Agriculture Monitoring System using IoT

Md. Shahidul Islam[1*], Md. Monowar Hossain[2], Md. Abul Hasnat[3]
[1,2,3,] Department of CSE, Hamdard University Bangladesh

Abstract: The study of this paper is to detect and measure soil nutrients using sensors, and comparing measured nutrients with other nutrients. Therefore, this system can produce better results faster. Automation of soil testing will provide an easy mechanism than the existing testing methods. In this modern world, people prefer to do their work using machines because of the facilitated world of work. Hence, this soil testing with hardware device will reduce the effort of human resources.

***Keywords* - Soil Test, internet of things, crops recommendation, increase crop productivity.**

1. INTRODUCTION

Agriculture is the science and arts of cultivating plants. Agriculture was the key development in the rise of sedentary human civilization. In many countries, agriculture is the main source of income and the backbone of the economy. The most common problem faced by farmers is that farmers do not select suitable crops for their soil. As a result, productivity suffers. Poor crop production leads to reduced crop production and food shortages in the country. This problem is solved by recommending suitable crops to farmers before sowing. Analysis of parameters is required to overcome the problems. Soil is an important component of agriculture. Soil health is essential for good food production. It provides essential nutrients, water, oxygen and support to the roots. There are different types of soil such as loamy soil, sandy soil, silt soil, red soil and laterite soil etc. Different types of crops grow better in different soils. For example cotton and rice grow well in alluvial soil, pulses, tea, coffee grow well in laterite soil. So soil health is important for good crop production. Accurate soil forecasting based on various soil nutrients is essential. In developed countries, the use of Internet of Things has started in the agricultural sector with the aim of increasing production.

In USA, Australia and even in our neighboring country India, Internet of Things is being used in agriculture as a result of which farmers are benefiting. It is not possible to lay wires inside the agricultural land or farm, so wireless technology will be very useful in this case. One of the characteristics of the Internet of Things is that it can integrate with the environment and gather information from the environment – leading to a variety of applications for such technology in agriculture. Population is increasing every year. So, from Industry that feeds so much population, agriculture must embrace IoT. Agriculture is the basis of human survival. Mankind must produce food in the right way to maintain success in agriculture and sustainable technologies like Internet of Things are needed. Smart agriculture monitoring system or simply smart farming is an emerging technology concept where data from several agricultural fields ranging from small to large scale and its surrounding are collected using smart electronic sensors. The collected data are analyzed by experts and local farmers to draw short term and long term conclusion on weather pattern, soil fertility, current quality of crops, amount of water that will be required for next week to a month etc. To get beneficial results IoT based smart to solve agriculture and problems. Agricultural systems are employed. There is a possibility Automation is one of the

solutions to overcome the problem that human involvement in agriculture is continuously decreasing.
Soil is a natural substance that provides nutrients and water to crops/plants in terms of fertility. This soil is one of the main natural resources for crop production. Proper use of this fertilizer improves soil health and increases crop yield. From this soil, plants get 14 out of 17 essential nutrients for their growth and development. It is also noted that if the physical, chemical and biological properties of the soil are suitable for crop production, crop yield and production increase. As a result, farmers' income increases and poverty alleviation accelerates. Therefore, it is very important to maintain the quality of the soil and produce crops. But due to unplanned use, soil health and soil fertility is gradually getting damaged/decreasing, as a result, the soil is not yielding as expected. One of the reasons for this is the lack of nutrients in the soil including organic matter.
This proposed system can improve these qualities by evaluating the soil through soil testing and it will give us soil pH, calcium, iron, temperature, nitrogen (N), phosphorus (P), potassium (K) and soil moisture. There are different types of soil such as chalk, peat, sandy, clay, silt and loam. Soil is made up of 45% mineral matter, 25% water, 25% air and 5% organic matter. Suitable soil types vary. A soil test is the best way to know if the soil can provide these elements to plants [8]. A soil test is a chemical method of estimating the capacity of the soil to supply nutrients. Taken every 4 years to monitor soil acidity and fertility, a soil test can be a very helpful tool before forages are planted. Soil tests determine what nutrients are in the soil; not the plant uptake, which can be measured by plant analysis. Technology is developing more accurate ways of soil sampling resulting in efficient, environmental-minded, and scientifically sound fertilizer application. But the basic guidelines include several highlights. Soil test samples should be taken every 2.5 - 5 acres and in areas of different geophysical features (hillsides, soil types, areas managed differently) to represent the entire field, but should avoid small unusual spots. Dig out a sample of soil from plow depth unless a shallower height is needed as in cases of renovation. Avoid contaminating sampling tools with fertilizer or soils from other spots. Selection of perfect soil according to crop is an important process in agriculture.
The need for soil testing is immense to apply fertilizers in quantity according to crop demand after increasing and preserving soil health and soil fertility. Soil testing is the most important factor for higher crop yield along with preservation of soil health. Crop type should be changed periodically to maintain soil fertility. Automated soil testing plays an important role. Soil testing is one of the major tasks in agriculture that can be handled using automation techniques Calculation methods help. Soil properties can be measured by a guided automatic soil tester combined with the necessary sensors and actuators .A system has been created Crop field monitoring with sensors like light, humidity, temperature, soil moisture etc. allows farmers to monitor field conditions from anywhere. The automated soil testing mechanism may increase the accuracy of the test results and also make the task easy. The work plan is to do a cost-effective automated guided vehicle to test the soil. Further, we decided to sense the pH using a custom-designed mechanism. Recently, there are some research being carried out which explores the possibility for an automated soil testing system, to achieve higher accuracy with the least cost. The purpose of this system is to make the results accurate meanwhile avoiding the physical barriers in the path.
Once the device is set with everything then it is automatically tested and reports back without human intervention. This can be done with the help of an Arduino Microcontroller board and with some sensors to sense the soil parameters and some communication modules to facilitate the

