E-ISSN 2581 – 7957
P-ISSN 2277 – 3916
CVR Journal of Science and Technology, Volume 23, December 2022
DOI: 10.32377/cvrjst2313

Smart Precision Interface for Conventional Agricultural Methods

S. Praveen Chakkravarthy[1], Gaddam Vivek[2], Kalakuntla Vishal[3], Sahithi Vangala[4] and Juluri Sai Teja[5]
[1]Assoc. Professor, CVR College of Engineering /ECE Department, Hyderabad, India
Email: too.spc@gmail.com
[2]UG Scholar, CVR College of Engineering/ECE Department, Hyderabad, India
Email: gaddamvivek9@gmail.com
[3]UG Scholar, CVR College of Engineering/ECE Department, Hyderabad, India
Email: vishalbadri2002@gmail.com
[4]UG Scholar, CVR College of Engineering/ECE Department, Hyderabad, India
Email: svangala56@gmail.com
[5]UG Scholar, CVR College of Engineering/ECE Department, Hyderabad, India
Email: julurisaiteja6789@gmail.com

Abstract: **The Indian agricultural industry needs a huge amount of water and fertilizers to produce a significant harvest. Applying precise farming methods can transform the agricultural industry. Utilizing cutting-edge methods like IoT (Internet of Things) and data analytics, the paper seeks to alleviate the gap between farmer and his crop. The goal of the information and technology-based farm management system is to recognize, assess, administer the temporal variability and abstraction among fields for maximum production and profitability, sustainability, and conservation of the land resource by reducing the assembly costs.**

Index Terms: **Conventional Farming, Internet of Things (IoT), Data Analytics, LoRaWAN Communication Protocol**

I. Introduction

The proposed LoRaWAN based agricultural solution provided improvement in yield of the plant by providing required quantity of water and nutrition, thereby reducing the expenses in terms of less usage of fertilizers compared to conventional agricultural practices. This LoRaWAN based solution can be used to monitor the farm from anywhere in the world and even to the remote areas where public access network is not possible.

A. Conventional Farming

Intensive until age or concentrated monoculture production, genetically modified species, targeted animal feeding operations, substantial irrigation, the use of artificial chemical fertilizers, insecticides, and herbicides are all examples of conventional agricultural practices. As a result, traditional agriculture is not only very energy and resource intensive, but also very productive.

Producers typically use too many inputs in an effort to increase crop output over the entire field. Overusing inputs results in decreased profitability and negative environmental effects on soil, surface water, groundwater, and drainage water resources. This is due to an improper number of fertilizers being added to the soil. However, alternating elements including soil compaction, loss of organic matter, water holding capacity, biological activity, and wind and water erosion of exposed topsoil are the cause of decreased production. It has been discovered that agricultural activities contribute to non-point source water contaminants, which include salts, fertilizers (particularly nitrate and phosphate), pesticides, and herbicides.

Food now is less nutrient-dense than it was in earlier generations, while having a lot more calories. In addition to polluting food with pesticide residues, conventional agricultural methods can harm the synthesis of vitamins, minerals, proteins, and phytonutrients in fruits and vegetables.

B. Impact of Conventional Farming

Because of the widespread use of synthetic fertilizers and pesticides, conventional farming has come under fire for causing biodiversity loss, soil erosion, and extreme pollution. The soil is affected by geological processes, urbanization, deforestation, erosion, and waterlogging. Traditional farming practices can contaminate food with pesticide residues while adversely affecting the synthesis of important vitamins, minerals, proteins, and phytonutrients in fruits and vegetables. Producers often use a lot of inputs to increase the overall crop output. Excessive input application reduces profitability, degrades soil fertility, and has a negative environmental impact on surface water, ground water, and drainage water.

C. Crop Nutrient Management

A perfect yield is frequently maintained by increasing Nutrient Use Efficiency (NUE). Controlling the usage of fertilizers will significantly improve atmospheric health. Through several on-farm comparative studies, rice and wheat were assessed in both high-input and low-input production systems throughout India's rice-wheat belt. The findings demonstrate that by lowering the chemical element nitrogen input by 15–30%, gains may be scaled up correspondingly by 2-4% and global warming can be decreased. [1]

The rest of the article is organized as follows:

II. Literature Survey
III. System Model
IV. Results and Discussion
V. Conclusion.

Received on 02-11-2022, Revised on 18-11-2022, Accepted on 30-11-2022.

