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Soil Monitoring and FertilizersRecommendation System

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Abstract— Agriculture comprises of cultivation of crops for food and fodder. Agriculture plays a significant role in the Indian economy as the main source of food. Scientific research and improved farming techniques helped India to achieve the Green revolution and attain a self-reliant status in terms of food production. India is the second-largest producer of wheat and paddy in the world. India is also the world largest exporter of spices, primarily exporting ginger, cardamom, curry powder, tamarind, fennel etc. Climate change and pollution have adversely affected the quality and yield of agriculture produce. Agriculture is the prime source of food production, and any mistake in it can adversely affect the food supplyand our normal course of life. This problem mainly arises due lack of appropriate tech for the farmers. So we have designed a Prototype that detects the soil contents and sends it to a server where the data is stored and displayed. Later we have deployed a model that takes the data from the server, does fertilizer recommendation and also crop prediction. And also the model can be also used to plant diseasedetection.

Keywords— Prototype, Model, Prediction, Recommendation, Detection

I. INTRODUCTION

The selection of plants based on the soil condition is an essentially important aspect of expanding productivity. The agricultural field must test and associate the fertilizer required for protecting the agriculture field. The crop classification can be done through the contiguously distributed information that is provided by the satellite remote sensing. Agricultural planning should begin by choosing suitable crop that gives a maximum output. The crop selection method is used to increase the yield rate with the following two factors: 1) crop selection and 2) the quality of the seed. Vast numbers of factors affect the yield rate of crops. To attain a maximum yield, various records about the different categories of crops over the years have to be predicted and analysed. With the database of these predicted values and suitable crops, highest yield can be obtained.[1]

Soil moisture, soil temperature and relative humidity are themost dominant parameters which play a vital role in the field of precision agriculture. Observation of these parameters is essential to inflate the crop productivity through Irrigation Management and by applying fertilizers in regular time periods. High soil temperature ruins the crops and low temperature restrains the roots from absorbing water from the field. Likewise, it is important to measure the soil moisture at proper time intervals because low moisture greatly affects the crops. Relative humidity (RH) is one another parameter which indirectly affects photosynthesis and the growth of the plant. High RH reduces carbon dioxide uptake in the plants.[2]

Composition of Soil with accurate amount of the fertilizer makes significant impact on the crop production. We are balancing deficient soil parameters with well-distributed right amount of nutrients. In a nutshell, soil preparation includes well distributed, healthy quality of nutrients with the right amount of water before the process of planting. This process of soil preparation is resulting in significant impact on the yield. Hence, before preparing the soil, there is the need of testing thesoil and analysing it, and finding the deficiency of soil nutrientsand parameters.

The Manual Soil testing has many shortcomings associated with it such as the attributes of the soil is not understood by checking, Consistent, time consuming and needs effort to reckon. During the scheduled process nutrient values may change.

II. RELATED WORK

Nikita et al 2016[3] indicates that the yield of the crop depends on the seasonal climate. In India, climate conditions vary unconditionally. In the time of crises- like drought, farmers face serious problems. So taking this into consideration they used some machine learning algorithms to help the farmers to suggest the crops that will give rise to better yield. They take various data from the previous years to estimate future data.

They used SMO classifiers in WEKA to classify the results. The main factors that are taken into consideration are minimum temperature, maximum temperature, average temperature, and previous year's crop information and yield information. Using SMO tool they classified the previous data into two classes thatare high yield and low yield. The acquired result for the crop yield production using SMO classifier gives less accuracy when compared to naïve Bayes, multilayer perceptron and Bayesian network. Eswari et al 2018[4] have indicated that yield of the crop depends on the perception, average, minimum and maximum temperature. Apart from that, they have taken one more attribute named crop evapotranspiration. The crop evapotranspiration is a function of both the weather and growthstage of the plant. This attribute is taken into consideration to get an appropriate decision on the yielding of the groups. Theyall gathered the dataset with these attributes and sent it as inputto the Bayesian network and classify into the two classes namedtrue and false classes and compared with the observed classifications in the model with a confusion matrix and bring the accuracy. Finally, they concluded that crop yield predictionwith Naïve Bayes and Bayesian network give high accuracy when compared to SMO classifier and forecasting the crop yield prediction in different climate and cropping scenarios willbe beneficial. Shruti Mishra et al 2018[5] has shown that by applying the data mining techniques on historical climate and crop production data, several predictions are made which haveincreased the crop productivity. The decision support system has to be executed for the farmers to take proper decisions aboutthe soil and the crops to be cultivated. They have collected the dataset with attributes of the crop season, area and production in hectares, and analysed it with various algorithms in WEKA. They analysed data with four methods and found their accuracyand compared with each other. The four methods used are J48,IBK, LAD tree, LWL in WEKA. They concluded that the IBKhad got more accuracy when compared to all other and that depends upon the nature type and the nature of the dataset. Chlingaryana et al 2017[6] indicated the major factor in the cropyield prediction is the level of nitrogen in the soil.

