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Review on Soil Analysis for Future Crop Prediction

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Abstract: As India is agricultural based country. In a field of agriculture, sustained harvesting must be followed with fixed check of fertility rate of soil because soil nutrient measurement is very essential and plays an important role in proper plant growth and effective fertilization. The more accurate method leads to better future of farmers. In this paper we have reviewed many methods for measuring the soil nutrients. The traditional approach is to perform test in soil testing laboratories where chemical process is performed after drying the soil and other preprocessing but it leads to more efforts and tedious process. As a solution a smarter way in which the level is observed and measured using Photodiodes, Light Emitting Diodes, analog-to-digital converter (ADC), FPGA and NIR Laser. AS a result it will leads to more time saving and detailed measure of nutrients. According to NPK values of soil that are acquired and whether attributes, prediction of future crop is possible. Using various techniques for measuring soil nutrients and according to that nutrients using various classification and machine learning algorithms we can make the prediction of which crop to cultivate. Those Methods are studied analyzed according to various requirements.

Keywords: Data mining, NPK detection, Optical transducer, Soil fertility, Classification, Crop prediction

I. INTRODUCTION

The agricultural yield relies on fertility of soil, the nutrients available in soil and other real time parameters like moisture level, temperature, humidity, rainfall, soil type, etc. Soil macronutrient testing is helpful to determine the nutrient content in soil before applying fertilizer for quality and process controls of agricultural productivity and soil fertility. In the current scenario, Because of the time difference of soil sample collected at the field and when it is measured in a laboratory the manual method of measuring the soil nutrients is less accurate and it is also expensive. It leads to necessity of creating a smarter agriculture [1] practice through Internet of Things (IoT) to focus on this challenge. Spectroscopy is an emerging technology which is rapid and simple has been widely used in agricultural and food analysis processes [1]. The capability of spectroscopy to characterize material from the transmission or absorbance has been used to measure nitrogen (N), phosphorus (P) and potassium (K) content in organic soil. Here we are mainly focusing on soil nutrients (NPK). Nowadays, soil nutrient testing or precision agriculture (PA) is required to determine the nutrients availability in soil in process control of agriculture produce and soil fertility. There are four types of soil sensor have been used to measure various soil parameters which are mechanical sensor, optical sensor, electrochemical sensor and electrical and electromagnetic sensor [1].

The rest of the paper is designed as follows. Section II involves methods for measurement of soil nutrients and data mining methods for crop prediction, section III contain a conclusion.

II. ANALYSIS

Here I have refer papers with reference to main two modules:

A. Soil Parameters acquisition:

Soil Parameters like pH, Humidity, Temperature, Moisture such real time variable parameters and Chemical concentrations such as NPK (Nitrogen, Phosphorus, Potassium) has to be acquired first to measure the soil fertility.

Spectroscopy is a rapid, less expensive and non-destructive analytical technique which is widely use in optical method to detect the nutrients content in soil without the needs of chemicals such as laser-induced breakdown spectroscopy (LIBS) and near infrared (NIR) spectroscopy. By absorbance or reflectance of materials, spectroscopy technique can distinguish the elements corresponding its specific wavelength. One of the method which is LIBS technique give real-time analysis, simple sample preparation and small amount sample requirement but due to soil heterogeneity and matrix effect, this technique is difficult to analyze [1].

To overcome LIBS technique limitation, LED and color reagent technique has been implemented which has low power consumption and less expensive. This technique is adopted for this research not limited to its efficiency and low power consumption, but it does not require acids or other dangerous chemicals. Objective of optical sensor method is to study the absorption of soil sample using visible light and obtain the optimum wavelength that shows the maximum absorbance for soil sample.

Using Beer's Law of Absorbance [2] the prototype of optical transducer to measure NPK of soil has been proposed which is shown in fig [1].

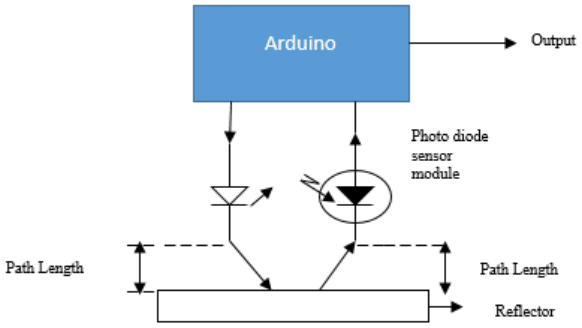

Figure 1 Schematic diagram of the experimental setup for measuring light path length [1]

Optical transducer is made up of Arduino, LED and Photodiode. Optical characteristic owned by NPK soil is used to implement such method. According to Beer's Law, following equation gives absorbance (A);

$$A = -\log 10 \frac{I_1}{I_0}$$

Where I_1 is transmitted light and I_0 is incident light [2]. Another method is based on NIR Laser absorption technique. When IR beam interacts with soil sample, the scattered light is detected at photo detector. The amount of photon absorption by a particular sample can be easily found out by calculating transmitted light intensity at detector [3]. As results Nitrogen (N), Phosphorus (P), and Potassium (K) gives different peak of absorption for different wavelengths of lasers in which, samples with nitrogen content shows high absorption characteristics of photons. It is simple and non-destructive analytical method to quantify several soil properties simultaneously. The use of Artificial Neural Network [4] where after taking images of sample and applying various image preprocessing techniques using neural network the level of pH and soil nutrients are determined. So, many farmers are not practicing the conventional method of soil preparation which includes the use of soil test kit.