II. Literature Survey

For a plant to develop to its full potential and be in a highly healthy state certain conditions must be satisfied i.e., these elements must be present in sufficient quantities in the soil. Ideally, the characteristics will enable caterpillar tracking of the farm's present state. The soil's pH, temperature, moisture content, electrical conductivity (EC), and nutrient content, namely nitrogen (N), phosphorus (P), and potassium, are all critical characteristics (K). [2]

Soil pH: The most significant physical characteristic of soil is pH. It has a significant impact on the concentration and uptake of solutes in soil. For several reasons, including the fact that some plants and soil life prefer either alkaline or acidic conditions, soil pH is a crucial factor for farmers and gardeners. Acidic soil is defined as having a pH of less than 6, normal soil is defined as having a pH of 6 to 8.5, and alkaline soil is defined as having a pH of higher than 8.5. The reality remains that soil response (pH) is not a reliable predictor of a plant's development characteristics; but it does give a decent indication of a number of plant growth parameters, primarily the soil's nutritional condition. The pH of the soil has a strong correlation with the nutrient availability in the soil.

The macronutrients, except for phosphorus, are more readily accessible in the pH range of 6.5-8. These include nitrogen, calcium, potassium, magnesium, and Sulphur. However, the micronutrients are offered in a pH range of 5-7, which is somewhat acidic. These are the ranges where nutrient availability to plants is ideal and beneficial. [3]

Soil Temperature: The soil's temperature has a significant impact on the chemical, physical, and biological processes involved in plant development. Season, time of day, and regional meteorological factors all affect soil temperature variations. The sun and heat produced by the soil's chemical and biological activities are the main sources of warmth. An increase in soil temperature speeds up chemical processes, decreases the solubility of gases, and lowers the pH of the soil. It also contributes significantly to seed germination. Temperature changes in the soil are a result of exchange activities that occurred at the soil surface**.** Soil temperatures has a profound effect on plant growth by influencing water and nutrient uptake, root and shoot growth. Water uptake decreases with low temperature. Decreased water uptake reduces the rate of photosynthesis. Increased metabolic activities of micro- organisms as a result of increase in soil temperature will stimulate the availability of nutrients for plants. Soil temperature influences soil moisture, aeration, and availability of plant nutrients which are necessary for plant growth. [4]

Soil Moisture: The most important physical characteristic of soil is moisture. As a nutrient and a solvent for other nutrients including salt, potassium, carbon, and nitrogen, soil moisture content is crucial to crop productivity. The soil's moisture affects how well nutrients are absorbed. Furthermore, the texture and structure of soil are related to its water content. The quantity of voids, particle size, clay minerals, organic content, and the state of the ground water, these all affect how wet the soil is. Since soil consistency mostly determines how wet anything is, clayey soil, which has a high porosity, often contains more water in it than do sandy soils. Intelligent water retention capacity reveals the excellent form of the soil. It is an important parameter for many hydrological, horticultural, agricultural, and meteorological applications. [5]

Soil Electrical Conductivity (EC): One of the simplest and most affordable soil measures now accessible to precision farmers is soil EC. It measures the number of ions in a solution. A soil solution's electrical physical phenomena get stronger as its ion concentration rises. Electrical conductivity changes with depth, although its range of variation was reduced in upland profiles. This was likely caused by the slope of the land's surface, as well as by its high permeability and high downfall, which caused alkali and alkaline bases to be leached away. Electrical conductivity is used to calculate the amount of soluble salt present in soil and is often used as a salinity indicator. It can serve as a measure of soluble nutrients but has often been used to determine soil salinity. One of the soil qualities that has a good association with the other soil characteristics is soil electrical conductivity (EC). It is possible to utilize measuring soil electrical conductivity as a suitable method for acquiring meaningful information about soil since it is simpler, less costly, and faster than other soil property tests.[6]

Nitrogen Content: The most vital component of plant nourishment is nitrogen. When salts of chemical elements are applied to plants, they react swiftly. This component promotes the development of above-ground plants and gives the leaves a rich shade of indigo, green. Biological processes have an impact on the organic cycle, which is crucial to the soil system. It is essential for plant growth and may be a component of nucleic acid, chlorophyll, and plant proteins. In addition, the relationship between soil organic carbon and nitrogen is direct. Nitrogen affects the quality of plants and fruit and raises the protein level of the latter**.**

Phosphorus Content: Every live cell in a plant, even the most advanced ones, may contain phosphorus. It is one of the most important micronutrients required for plant development. Most typically, phosphorus acts as an energy storage substance and restricts the amount of nutrients that may be found in plant nuclei. It facilitates the movement of energy. Since phosphorus is necessary in significant quantities for plant development, it is a crucial element. It also plays a vital role in the process of photosynthesis and is involved in the production of all fats, sugars, and carbohydrates. The amount of phosphorus in the soil in which a plant is growing is a major factor in determining how active the plant is, including its ability to grow, breathe, and reproduce.