Nowadays remote sensing systems are generally used in decision making. These remote sensing data is used to help thefarmers to improve the crop yield. Huge remote sensing data isused to make a decision. Nitrogen is used to improve the crop yield and make the soil fertile. Machine Learning algorithms are used to make the decision. We are going to take major factors into consideration such as nitrogen, the type of soil and yield analysis of earlier data of these factors are helpful to makethe accurate decision and predict the yield and helps the farmer.Nowadays precision agriculture is used to improve the yield andin giving suggestion to farmers. It uses information technologyto ensure the crop and soil. It says how they need to utilise the production and health of the soil. The obtained results are back- propagation neural network and are used to get different vegetarian incidents. The conventional neural network of long term memory is used to predict future data. Dakshayini Patil at all 2017[7] indicated that rice crop plays a major role in the economy. They used various data mining techniques to predict the yield of the rice crop. Rice crop is the sustainable security of India. In general, it contributes 40% to the general yield. High yield of the crop is based on the appropriate climatic conditions. Learning a better strategy to grow the crop according to the climatic conditions can improve the crop yield. The reports utilize various mining techniques based on the previous data of the crop yield and different climatic regions. Inthis, the authors used data of 27 regions of Maharashtra to predict the yield of the crop. This weighted contribution to its yield enactment. One sort of system sees the hubs as “artificial neurons”. These are called neural systems. The back engendering calculation (Rumelhart and McClelland, 1986) is utilized in layered feed-forward ANNs. This implies the counterfeit neurons are sorted out in layers and send their signs "forward", and after that, the blunders are spread in reverse. Thesystem gets contributions by neurons in the info layer, and the yield of this arrange is given by the neurons on a yield layer. There might be a minimum of one middle of the road concealed layers. This neural arrange engineering is extremely mainstream, since it very well may be connected to a vast range of undertakings. The principal term, "feed forward" depicts how this neural arrange procedures and reviews designs. In a feed- forward neural system, neurons are just associated with forward. Each layer of the neural system contains associations with the following layer (for instance, from the contribution to the covered up layer), yet there are no associations back. The expression back spread portrays how this kind of neural system is prepared. A back spread is a type of managed preparing. When utilizing a managed preparing strategy, the system must be given both example inputs and foreseen yields. The foreseen yields are looked at against the real yields for given information. Utilizing the foreseen yields, the back proliferation preparing calculation at that point takes a determined mistake and changes loads of the different layers in reverse from the yielding layer to the info layer.

Abdipour et al.[8] calculated the performance of three different models which contained of artificial neural network (ANN) with radial basis function (RBF), component analysis and multi-linear regression model. This study aims at differentiating the performance of yield prediction of crop seedwith compositional effect on substances with error analysis holding of coefficient of determination (R2),Root Mean SquareError (RMSE), and Mean Absolute Error (MAE). Khosla et al.[9] conducted the estimation of kharif crops yield in two steps, the first of which predicts the rainfall with modular artificial neural network (MANN) and then estimates the yield with support vector regression (SVR). The dataset in this experiment contained information from the years 2000-2016 and got the output for the year 2018-2019 Jheng et al.[10] suggestion a different model with a surplus of the bootstrap method in the steps within the data, pre-processing the training data. This particular model which is being discussed is a hybridof SVR and the traditional SVR. The hybrid SVR model has a better performance in terms of predetermining the agricultural output with high sustainibility and high reliability. The model was assessed with the Root Mean Square Error (RMSE) and theCorrelation Coefficient (CC).

