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Automatic testing of Soil Moisture, pH using Arduino and Selection of Specific Crop

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Abstract - A soil test may refer to one or more wide variety of soil analyses conducted for one of several possible reasons. Possibly the most widely conducted soil tests are those done to estimate the plant- available concentration of plant nutrients in order to determine fertilizer recommendations in agriculture. Soil testing is used to facilitate fertilizer composition and dosage selection for land employed in both agriculture industries. Automated soil testing device is an electronic device which can be used to measure soil moisture, soil pH values to ensure the fertility of the soil in the field of agriculture to select the suitable crop using Arduino.

Keywords – Soil Moisture, Soil pH, Arduino, Agriculture and Fertilizers.

I. INTRODUCTION

From time immemorial agriculture has been a part of the human civilization. It has transformed the way humans survive. The economy of a particular area was indirectly dependent on agriculture and was a major thrust behind the industrial revolution. Advancements in the field of science and technology led to increased yield. Applying electronic monitoring systems is one of the technologies for analyzing important conditions required for optimum growth of crops. The conditions can be listed as soil moisture and soil pH. There are valuable data that could decide the crop life cycle. Efficient use of these parameters increases the output per crop and minimizes crop loss.

The precision agriculture involves the effective control of farming inputs to raise the profitability of crop production, improve crop quality, and protect the surroundings. Information regarding variability of different soil parameters in a field is necessary to the decision-making process [1]. The chemical and physical properties of soil can be easily mapped by various soil sensors.

Soil moisture is one of the most important parameter influencing crop yield. It plays a major role for efficient photosynthesis, respiration, transpiration and transportation of minerals and other nutrients through the crops [2]. If the moisture content of a soil is optimum for crops growth, crops can readily absorb soil water. Soil water dissolves salts and makes up the soil solution, which is crucial as a medium for the supply of nutrients to developing crops.

The pH of the soil solution is very important because the soil solution carries major nutrients such as Nitrogen (N), Potassium (K) and Phosphorous (P) that plants need in specific amounts to grow, thrive and fight off diseases [3]. If the level of pH of soil more than 5.5, it raises the nitrogen content in it. When soil pH is between 6.0 and 7.0 then phosphorous is also available to the plants. Certain bacteria convert atmospheric nitrogen into a form that can be used by plants for its growth. Plants cannot utilize N, P, K and other nutrients if soil solution is too acidic. In acidic soils, plants are more likely to take up toxic metals and some plants eventually die of toxicity.

II. LITERATURE SURVEY

Miao Zhang et al., [4] worked on detecting soil nutrients using the automatic fluidic system. In this study, an automated fluidic control system was developed for rapid detection of soil nutrients. Micropump and valves, controlled by a laptop computer, delivered a sequence of test solutions to a test chamber where ion-selective electrodes are mounted. A 90 seconds test time with acceptable accuracy was demonstrated. This automated soil nutrient fluidic system can further be miniaturized and may be useful for in-field rapid detection of soil nutrients. Micropump and valves were used for solution delivery. A custom controller software runs on the laptop was programmed to automatically control the fluidic system. ISE electrodes were employed as the soil nutrient sensors. This automatic fluidic system can further be miniaturized for in-field rapid detection of soil nutrients. To lower the cost, the laptop computer can be replaced with a low-cost stand-alone embedded system.

John Carlo Puno et al., [5] worked on determining soil nutrients and pH using Image processing and Artificial Neural Network. In this study, image processing and the artificial neural network was used to efficiently identify the nutrients and pH level of soil with the use of Soil Test Kit (STK) and Rapid Soil Testing (RST).The use of an artificial neural network is to hasten the performance of image processing in giving an accurate result. Soil Test Kit is a method that gives the macronutrient level of the soil in a short period of time. It involves colorimetric that measures a qualitative number of primary macronutrients and it also includes the pH level of the soil where it determines whether the soil is acidic, neutral or basic. The result will be used as a basis for making fertilizer recommendation. BSWM continues to make new soil test also known as Rapid Soil Testing (RST) that measures secondary macronutrients that are essential nutrients for plant growth and gives information on how much specific fertilizer are prescribed. The composition of the system is made up of five sections namely soil testing, image capturing, image processing, a training system for neural network and result. The outcome will provide the result of the qualitative level of soil pH, nitrogen, phosphorus, potassium, zinc, calcium and magnesium.