Potassium Content: Although metallic content is not a fundamental element of any significant plant component, it is crucial to a wide range of physiological activities necessary for plant growth, from protein synthesis to maintaining the water balance in the plant. It is engaged in number of plant metabolism events, from the generation of cellulose and lignin for cellular structural components to the control of photosynthesis and the production of plant sugars for diverse metabolic requirements. In its mineral form, potassium is present and has an impact on plant growth, the production of carbohydrates, the movement of sugar, the activity of different enzymes, and disease resistance. [7]

III. System Model

A. IoT Based Plant Growth System

The Internet of Things (IoT) is one of the most obvious essential technology advancements in modern farming. IoT refers to networks of digitalized physical objects, each of which has a special identification number. A network of seamlessly linked sensors is utilized to supply data targeted at delivering healthier plant development and a much better environment, making the usage of Internet of Things (IoT) for plant growth and environmental management a potential strategy. Modern farming requires high levels of output without requiring more land. One way to increase productivity is to repurpose existing land, however owing to a variety of environmental factors, this approach may not always succeed. Contemplating the current international scenario of farmlands, an IoT based smart farming device will impact the eco-friendly country. So as to monitor several factors differently related to the conditions of crops, soil, and environment. Potency in terms of plant growth and agriculture could also be achieved in various ways, one among those is healthier management of the basic farming environment. Through IoT it is attainable for farmers to study their land far better and observe changes in it. IoT will give humans free aid to the agriculture sector. The field can be machine-controlled exploitation technology and therefore the method of watering the field can be done without delay and only at required intervals. [8]

B. Data Analytics in Agriculture.

We may get information about which crop can be cultivated for specific pH and other parameter levels by analyzing the data. By estimating the quantity of drainage capacity in the particular soil, it also aids in our investigation into whether agriculture is practical or not. The act of acquiring, organizing, and analyzing huge collections of data in order to identify patterns and other important information is known as big data analytics. Organizations may benefit from using big data analytics to better comprehend the data that is present in their information. These analytics will also help them discover the data that is more important to their operations and upcoming business choices. Fundamentally, analysts working with vast amounts of data need the information gleaned through the analysis of the data. Big data analytics often makes use of sophisticated computer-coded software tools and applications for text mining, forecasting, and data optimization as well as predictive analytics and data mining to evaluate such a massive amount of data. These procedures work together as distinct but highly interconnected components of outstanding performance analytics. The ability to process enormous amounts of data that a company has gathered and identify the data that is useful and can be studied to inform future business choices is made possible by using big data tools and technologies. [9]

C. Smart Precision Interface

The current standard technique for practical farming is based mostly on GSM. It frequently requires a monthly expenditure, requires electricity to operate, and, in many cases, is located in a remote place where it is difficult to encourage sufficient network coverage for using GSM. As a result, it is nearly impossible to implement automation in such situations. In contrast to the current strategy, including IoT and Data Analytics can have a significant influence on agriculture production, improving accuracy and moving the industry toward more logical and improved farming practices. The farm may be linked with the IoT nodes to monitor the field's trend and make the required adjustments regarding the resources. Resources might be made available in sufficient quantities, and investments for buying different fertilizers could be managed. The LoRaWAN (Long Range Wide Area Network) communication protocol may be utilized successfully to improve the farm's technical capabilities. The full prototype is made up of LoRaWAN based sensors that measure the parameters in part II, evaluate the gleaned information, and alert the farmer to supply the field with enough resources.

D. LoRaWAN Communication Protocol

To establish communication between the farm and the end user, the Long Range Wide Area Network (LoRaWAN) communication protocol is used. LoRaWAN offers unlicensed spectrum with low latency of 1–10ms and coverage of roughly 10 km, which is our desired Indian frequency of 865-867 MHz It has an SX1301 LoRaWAN concentrator, which offers 10 demodulation methods that may be processed concurrently. The frequency bands can be changed by end users for usage in their specific LoRaWAN networks. Along with the Dragino Outdoor gateway, soil moisture, EC, NPK, pH, and temperature sensors are utilized to create a link between the farm and the farmer. Sensors are used to measure the parameters, and the data is analyzed by comparing it to the optimal values needed for the crop in question. This is accomplished by using data analytics to transform the measured raw data into information that farmers can easily understand and by prompting the farmer with the current status of his field.