proposed automated soil tester. The automated soil tester will rove and collect samples within the given boundary, and after completing the process it will update the collected results to the computer with connected to the microcontroller.
The main objective is to increase the productivity of the crops. Therefore, we can produce better results faster. Crops are monitoring through IoT. The main goal of our system is to increase crop production. The data obtained by NPK sensor, soil moisture, PH sensor sensors will go in the form of input to our system. Then it will be seen what amount of nutrients are there and then our system will check which crops are suitable with these nutrients. And production can be increased. Production can be increased through fertilizer management. Fertilizer should be used in the right amount. It will increase the fertility of the soil. As a result production will increase. Alternating plants on a given field plot prevents soil exhaustion and breaks pest cycles, which will result in better agricultural output and, therefore, will increase the average crop yield per acre. Automation of soil testing will provide an easy mechanism than the existing testing methods. In this modern world, people prefer to do their work using machines because of the facilitated world of work. Hence, this soil testing with a hardware device will reduce the need for human resources. The automated 2 soil testing mechanism may increase the accuracy of the test results and also make the task easy. There are many challenges in developing an automated soil tester to test the soil. The work plan is to do a cost-effective automated guided vehicle to test the soil. Further, we decided to sense the pH using a custom-designed mechanism. Recently, there are some research being carried out which explores the possibility for an automated soil testing system, to achieve higher accuracy with the least cost. The purpose of this system is to make the results accurate meanwhile avoiding the physical barriers in the path. Once the device is set with everything then it is automatically tested and reports back without human intervention. This can be done with the help of an Arduino Microcontroller board and with some sensors to sense the soil parameters and some communication modules to facilitate the proposed automated soil tester. The automated soil tester will rove and collect samples within the given boundary, and after completing the process it will update the collected results to the computer with to the microcontroller. The main objective is to speed up the working process through the device developed. Also, making more accurate measurements is another task of this system.
Therefore, we can produce better results faster. Automation of soil testing will provide an easy mechanism than the existing testing methods. In this modern world, people prefer to do their work using machines because of the facilitated world of work. Hence, this soil testing with a hardware device will reduce the need for human resources.

2. LITERATURE REVIEW

This section presents some previous works related to out proposed work done by various researchers. The contributions of various researchers in the field application of computers and electronics in agriculture are mentioned in this section.
Al-Faiz et al (2015) implemented Global Positioning System (GPS) based navigated autonomous robot to find a path using an A* algorithm between start and goal locations in the satellite image. The aim of the study is to develop and implement a GPS guided automated soil testing device. They have used comprised of a Perspex base, battery pack, servo motors, Unbox GPS module and an ATMega328 Arduino microcontroller. Here they concluded with a drawback of time consuming to move the Automated Soil Tester between the given points. The velocity is around

0.8m/s. However, in the implemented system the time consumption problem has been solved with effective path finding algorithm. The digital compass and an efficient GPS module have been used in some GPS guided Automated Soil Tester. Therefore, the digital compass is used in the given system for further enhancement of navigation. The soil sampling techniques were learned from the study which discuss about characterizing and recognizing soil sampling strategies.