Ananthara, M. G. et al. (2013, February)[11] proposed a prediction model for datasets affiliating to agriculture which is known as CRY algorithm for crop yield using the techniques of beehive clustering. They considered the following parameters namely: crop type, soil type, soil pH value, humidity and crop sensitivity. Their analysis was majorly in paddy, rice and sugarcane yields in India. Their proposed algorithm was then compared with C&R tree algorithm and it performed extremelywell with an accuracy of 90 percent. Awan, A. M. et al. (2006, April)[12] built a new, intelligent framework focused on farm yield prediction clustering kernel methodology and they considered parameters like plantation, latitude, temperature andprecipitation of rainfall in that latitude. They had experimentedweighted k-means kernel method with spatial constraints for the survey of oil palm fields . Chawla, I. et al. (2019, August)[13] used distorted logic for crop yield prediction through statistical time series models. They took into consideration parameters like rainfall and temperature for prediction. Their prediction was of classification with levels of 'good yield' and 'very goodyield'. Chaudhari, A. N. et al. (2018, August)[14] used three algorithms namely Clustering Kmeans, Apriori and Bayes algorithm, then they merged the algorithm for improved efficiency of yield prediction and they considered criterias like Area, Rainfall, Soil type. Their system was also able to tell which crop is suitable for cultivation based on the mentioned features. Gandge, Y. (2017, December)[15] used many machinelearning algorithms for different crops. They studied and analysed which algorithm would be suitable for which crop. They have used Bee-Hive Clustering, Support vector Regression, K-means, C4.5 Decision tree, Neural Networks, etc. The factors implying were soil nutrients like N, K, P and soil ph.

III. PROPOSED SYSTEM

A. Soil sample collection

The soil test results will depend on the samples collected fortesting. Soil samples will be collected at various timespan of a year over different seasonal changes. The test soil can take fromthe field that possesses the changes in colors, changes in soil texture, before, fertilizers, organic amendments, and lime used. Soil samples will be collected using soil tubes, soil auger, gas vapor sampling, soil probes, sieves, and sampling probes, garden trowel, and spade. Scrape off all surface vegetation or litter from the soil to a certain depth.

The samples for soil tests should be collected randomly from the specified selected areas. Take 5-10 samples for relatively small areas like lawns, gardens, etc. For relatively large areas,

10-15 samples should be taken. Collect the subsamples in the clean plastic pail, mix it well and take one pinch of the samples and place it in a separate clean bag. Label each of the samples, for keeping it as a record. In this study, 15 samples have been taken from the area which has to be tested and sent directly to the testing centre.

B. Prototype

We have made a prototype for detecting the contents of soil sample. We have used the Arduino Nano for uploading the code for the prototype. The Arduino Nano is programmed using Arduino IDE. It operates at a voltage of 5V supply. ESP32 can perform as a complete standalone system or as a slave device to host MCU, reducing communication stack overhead on the main application processor. We have used ESP32 to receive the data transmitted from the Arduino Nano. To measure the soil moisture level, we used a Capacitive Soil Moisture Sensor. To measure the soil temperature we have used the DS18B20 Waterproof Temperature Sensor. The soil NPK sensor is used for detecting the content of nitrogen, phosphorus, and potassium in the soil. Basically it is used to detect the fertility of the soil. We have used the NRF24L01 Wireless Transceiver Module to send and receive data.

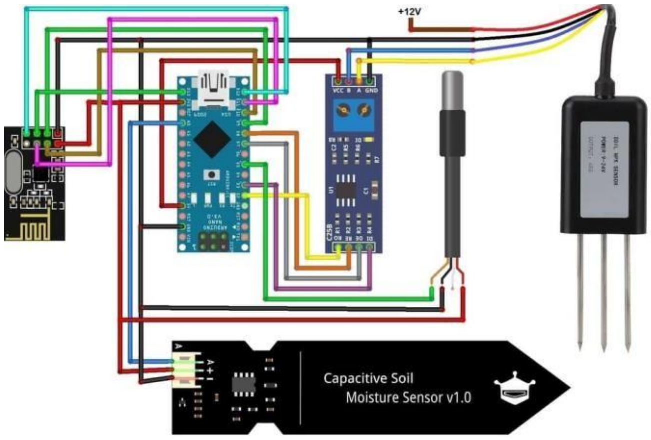

Fig. 1(a) Prototype connection 1

Various libraries are used for the deployment of the prototype. The libraries are NRF24L01, RH24, One Wire and Dallas Temperature Sensor Library.

