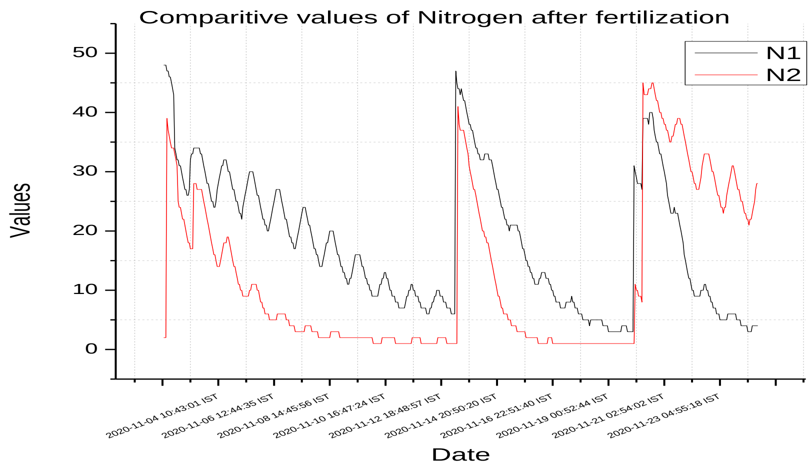

Figure 33: Comparative values of ‘N’ for Pot 1 and Pot 2 after fertilization

Figure 33 shows graphical comparison between the N values in Pot 1 and Pot 2. The graph shows declining behavior in the values of N for some period of interval. It also shows significance difference in rate of consumption of fertilizer in Pot 2.

Hypothesis Testing for P: (after fertilization)
Null Hypothesis
Ho: µP1 = µP2
Alternate Hypothesis
Ha: µP1> µP2

TABLE 10
Z SCORE CALCULATION FOR ‘P’ (AFTER FERTILIZATION)

Z Score Calculation for P:		
	P1	P2
Mean (X)	16.40075	11.4275
Standard Deviation (S)	10.52579	12.24406
n	534	531

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$$Z = \frac{(X_1 - X_2) - (\mu_{P1} - \mu_{P2})}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

$$Z = 7.11$$

$$P = 0.00001$$

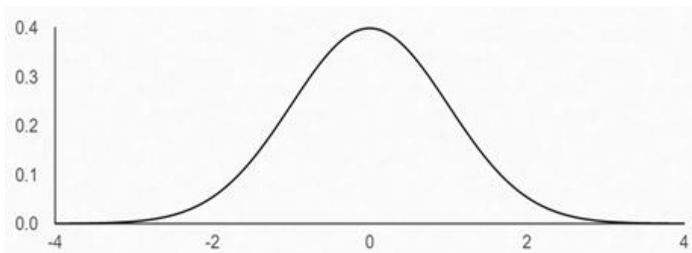

Figure 34: Standard Normal Distribution Curve with Z-value for P after fertilization

From table 10 and figure 34 As the value of P is 0.00001 and at a 5% significance level there is not substantial evidence to accept the null hypothesis, thus it will reject the null hypothesis is favor of alternate hypothesis.

$\text{Ho} : \mu P1 = \mu P2$

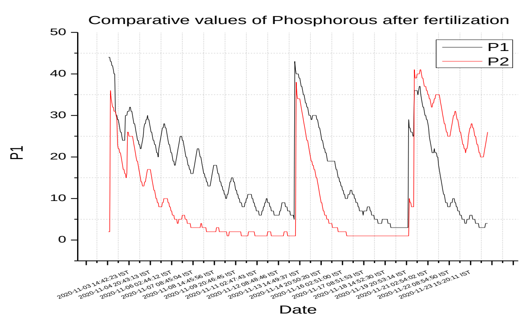

Figure 35: Comparative values of ‘P’ for Pot 1 and Pot 2 after fertilization.