Banđur Đ. Et al (2019) analyzed the energy efficiency in Wireless Sensor Networks (WSNs) applied in smart agriculture. The research primarily focuses on the power consumption of the several WSN components, both functionally and physically. A comparative study and discussion of the most widely used protocols on the physical, data connection, and network layers are included in the analysis from the perspective of energy efficiency. The results of the analysis offer a clear identification of the primary power users, an estimate of the amount of power they consume, and a thorough comprehension of the critical processes that must be implemented to raise a WSN's energy efficiency. A simulation of a WSN operation in a smart agricultural application is also included in the analysis. The results of the analysis, which included a detailed look at potential directions for the strategy to improve energy efficiency, were confirmed by the simulation scenario and the measured values of the average power consumption and the average time of activity of the radio component of each network node. Furthermore, the scale of the energy savings achievable through the deployment of duty cycle mechanisms within the WSNs is also shown by the simulation findings. Lastly, the study discusses a number of variables and how they affect energy efficiency. These variables must be taken into account during the requirements collecting, thorough analysis, and design stages of a WSN life cycle implementation.

Bugai T. et al (2013) provides the development and implementation of a Global Positioning System (GPS) guided rover. The rover is going to race on a pre-planned course made up of GPS coordinate-based vertices. A perspex base, battery pack, servo motors, Ublox GPS module, and an ATMega328 Arduino microcontroller make up the design. Through serial communication, the GPS module sends string formatted input to the microcontroller. After that, the direction is determined by running this data through our path finding algorithm. The rover navigates the course with only a few minor incidents. Other suggested improvements are different algorithms and more sensors.

Chandramohan J. et al (2017) proposed a Intelligent Smart Home Automation and Security System Using Arduino and Wi-fi. With the help of an integrated micro-web server with internet protocol (IP) connectivity, this paper offers a low-cost, adaptable home control and monitoring system that can be accessed and controlled remotely using an Android-based smartphone app. Unlike prior systems, the suggested system offers a unique communication protocol for monitoring and controlling the home environment with features beyond simple switching and does not require a dedicated server PC. In order to guarantee compatibility between Wi-Fi devices from different producers of electrical equipment, meters, and smart energy permits goods to be made, smart home interfaces and device definitions are used. The provided system provides intelligent fan and light operation. Here, the system is linked to both bulb and temperature control. Light-dependent resistors (LDRs) and temperature sensors (LM35s) are the key parts of this automated lighting and ventilation operation. In this case, the LM35 is in charge of managing the fan's operation, and the LDR is in charge of controlling the lamp. The suggested home energy control systems are implemented using smartphones and offer intelligent services for users.

Chavan C.H. et al (2014) proposed Wireless Monitoring of Soil Moisture, Temperature & Humidity Using Zigbee in Agriculture. The development of a smart wireless sensor network (WSN) for an agricultural setting is the primary goal of the current effort. It can be important to monitor the agricultural environment for a number of variables, including temperature, humidity, and soil moisture. In the past, measuring these variables in an agricultural setting required humans to take measurements by hand and double-check them at different points in time. This study looks on a Zigbee-based remote monitoring system. These nodes wirelessly transmit data to a central server, which gathers, stores, and permits analysis before displaying it as needed. The data can also be delivered to the client's mobile device.

Delgado J.A. et al (2013) proposed the first Nitrogen Index app for mobile devices: Using portable technology for smart agricultural management. Agroecosystems all around the world employ nitrogen fertilizer derived from both organic and inorganic sources. It is crucial for food security and helps to increase yields and farmers' financial returns. On the other hand, substantial amounts of nitrogen may leave the system and have an adverse effect on the environment if more is applied than is necessary. Conservation depends on appropriate nitrogen management, which applies the proper amounts of nitrogen and employs optimal techniques to guarantee increased use efficiency. According to a recent USDA research, almost 66% of US cropland did not adhere to the three best nitrogen management practices: the best rate, the best time, and the best mode of application. We can improve nitrogen use efficiency and evaluate the risk of nitrogen losses from a field to the environment with the aid of nitrogen tools. Tools for quickly and portable risk assessments of nitrogen management that may be used in the field and other locations are needed. February 26, 2012 saw the publication of the Nitrogen Index's first smartphone/tablet application, or "app." Users can email the results from their Nitrogen Index app, which was created for smartphones and tablets in the field, to their computer back at the office (or a farmer's or consultant's computer) by using the internet service on their portable device. A PC version 1 of the Nitrogen Index is also available, and it can be used on PC desktop and laptop computers. The Nitrogen Index is a quick tool, and its assessments of nitrogen loss risk are correlated with observed values. This is the first Nitrogen Index app in the world and it is the beginning of more advances to come in the field of portable agricultural technology.