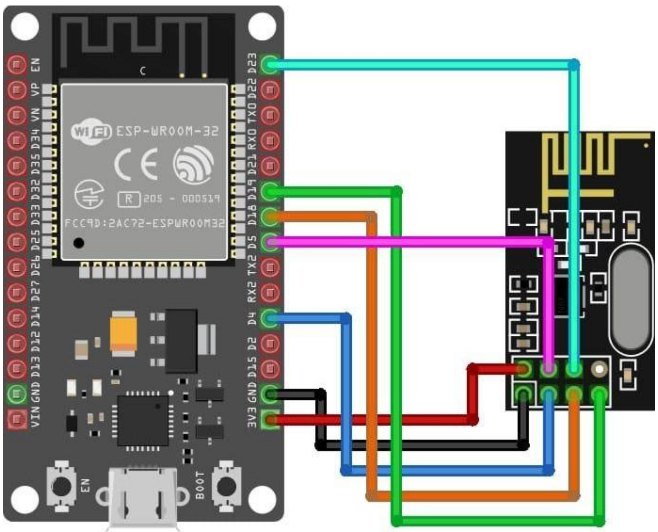

Fig. 1(b) Prototype connection 2

We have used Django for the web app so that it can be usedon the other platforms. HTML is used for frontend, backend andCSS. JavaScript is used to make the website more responsive and to create dynamic and interactive web content. NumPy is used for optimization for the heavy lifting coding work. Pandasis used for the preprocessing of the data. Matplotlib is used to plot the various data as well as to get the most out of the data. Especially for training and testing purposes. SicKit learn used for the recommendation part. We have used Heroku for the deployment of the project. We have used the Random Forest Algorithm for classification and regression problems.

C. Methodology

Environmental analysis of soil is in reference to figuringout the environmental measures of soil like humidity, temperature and soil moisture. We are using DHT11 sensor fordetectingtemperature and humidity connected withmicrocontroller ESP8266 WIFI Module. The frameworkutilizes software as ArduinoDroid_Arduino IDE. After compiling the code, we have uploaded code on the esp8266 anderified the output on serial monitor. For uploading data to the cloud, we have used thingspeak cloud service. While adding code for accessing thingspeak we create modules and variables.These variables help us in tracking data on cloud with API keys.

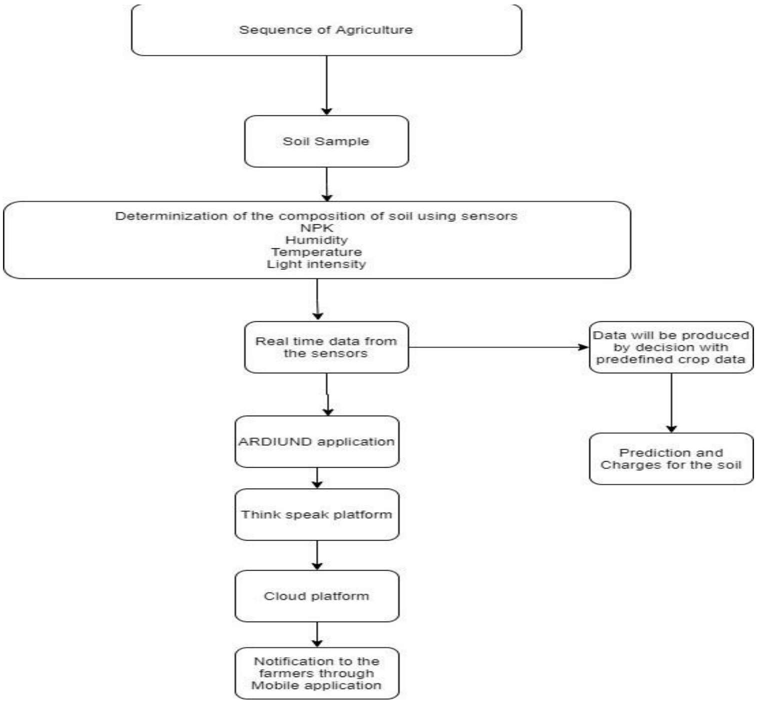

Fig. 2(a) Methodology

The nutrients content in the soil cannot be identified with human eye. Chemical analysis method is popular in laboratoryfor testing it, and that needs time, chemicals and instruments.

Our suggested method is to provide spontaneous results, withina portable device and remote access for the detection of soil nutrient. For soil nutrient Identification we used RGB colour sensor and soil doctor plus kit. The Soil doctor plus kit consistsof chemical tablets for chemical analysis of potassium, nitrogen, phosphorus and pH of soil. So, this unit isexceptionally a helpful nutrient detector.