NPK Sensor: A LoRaWAN Soil NPK Sensor for IoT in Agriculture is the Dragino LSNPK01. It is intended to measure the Soil Fertility Nutrient, Nitrogen (N), Potassium (K), and Phosphorus (P) in the soil and serve as a reference for plant growth. The probe may be submerged into soil for long-term use and is waterproof to IP68 standards.

Outdoor Gateway: An open source outdoor LoRaWAN gateway is DLOS8. It enables you to connect a LoRa wireless network to an IP network using Wi-Fi, Ethernet, 3G, or 4G cellular (optional module supports 3G/4G). Users can send data and cover incredibly vast distances at little cost with LoRa wireless data-rates. Figure 1 represents the complete architecture of the prototype beginning from the sensors on the field followed by the gateway, server, cloud storage and lastly the end user.

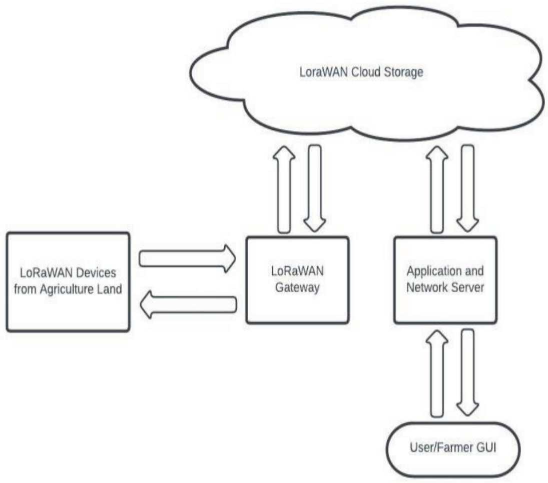

Figure 1. Block Diagram of the Proposed Work

The LoRaWAN gateway, which serves as a communication route between the users, has embedded sensors. Utilizing the TTN, the obtained data is kept on the cloud server (The Things Mate Network). Data is retrieved from the gateway via the Things Mate network server so that it may be saved, examined, and seen by the end user. Both the network server and the application are present in the TTN server. While the network server is utilized by the service provider and keeps measured data in hexadecimal form, the application server stores values that may be comprehended by the end user. The Outdoor Gateway must always have a reliable internet connection and a DC power source. Both wireless and cellular networks can be used to deliver internet service. The sensors and gateway are first set up using the TTN network server's Application EUI and Device EUI (Extended Unique Identifiers) and OTAA (Over the Air Activation) keys. For the needed period of data retrieval, a payload must be provided. Direct access to the findings is available via the TTN network dashboard. The end user may see both tabular data and graphical depiction on the application server. However, the information can be shown to the public or depicted on any digital device, such as a smartphone or television. "The Things Mate" has a versatile usage since it may be used from any location and with any device. Figure 2 illustrates the three sensors deployed in the field.

Figure 2. Sensors deployed on field

Figure 3. Outdoor Gateway

Figure 3 depicts the installation of the LoRaWAN outdoor gateway. Smart precision farming, by facilitating remote crop monitoring, reduces hazards for farmers. To avoid poor output, crop delays, and crop current conditions that would make more accurate maintenance possible. One advantage of linking agricultural solutions to crop yields is that information can be shared more easily between farmworkers and external stakeholders. Additionally, by examining and comparing the present crop values to the assessed ideal values, data analytics enables the farmer to determine how best to use his resources to save time, effort, and energy. Farmers may check on their fields at any time because the data is accessible from anywhere in the globe and can be seen using an application. Additionally, the water motor may be remotely operated to water the field automatically based on the moisture level. Additionally, the application that is offered for the smart farming visualization may be used to run the motor.

IV. Result and Discussion

Sensor specifications:

1. **LoRaWAN soil NPK sensor:**

Figure 4. LSNPK01 sensor

- LoRaWAN 1.0.3 class A
- Ultra low power consumption
- Default band: IN865
- IP66 & IP68 water proof enclosure

Figure 4 shows the soil NPK sensor with probe along with transmitter and antenna.

2. **Outdoor Gateway:**

Outdoor gateway is displayed in figure 3.