Elashmawy R. et al (2022) proposed a novel dataset for wireless soil monitoring of a strawberry harvest and respective evaluation of physicochemical qualities. The report offers the entire data set and initial statistical analysis from a large-scale soil research on how to use sensor-assisted real-time field monitoring to increase strawberry production and produce sustainable and high-quality harvests. A commercial strawberry farm in Central Florida was equipped with six real-time loggers, which were used for the whole harvest season—from planting to harvesting to soil preparation. Strawberries were harvested three times from each of the six locations, in addition to temporally high-resolution soil sensory measurements of temperature, electrical conductivity, and water content. Their objective physicochemical characteristics were then recorded and monitored in a food chemistry lab. This paper's main objectives are to expose the dataset to the food science and engineering research community and the findings of its initial statistical analysis, which aims to determine which factors, are related to each other. The results of this study show that although there is a weak correlation between the quality of the harvest and the water content of the soil just before it, there were multiple instances where statistically significant differences were found between the sensory measurements of the soil from different locations, differences that did not translate into differences in the corresponding qualities of the harvested crop.

Fernando D. et al (2020) proposed A Smart Agriculture Monitoring System Using Iot. Over the previous ten years, rainfall and climate changes have been unpredictable. As a result, many Indian farmers have embraced climate-sensitive techniques, sometimes known as "smart agriculture," in recent years. Smart agriculture is one of the major uses of I0T. It boosts agricultural productivity and decreases waste of fertilizer and water. Smart agriculture refers to the application of Internet of Things (IoT)-based automated and directed information technologies. IOT is expanding quickly and is being used extensively in all wireless contexts. This study has examined and assessed sensor technology and the integration of IOT with wireless networks based on the real-world circumstances of agricultural systems. Three sensors that measure the soil's temperature, moisture content, and pH: temperature, moisture, and pH. The Remote Monitoring System (RMS), a combined internet and wireless communications method, is suggested. The main goal is to gather real-time data on the agricultural production environment that facilitates cultivation and boosts crop yield. Nutrient deficiencies in the soil are found and fixed by employing the IP address to monitor the field.

Jaiswal A. et al (2020) proposed Crop Health Monitoring System using IoT. IoT technology is used to gather data on environmental factors including soil moisture, air temperature, and atmospheric humidity that are conducive to the growth of different microorganisms and the development of agricultural illnesses. Farmers' desire to connect to their farm from anywhere in the globe at any time is supported by IoT. Wirelessly networked sensors track the state of the farm, and microcontrollers are utilized to automate and regulate farm operations so that conditions may be viewed remotely. With a smartphone and IoT, farmers may use their land at any time and from anywhere in the globe to stay informed about its ongoing problems. IoT technology can help traditional farming become more productive while lowering its obstacles. Farmers get real-time access to the information, which helps them identify the sickness that is actually caused by conducive environmental conditions. As a result, farmers may act promptly to protect their crops from additional disease-related harm. For the purpose of creating better farmer policies, the agriculture ministry can also benefit from real-time monitoring and access to sensor data.

Muangprathuba J. et al (2019) proposed IoT and agriculture data analysis for smart farm. The study suggested creating a wireless sensor network-based system for agricultural crop irrigation. The goal of this project was to design and create a crop field control system with node sensors and online application and smartphone data management. The mobile application, web application, and hardware make up the three components. The first part was created and put into practice using electronics attached to a control box to gather crop data. Connected to the control box, soil moisture sensors are utilized to monitor the field. A web-based application that was created and put into use to edit crop data and field information details makes up the second component. In order to estimate the ideal temperature, humidity, and soil moisture for future crop growth management, this component used data mining to analyze the data. Using a smartphone app, the last component is mostly utilized to regulate crop watering. This enables the user to regulate either automatically or manually. For watering, the automatic control employs information from soil moisture sensors. In the functional control mode, the user does have the option to manually manage crop irrigation. Via the LINE API for the LINE application, the system is able to deliver notifications. In Thailand's Suratthani Province's Makhamtia District, the technology was put into use and tested. The outcomes demonstrated the application's value in agriculture. The right amount of moisture was kept in the soil for the growth of vegetables, which decreased expenses and raised agricultural output. Furthermore, this effort exemplifies advancing agriculture via digital innovation.