Connecting Node MCU to Arduino permits internet access for uploading values to the cloud. We then link RGB sensor to the Arduino for taking readings. After connecting RBG sensor to the Arduino we have strengthened its accuracy and then we recorded RGB value readings of that test tube (Test tube is loaded up with soil sample and soil doctor plus kit’s tablets).

Several readings for getting accurate color values are taken. Additionally, we have made the device more interactive by floating a message on the on serial monitor window of Arduinodroid. This R, G, B value data is uploaded on the cloud (ubidots) through internet. After completion of upload, we have checkedthe readings on the cloud (ubidots). Output of RGB Values canbe visualized on Serial Monitor relating to Nitrogen, Ph. and Phosphorus, Potassium.

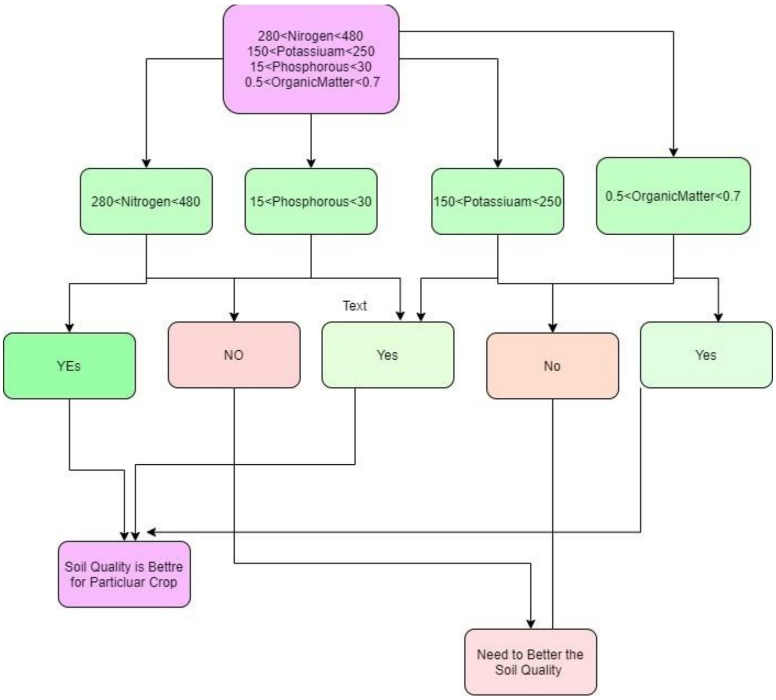

Fig. 2(b) NPK Sensor Working

IV. EXPERIMENTAL RESULTS

The prototype collects the data from the soil as shown in the below figure.

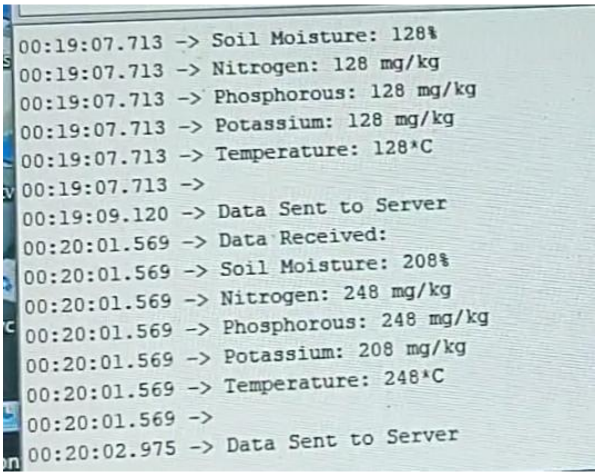

Fig. 3(a) Data collected by prototype

After that the Arduino Nano sends the data to the Thingspeak server where the data can stored, displayed and further used for various purpose. The Thingspeak website displays the results in graphical format like shown in the figurebelow.

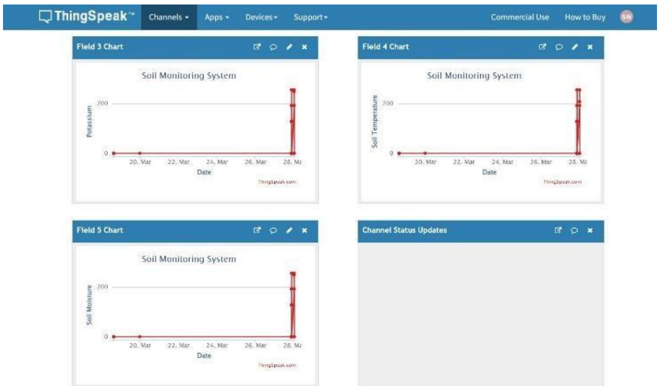

Fig. 3(b) ThingSpeak Server page

From here the data is taken used for the website model thatwe have developed using ML and DL. In the below figure we are inputting data received from our prototype through thingspeak server to our website model.