Figure 35 shows graphical comparison between the P values in Pot 1 and Pot 2. The graph shows declining behavior in the values of P for some period of interval. It also shows significance difference in rate of consumption of fertilizer in Pot 2

Hypothesis Testing for K: (After fertilization)

Null Hypothesis

Ho: µK1 = µK2

Alternate Hypothesis

Ha: µK1> µK2

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TABLE 11
Z SCORE CALCULATION FOR 'K' (AFTER FERTILIZATION)

Z Score Calculation		
	K1	K2
Mean (X)	44.51498	31.21469
Standard Deviation (S)	28.06109	32.64288
n	534	531

$$Z = \frac{(X_1 - X_2) - (\mu_{P1} - \mu_{P2})}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

$Z = 7.12$

$P = 0.00001$

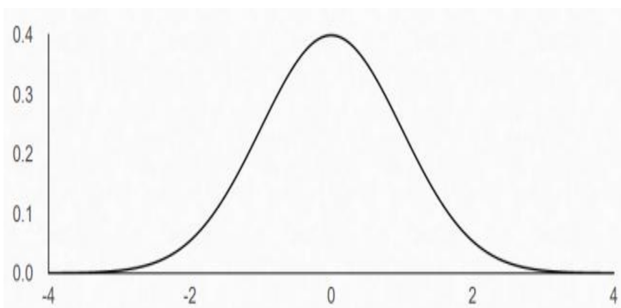

Figure 36: Standard Normal Distribution Curve with Z-value for K after fertilization

From table 11 and figure 36 As the value of K is 0.00001 and at a 5% significance level there isn't substantial evidence to accept the null hypothesis, thus it will reject the null hypothesis is favor of alternate hypothesis.

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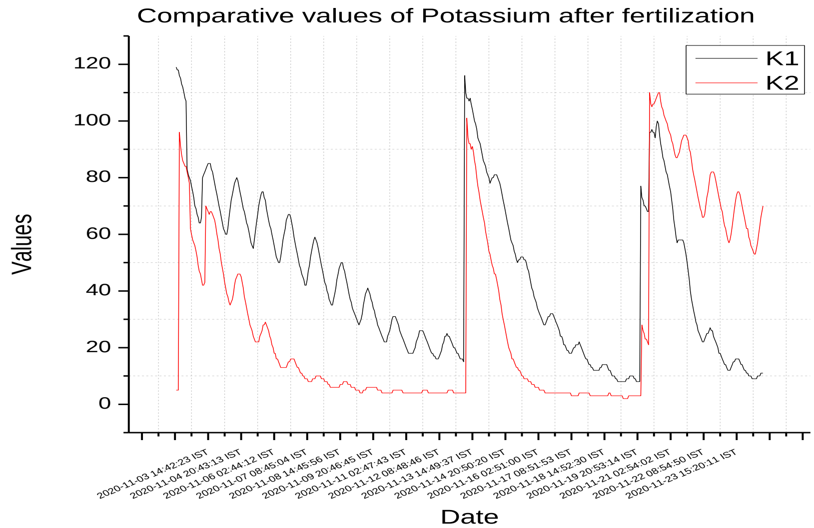

Figure 37: Comparative values of ‘K’ for Pot 1 and Pot 2 after fertilization.

Figure 37 shows graphical comparison between the K values in Pot 1 and Pot 2. The graph shows declining behavior in the values of K for some period of interval. It also shows significance difference in rate of consumption of fertilizer in Pot 2.

5. CONCLUSION

At the nursery, vegetative, mid-season, and late-season stages of plant development, a novel Multilayered Fertilization Technique is suggested, in which fertilizer would be applied in three depths and three points of soil. Two pots were considered to obtain effective performance, in one pot traditional fertilization is used, and in the other multilayered fertilization is used at three separate depths of 2 inches, 4 inches, and 6 inches. According to the results of the experiment, there is no difference in the absorption of N, P, and K by the plant when fertilizer is not used. When fertilizer is used, there is a noticeable difference in the absorption of N, P, and K by the plant. Thus from observations, the rate of N, P, and K absorption in the cotton plant appears to be influenced by fertilization location.

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