Sadowski S. et al (2020) proposed Wireless technologies for smart agricultural monitoring using internet of things devices with energy harvesting capabilities. In order to monitor agriculture, an experimental comparison of Internet of Things (IoT) devices with energy harvesting capabilities using IEEE 802.11 g (WiFi 2.4 GHz), IEEE 802.15.4 (Zigbee), and Long Range Wireless Area Network (LoRaWAN) is conducted in this study. To investigate each technology's performance in various environmental settings, four experiments were carried out. Based on the findings, LoRaWAN is the best wireless technology to use in an agricultural monitoring system where network lifetime and power consumption are important considerations.

Saleheen M. M. U. et al (2022) proposed IoT-Based Smart Agriculture Monitoring System. In this paper, an internet of things- based smart agriculture monitoring system has been developed to reduce manual labor and water wastage. In this proposed system, a Node MicroController Unit integrates all of the sensors and sends the sensors' data to an internet of things-based cloud framework known as Adafruit IO. Consequently, Adafruit IO stores all the sensors' data. A soil moisture sensor acquires the moisture data of the farm field. The acquired moisture data is in a percentage value, where 0% means no moisture content, and 100% indicates high moisture content. Depending on the moisture content, a message is sent automatically to the user to turn on/off irrigation. Through Adafruit IO, a user can control the irrigation process remotely. A waterproof temperature sensor is employed to measure soil temperature, and a temperature and humidity sensor measures the temperature and humidity of the surrounding environment of the farming field. An air quality sensor reads the air quality of the farming field and a barometric pressure sensor measures the sudden change of atmospheric pressure in this system, which can help predict rainfall. In this proposed system, a light-dependent resistor measures the amount of light. Finally, the DHT11 sensor gives 20% and 28% errors in temperature and humidity value, respectively.

Sivasankari M. A. et al (2019) proposed the Implementation of Automated Organic Fertigation System by Measuring the Plant Parameters. This paper elucidates about the concept of smearing automation on agronomy. The system will monitor the basic parameters in horticulture field such as pH level, temperature, soil moisture, water flow and the characteristics of the soil. It also includes the automatic feeding of fertilizers based on the measurement of essential nutrients in the soil in order to yield effective growth. The agricultural industry is very much enclosed when compared to all other industries because of the sort of job involved in agriculture which cannot be predicted and many monotonous tasks are not exactly the same at every time. Lots of factors have to be considered (i.e. atmospheric condition, land status, etc.) before the emerging of the task. The type of crop to be planted is based on pH value of the soil and it can be determined from the soil fertility test report. The pH value, temperature, moisture of the soil is determined using pH sensor; temperature sensor, moisture sensor respectively and the corrective action for that particular range will be displayed. The displayed corrective action occurs accordingly with the help of relay and valve setup. So with the help of this setup automatic Fertigation can be implemented. The entire process is monitored and recorded using IOT on Webpage.

Srividyadevi P. et al (2013) proposed the Measurement of Power and Energy Using Arduino. This paper discusses the use of Arduino for power and energy measurement. Over the past century, there has been an exponential increase in the need for power. A potential solution to the current energy issues is to decrease residential energy consumption. This has made it even more important to have precise and affordable power measurement techniques. Optimizing and lowering their power consumption is the aim of supplying such information. This document describes the steps involved in creating a laboratory-scale prototype, including measuring the load's energy consumption and outlining its benefits, as well as a simplified design description.

Zhang H. et al (2022) proposed LoRaWAN based internet of things (IoT) system for precision irrigation in plasticulture fresh-market tomato. The low-power wide-area network (LPWAN), also known as the long-range wide-area network (LoRaWAN), is a low-cost and simple-to-install Internet of things system that can be utilized for precision agricultural irrigation. A LoRaWAN-based Internet of Things system was created and assessed in this study to be used as a precision irrigation tool for fresh-market tomato production in a plasticulture system. The GesCoN fertigation decision support system (DSS), soil matric potential sensors (Watermark 200SS-5) at -60 kPa (MP60) or -40 kPa (MP40), and crop evapotranspiration (ET) were the four irrigation scheduling treatments that were devised and tested. Four replicates of a randomized complete block design were used to organize the treatments. Crop yield, irrigation water use efficiency (iWUE), and system viability were assessed. During the season, ET, MP60, MP40, and GesCoN had respective overall water use efficiencies of 22.2, 26.5, 27.9, and 28.4 $kg \cdot m^{-3}$. According to the data, MP40 had a 12.5% lower marketable yield than ET, while MP60 and GesCoN treatments had marketable fruit yields that were 15.2 and 22.1% greater than ET. The LoRaWAN-based Internet of Things system functioned well overall in terms of connectivity, power consumption, sensor reading, and valve management. These findings showed that the application of IoT systems for precision and autonomous watering of vegetables and other horticultural crops could improve the sustainability and efficiency of agricultural water consumption.