- 1xSx1301 + 2X1257 LoRa Transceiver
- 1x2.4G Wi-Fi
- Default band: IN865
- 802.3 of PoE
- IP65

3. **LT3322RL I/O Controller:**

Figure 5. LT3322RL I/O Controller

- STM32L072CZT6 MCU
- SX1276/78 LoRa Wireless Chip
- LoRaWAN Class A & Class C protocol
- Power input (0-24V)

Figure 5 shows the I/O controller that connects input and output devices.

The nitrogen, phosphorus, and potassium of a paddy field are periodically monitored using the NPK Sensor, and the acquired data is displayed using the TTN application server, as fertilizers play a significant role in the growth of a crop. The clay, slit clay, and slit clay loamy soils are the most optimal for an optimum paddy crop. For a higher yield with less resources, the optimal NPK ratio for paddy crop is 55:80:160.

TABLE I.
NPK Trend in Paddy Farm

TIME	NITROGEN	PHOSPHORUS	POTASSIUM
12:00	5632	8192	16384
12:10	5888	8182	16389
12:30	5888	8192	16384
1:00	5878	8194	16640
1:10	5888	8196	16648
1:30	5845	8456	16658

The paddy field was monitored for the nutrient contents at particular interval of time. Figure 6 illustrates the variation in the soil NPK content in the paddy field, phosphorus content was the maximum compared to the other nutrients.

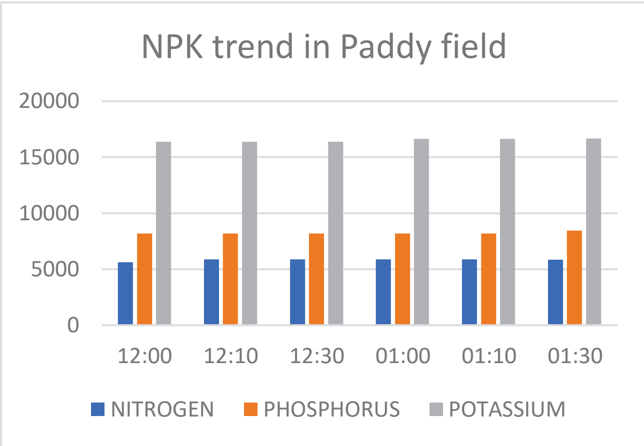

Figure 6. NPK values versus time.

TABLE II.
NPK Content Measured on Paddy Field

TIME	NITROGEN	PHOSPHORUS	POTASSIUM
12:25	7168	10240	20736
13:10	7158	10256	20738
13:45	7169	10240	20480
14:15	7166	10235	20690
14:45	7168	10245	20736

The paddy field is monitored for NPK content on a different day with respect to time. Figure 7 depicts the trend of the NPK content of the paddy field, when compared to the previous tendency, the nutrient contents raised.

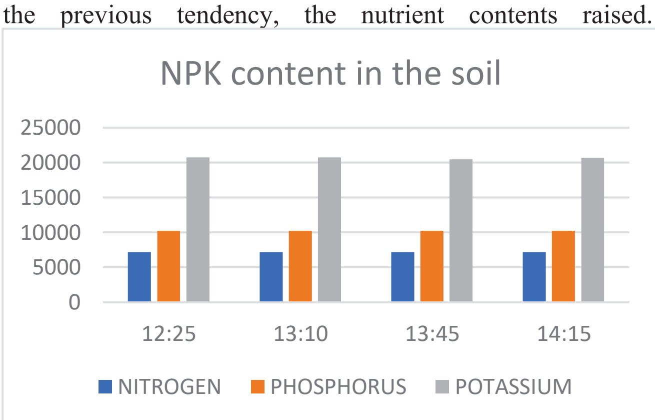

Figure 7. NPK content in the paddy field on another day at time intervals.

CVR Journal of Science and Technology, Volume 23, December 2022
DOI: 10.32377/cvrjst2313

TABLE III.
NPK TREND IN BOTTLE GUARD FARM

TIME	NITROGEN	PHOSPHORUS	POTASSIUM
12:06	9472	13312	26880
13:06	9728	13824	27648
13:26	9726	13824	27649
14:06	9725	13725	27705
14:26	9735	13728	27650

The nutrient content in the bottle guard field was measured for particular time interval.