Piyush K. Surkar and A R Karwankar [6] worked on automatic testing of soil samples using Ion selective electrodes. Ion-selective electrodes (ISEs) are a favorable approach due to their small size, quick response, and ability to directly measure the analytic solution. These sensors provide the conversion of chemical information into an electrical signal. The control unit consisting of Arduino Uno converts this analog information and provides suitable data to the output unit consisting of LCD and printer. With the increased capability of modern automatic titrations, it is possible to measure ion content in minutes using an ion-selective electrode (ISE). The Arduino Uno is based on the ATmega328 microcontroller. Automatic soil testing is a favorable method to measure the soil properties in a speedy manner than many traditional lab methods. They can be used for on-field soil inspection for better precision farming. Ion-selective electrodes provide for the majority of measurable macronutrients in the future.

III. PROPOSED METHODOLOGY

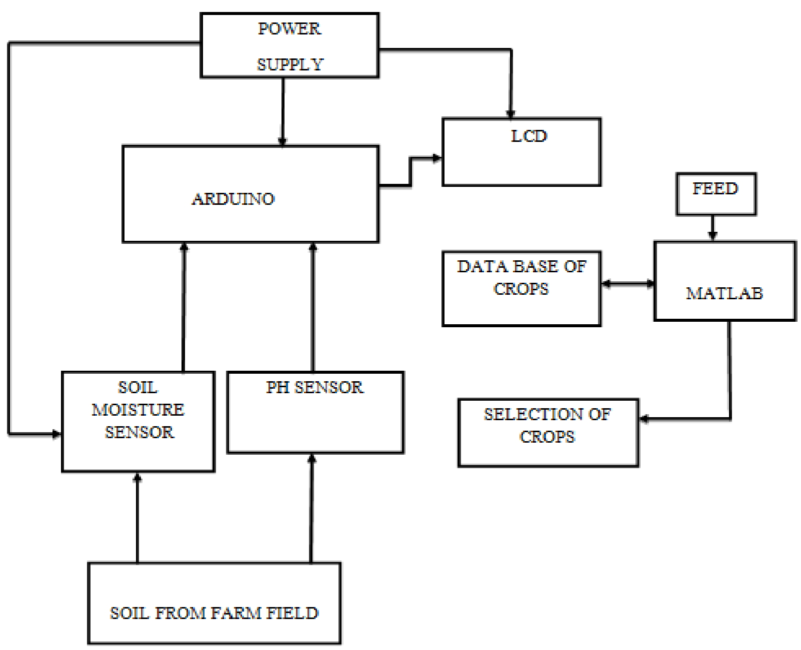

Figure 1: Proposed Model for automatic testing of Soil samples and Selection crops.

The proposed model works in two stages, firstly testing of soil samples in the farm field of Soil moisture and soil pH using the Arduino processor, secondly feeding the gathered dataset of Soil moisture and soil pH gathered through a processor and feed for the decision model to select the specific crop to be grown in that condition to get better productivity and manage resistance of crop.

a. pH Sensor

Hydrogen ion concentration of any solution can be measure by its pH value. The range of pH varies from 0 to 14, if any solution having pH value close to 0 it treated as a highly acidic, where as its value close to 14 is consider as a highly alkaline. A special selective hydrogen ion electrode (pH rods) is also immersed in the solution for electrically measurement of the pH value. This electrode gives an output voltage that changes its value according to the concentration ratio of Hydrogen ions inside the electrode as comparison to those which are outside the electrode [7]. The output of the reference electrode does not depend on the concentration of ion ratio. After measuring the voltage between these 2 electrodes i.e. between reference and a special electrode, the pH of the solution can be determined. In order to measure pH and get accurate results, several challenges must be taken into account. These are:

1. The voltage obtained by the standard pH sensor varies from +400 mV to -400 mV, whereas pH range varies from 0 to 14 at room temperature.