Various electrochemical sensors can also be used which are Ion Selective Electrode (ISE), Selective Field Effective Transistor (ISFET), etc. ISEs were reported to detect soil nitrate, ammonium and potassium. To now date, no auspicious ISE for phosphorus detection was announced, but several literatures introduced that the PVC-based membrane ISEs could be used to measure phosphate content in biological samples [5]. ISEs were used for soil nutrient detection in two directions: (1) Flow Injection Analysis (FIA) systems and (2) vehicle-based soil sensing systems. ISEs might not have been ready for real-time sensing applications because of their response delay (several minutes) [5]. ISFET is the integration of an ISE and a field effect transistor (FET), where the ion selective membrane is placed on the top of the insulator layer of the FET structure, so the threshold voltage of the ISFET can be chemically modulated and the measured voltage is related with the concentrations of a target ion and have several advantages over ISEs, such as small dimensions, low output impedance, high signal-to-noise ratio, fast response and the ability to integrate multi-ISFETs on one chip [5]. Real time soil monitoring is also possible using wireless sensor network (WSN) where different sensors senses continuously and sends the data to the cloud [6] [7].

B. Crop prediction according to Soil Nutrients:

Soil nutrients plays an important role in growth of crops. There is a close relationship between what yield and soil nutrients.

Various methods of data mining techniques for classification like Naive Baye's [9], KNN, SVM [10] and Machine learning algorithms like Neural Networks [11], linear regression [12] or multiple linear regression is used to predict the future crop.

Predicting agriculture product plays a significant role in agriculture planning. It helps in making business strategy, product storage, and risk management [10]. There are mainly two methods to predict agriculture product in advance. First one is statistics method such as Autoregressive Integrate Moving Average (ARIMA), Holt-Winter, etc. and another one is machine learning method such as Support vector machine and artificial neural network. These methods are comparatively study over Thailand's pacific white shrimp export data and Thailand's produced chicken data using support vector machine and ARIMA model [11]. Whereas support vector method gives more accurate result than ARIMA. Moreover, machine

learning methods are convenient to implement and comparably faster than statics methods.

For establish the causal relationships between the winter wheat yield and the soil spatial distribution nutrients, i.e., water content, organic matter, total nitrogen, alkali-hydrolysable nitrogen, rapidly available phosphorus and potassium, a feasible method was, BP neural network [11]. The topological structure of the network model was 6:9:1 in which after the network was trained by 50 soil samples and then it was and validated by the remaining 13 ones, the average relative error of the prediction crop yield was 3.65%, 8% was maximum and the 0.7% was minimum. The fitting results of the crop yield and each soil characteristic showed that the water content and alkali-hydrolysable nitrogen were linear to the crop yield, the total nitrogen, organic matter and rapidly available potassium were respectively multinomial to it and that the rapidly available phosphorous was of the exponential relationship with the crop yield [11]. So, this model can also be useful in other accurate management of fertilization like fertilization and irrigation.

Using regression analysis we can study the relationship between independent variables in different scientific researches and production practices. In the current weather and soil conditions to predict most profitable crops Zingade has used machine learning technique. The proposed system will integrate the data obtained from repository, weather department and by applying machine learning algorithm: Multiple Linear Regression, a prediction of most suitable crops is made as per the present environmental conditions [12]. A careful examination of the data related to soil, weather, pH and past year production has been done by the system and suggests which are the most profitable crops that can be cultivated in the present environmental condition, also examines the past production of data which will help the farmer get insight into the demand and the cost of various crops in market [12]. Prediction analysis can improve crop yield productivity and increase the gross margins of farmer which is going to help them over a longer run.

[14] has presented a new method called Crop Selection Method (CSM) to select sequence of crops to plant over the season. CSM method may improve net yield rate of crops to be planted over season which resolves selection of crop (s) based on prediction yield rate influenced by parameters like weather, soil type, water density, crop type, etc. and takes crop, their sowing time, plantation days and predicted yield rate for the season as input and finds a sequence of crops whose production per day are maximum over season. Performance and accuracy of CSM method depends on predicted value of influenced parameters, so there is a need to adopt a prediction method with more accuracy and high performance [12].

III. CONCLUSON

Various methods those are studied are having its own pros and cons. By use of optical transducer it can be reduce the problems in determining the amount of nutrients in soil with cheaper cost then other technology. For crop prediction KNN is good and easy to implement also multiple crop suggestion can be done by maintaining the threshold value. It will leads to the big change in Indian agriculture. Framers and the nation can take the advantage of technology to make farming smart.

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