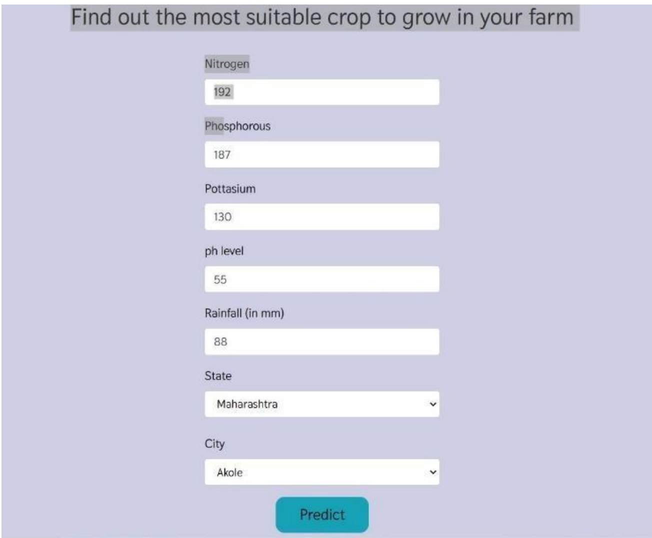

Fig. 4(a) Crop Prediction Website interface

In the below figure, this is how our model will pre- processthe data and predict the crop suitable for the sample soil we haveprovided the data for.

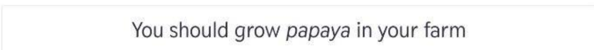

Fig. 4(b) Prediction Result

Our application also predicts the fertilizer for the soil that isneeded to grow a particular crop.

Fig. 5(a) Fertilizer Recommendation website interface

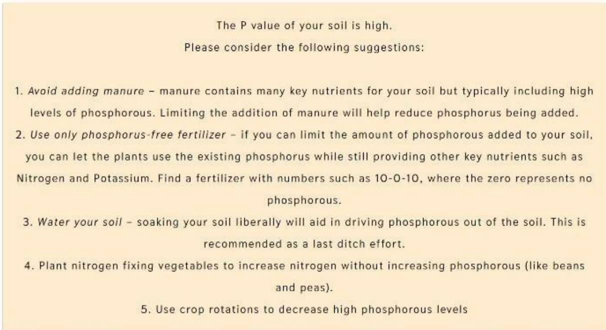

Fig. 5(b) Fertilizer Recommendation results

Our website application can also be used for detecting thetype of disease on the plant using image preprocessing.

Fig. 6(a) Plant disease detection website interface

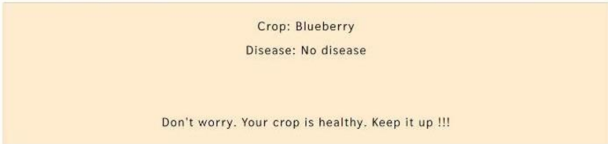

Fig. 6(b) Plant Disease Detection Results

V. CONCLUSION

We have successfully done soil analysis of samples at variouslocations using the framework suggested in this report. An APPhas been developed and installed on the mobile phone of the farmers. The soil test report has been entered in the APP, and itwill find the respective crop suitable for the agriculture field. Moreover, the APP sends all the information such as fertilizer requirement, nature of the soil, etc. to the field controller. The algorithm developed for the Soil-test-based Crop Selection Method evaluates different parameters of the field based on thedata received from the field sensors. Pillared on the fertilizer information, the controller merges the percentage of each of them, and properly distributes it to the field.

The output values of the color sensors are captured on cloud as R, G, B values. These values are mapped with color chart provided by manufacturer. We have made all the real time values accessible on cloud related to temperature, humidity, soilmoisture, R, G, B location to any person with valid credentials.This facility is useful for farmers to monitor soil parameter at fingertip from smart phones with valid API credentials. This proposed framework is useful for farmers for getting real time soil parameters at fingertips, without waiting for soil testing labresults. Implementation and real time monitoring of the soil contents can be performed.

Based on the results we can make changes and can again track the progress of the crop for better quality and quantity of the yield.

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