3. METHODOLOGY

Automated Soil Tester system is gaining importance as there is need to use water resources efficiently and also to increase the field productivity. The system is used for sensing, monitoring, and for controlling purpose. The data obtained by NPK, soil moisture, ph sensor, calcium, magnesium and iron sensors will go in the form of input to our system.

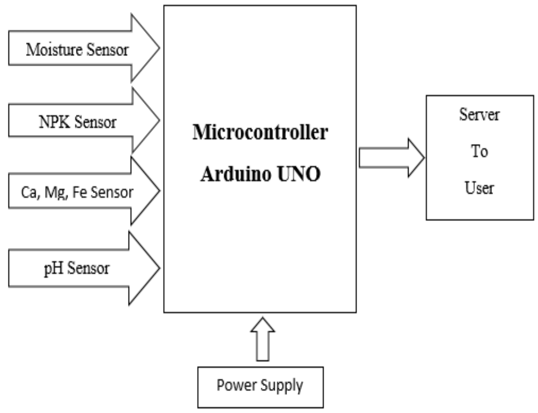

Figure 3.1: Block Diagram of the system

Then it will be seen what amount of nutrients are there and then the system will check which crops are suitable with these nutrients and increase the productivity of crops. The system block diagram is shown in Figure 3.1. It consists of six sensors and a microcontroller. The pH, moisture and NPK sensors and Ca, Mg, Fe sensors are inserted in the soil and the measured parameters are sent to the controller. All the sensors will record the value and give it to the microcontroller. Microcontroller then send this value on Server Side. By determining that, our system crosschecks will with specific crops to suggest which crops produce better and give ideas on how to increase productivity.

4. NUTRIENT MEASURED SYSTEM

A system architecture is the conceptual model that defines the structure, behavior, and more views of a system. The system architecture of the automated soil tester is shown in Fig. 3.1.

4.1 NPK sensor

The soil NPK sensor is suitable for detecting the content of nitrogen, phosphorus, and potassium in the soil.

Figure 4.1: NPK sensor

4.2 Jumper wires

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering.

Figure 4.2: Jumper wires

4.3 Calcium Sensor

Calcium sensor is suitable for detecting the content calcium in the soil.

Figure 4.3: Calcium Sensor

4.4 pH sensor

A pH sensor is one of the most essential tools that's typically used for water measurements. This type of sensor is able to measure the amount of alkalinity and acidity in water and other solutions.

Figure 4.4: pH sensor

4.5 Soil moisture sensor

Soil moisture sensors measure the volumetric water content in soil.

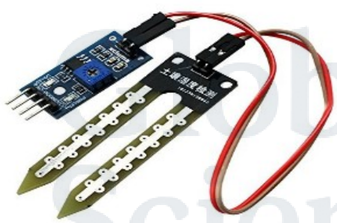

Figure 4.5: YL 69 sensor

4.6 Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet).

Figure 4.6: Arduino UNO

4.7 Breadboard

A breadboard is a solder less device for temporary prototype with electronics and test circuit designs.

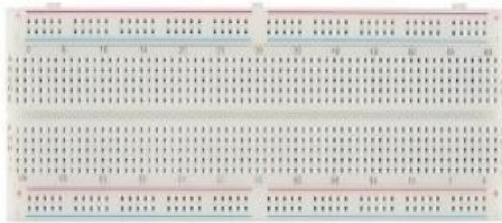

Figure 3.7: Breadboard

5. RESULTS AND DISCUSSIONS

Every electronic device and the sensors are tested separately to understand and ensure the functionality of the devices and sensors are calibrated based on the standard environment. The current weather data at the time of calibration is taken into the consideration. The DS18B20 temperature sensor is tested by receiving the data from the sensor in a particular time interval. The output is shown in the serial monitor of the Arduino IDE (for testing purposes) which shows the response from the sensor is rapid and the temperature changes also measured as efficiently by the DS18B20 sensor.