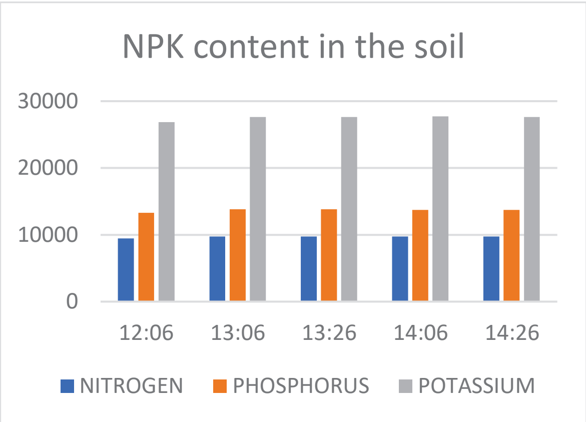

Figure 8. NPK trend on the bottle guard field versus time.

The bar chart in Figure 8 illustrates the nutrient contents in the bottle guard field, nitrogen content is the least when compared to other nutrients. Overall, the fore mentioned result shows that, during a period of half an hour, the paddy field is rich in potassium relative to nitrogen and phosphorus. As a result, the farmer is advised to provide the crop with only the nutrients needed based on the analysis by contrasting with the predetermined results. For instance, if the soil's nitrogen concentration is significantly higher than the desired level, the farmer will be advised to lower the nitrogen content and only add phosphorus and potassium as needed after the study. After comparing the present parameter values in the soil at that moment to the real values that are required by the crop, the conclusion on the composition of the soil is given. If certain values deviate from the ideal value, the inputs are changed. Investment may be regulated and managed in this way.

V. CONCLUSIONS

Smart precision farming is a promising technology that has the potential to replace outdated and erroneous farming practices with one that is reliable and accurate. From anywhere around the world, one may keep an eye on their field's condition. The necessary adjustments may be made with ease. It is affordable because the farmers in each hamlet may band together to buy one gateway. The farmer has the option to buy the sensors for their land. The sensors are dependable and require little upkeep. The gateway, on the other hand, is water-resistant and can be positioned at a reasonable level to cover as many nodes as possible within a 10-kilometer radius. Additionally, data analytics may be quite helpful in comparing and delivering precise findings. When put at close ranges, the different soil properties cannot exhibit significant variations. As a result, the sensors may be strategically arranged to cover the largest possible area with the fewest number of nodes.

REFERENCES

[1] Tek B. Sapkota 1, Mangi L. Jat, Dharamvir S.Rana, Arun Khatri-Chhetri, Hanuman S.Jat, Deepak Bijarniya, Jhabar M.Sutaliya, Manish Kumar, Love K. Singh, Raj K.Jat, Kailash Kalvaniya " Crop nutrient management using Nutrient Expert improves yield, increases farmers income and reduces greenhouse gas emissions" Scientific report, vol. 11, Number 1564, January 2021.

[2] Ku. Sumita Tale and Dr. Sangitha Ingole "A Review on Role of Physico-Chemical Properties in Soil Quality" ISSN 2278-6783 vol. 4, Number 13, pp. 57-66, February 2015.

[3] Khaidem Jackson, Thounaojam Thomas Meetei "Influence of soil pH on nutrient availability" JETIR, vol. 5, Issue 12, pp. 707-713, December 2018.

[4] Onwuka, B.M "Effects of soil temperature on Some Soil properties and plant growth" Michael Okpara University of Agriculture, Umudike, Abia State, pp. 89-93, July 2016.

[5] Saima Ansari and Ratnadeep R. Deshmukh "Estimation of Soil Moisture Content" ISSN:0973-6085, vol. 12, pp. 571-577, November 2017.

[6] Pravin R. Chaudhari, Dodha V. Ahire , Manab Chkravarty and Saroj Maity "Electrical Conductivity as a Tool for Determining the Physical Properties of Indian Soils" ISSN: 2250-3153 vol. 4, Issue 4, pp. 1-4, April 2014.

[7] C.V. Swarna Under Shade Net Condition "Effect of NPK on Plant Growth, Yield and Quality of Capsicum (Capsicum annum L.)" ISSN: 2319-7706 vol. 6, Number 3, pp. 1085-1091 March 2017.

[8] Syed Mohammad Kamruzzaman, Saifur Rahman Sabuj, Monirul Islam Pavel "Promoting Greenness with IoT-Based Plant Growth System: Intelligence and Sustainable Computing"research gate publications, chapter 12, September 2020.

[9] Priyanka Gnanalingam "Data Analytics in Agriculture" IISN: 2394-6598, vol. 4, Issue 5, pp.91-94, August 2018.

.