5.1 Nutrient uptake by crops

Nutrient uptake by a crop is the resultant product of the nutrient concentration of that crop and the level of yield including by-product. In general, higher is the yield, higher is the removal of nutrients. Modern varieties of crops absorb relatively higher amounts of nutrients than the traditional varieties. Nutrient uptake by various crops is given in the following table.

Table 5.1: Nutrients Standard Table (NST) for Crops

Crops	Yield (t/th)	Nitrogen (N)	Phosphorus (P)	Potassium (K)	pH	Calcium (Ca)	Magnesium (Mg)	Iron (Fe)
Rice	6	108	18	102	5.5-6.5	20	14	50
Jute	3	98	20	193	4.0-4.8	80	26	12
Banana	40	109	79	45	5.5-6.7	2	126	145
Pomegranate	15	11	18	42	5.5-7.5	68	20	13
Watermelon	50	119	25	51	6.0-6.9	81	23	10

Moisture sensor YL69 is tested in different environments such as in the dry, wet soil and the water. The sensor's analog outputs are shown in the serial monitor of the Arduino IDE. Calibration of the moisture sensor is done in the air.

Table 5.2: Results of the moisture sensor

Time(Second)	Reading	Remark	Land
1	546	Soil is wet	Jamaldi
2	548	Soil is wet	Jamaldi
3	669	Soil is wet	Tengarchor
4	667	Soil is wet	Tengarchor
5	354	Soil is wet	Fuldi
6	355	Soil is wet	Fuldi

The pH sensor is tested with the various sample pH solutions in chemical laboratory with the help of chemistry expert. We compare the pH reading between the laboratory pH reading with the pH sensor and also voltage of the pH sensor is measured. After that a graph has been plotted against the obtained voltage and the actual pH value as shown in Fig.6 to retrieve the formula to code the microcontroller (customized-method).

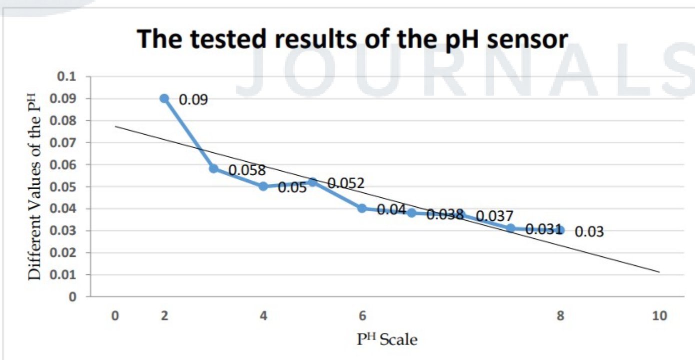

Figure 5.1: The tested results of the pH sensor

Rice:

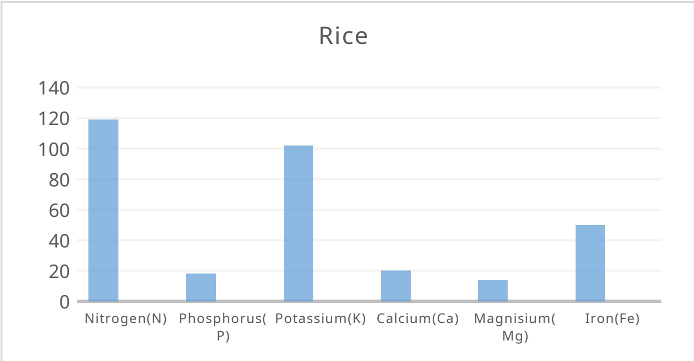

Figure 5.2: The test result of the NPK average, Ca, Mg and Fe sensor value

Jute:

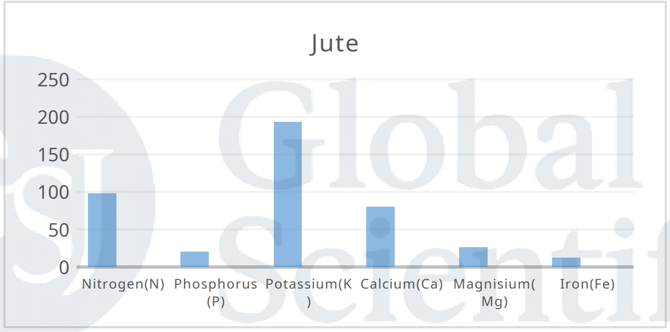

Figure 5.3: The test result of the NPK average, Ca, Mg and Fe sensor value

Pomegranate:

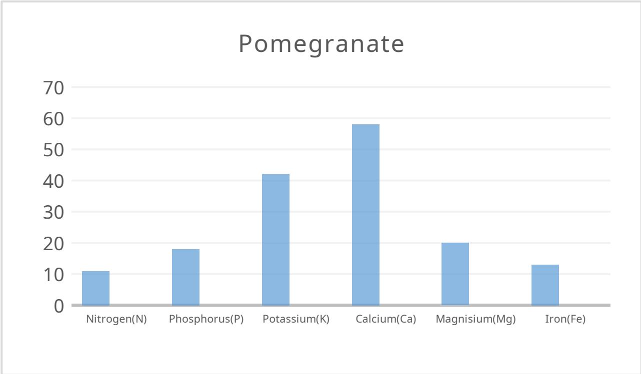

Figure 5.4: The test result of the NPK average, Ca, Mg and Fe sensor value

Watermelon:

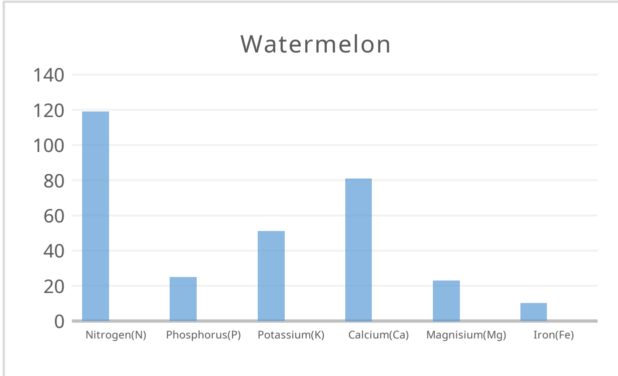

Figure 5.5: The test result of the NPK average, Ca, Mg and Fe sensor value

5.2 Final Testing

The automated soil tester is tested in the Hamdard University Bangladesh. The automated soil tester visited three points according to the given GPS coordinates the final results are recorded and described. The Point No given in the Table 5.3 is according to the shortest path algorithm. The sample soiof each point is taken to the laboratory to test the pH and moisture is described in Table 5.2. The traditional soil testing method is used to test the soil sample taken.

Table 5.3: Final readings are taken by the automated soil tester

Land	Nitrogen (N)	Phosphorus(P)	Potassium (K)	pH	Moisture	Calcium (Ca)	Magnesium (Mg)	Iron (Fe)
Jamaldi	125	25	133	5.6	523	68	36	34
Tengarchor	136	20	102	6.3	625	45	54	23
Fuldi	120	18	110	5.5	490	27	38	12

6. CONCLUSION

The main goal of this system is to increase crop production. The data obtained by NPK sensor, soil moisture, PH sensor, calcium, magnesium, iron sensors will go in the form of input to our system. Then it will be seen what amount of nutrients are there and then our system will check which crops are suitable with these nutrients. And production can be increased. Production can be increased through fertilizer management. Fertilizer should be used in the right amount. It will increase the fertility of the soil. As a result production will increase. Also temperature, humidity should be right. The soil nutrient content can be easily measured using NPK sensor, soil moisture, PH sensor, calcium, magnesium, iron sensors & Arduino microcontroller. Measurement of soil content N (nitrogen), P (phosphorus) and K (potassium) are the main necessary nutrient. And Ca (calcium), Mg (magnesium) and Fe (iron) are secondary necessary nutrient. These nutrient is necessary to determine how much additional nutrient content is to be added to soil to increase crop fertility. Because one of the best ways to maintain the soil in good health is to practice crop rotation, among others.

Alternating plants on a given field plot prevents soil exhaustion and breaks pest cycles, which will result in better agricultural output and, therefore, will increase the average crop yield per acre. Temperature, humidity, PH level, moisturizer are the most important factors for the productivity, growth, and quality of plants in agriculture. So this system periodically measures these parameters inside the fields, thus the farmers or the agriculture experts can observe the measurements from the web simultaneously.

The instant soil testing is crucial. The instant results can be accurate in the point of moisture and temperature testing. Moisture percentage and the pH is needed from the beginning of the plantation for cultivation. This automated soil tester is the best solution to overcome the problems of above discussed bottlenecks of agriculture in the background section.

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