2. The impedance of the pH electrode is very high that act as a second major issue. Due to this high impedance the current that passed to the measuring circuit by the electrode is very small.

3. Temperature also effect on the pH measurement. The effect of temperature becomes critical as we move away from a pH value of 7 and as the temperature moves away from 45 °C. For example, at a pH of 4 and temperature of 95 °C the error could be as much as 0.7 pH.

In order to overcome all these challenges, a circuitry has been designed with Adjustable gain and offset. In order to normalize (Zero for 7pH) we will need to add an adjustable offset control. Since the pH probe should produce 0V at pH7 the gain portion of the circuit will not affect this reading, which is why we adjust it in the offset portion. When combined with gain adjustments we can make a simple circuit that is able to be calibrated much like most commercial pH units. Below is the simple schematic which incorporates the trimmer pots that will let us adjust for calibration and normalization.

Table 1: pH electrode characteristics

VOLTAGE (mV)	pH value	Voltage (mV)	pH value
414.12	0.00	-414.12	14.00
354.96	1.00	-354.96	13.00
295.80	2.00	-295.80	12.00
236.64	3.00	-236.64	11.00
177.48	4.00	-177.48	10.00
118.32	5.00	-118.32	9.00
59.16	6.00	-59.16	8.00
0.00	7.00	0.00	7.00

b. Soil Moisture

Soil moisture sensors measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors [8]. One common type of soil moisture sensors in commercial use is a Frequency domain sensor such as a capacitance sensor. Another sensor, the neutron moisture gauge, utilizes the moderator properties of water for neutrons. Soil moisture content may be determined via its effect on dielectric constant by measuring the capacitance between two electrodes implanted in the soil. Where soil moisture is predominantly in the form of free water (e.g., in sandy soils), the dielectric constant is directly proportional to the moisture content. The probe is normally given a frequency excitation to permit measurement of the dielectric constant. The readout from the probe is not linear with water content and is influenced by soil type and soil temperature.

- In this sensor we are using 2 Probes to be dipped into the Soil
- As per Moisture We will get Analog Output variations from 0.60volts - 5volts
- Input Voltage 5V DC

Hardware implementation done on an Arduino Uno board with operating voltage range varying from 5-12 volts, the mapping of the read and write digital pin done at 5 volt with 20mA operating condition using Soil pH sensor and Soil Moisture sensor. pH sensor output pin is connected to A0 pin Arduino Uno board. Soil moisture sensor output is connected to A1 pin of Arduino Uno board. The outputs of these two sensors are analog values. The analog values can be converted into digital values by using the formula,

Moisture = (analog value/1023)*100
pHv = analog value*5/1024/6
pH = -5.70*pHv + calibration
These digital values are displayed on 16*2 LCD.

Table 2: standard values for crop selection

Crops	Soil pH
Cabbage	6.5-7.0
Capsicum	6.0-6.5
Potato	5.0-6.0
Radish	6.0-7.0
Tomato	5.5-6.5
Cucumber	5.5-6.0

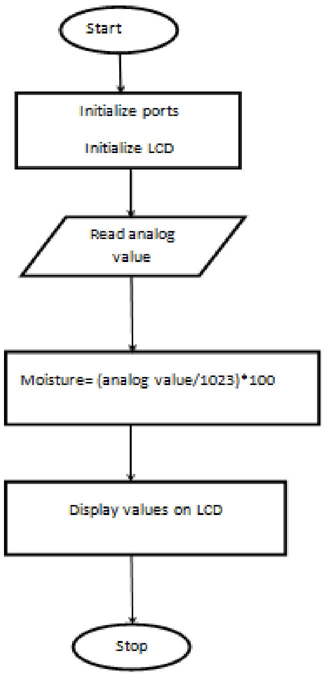

Figure 2: Flowchart to find Soil Moisture in the soil

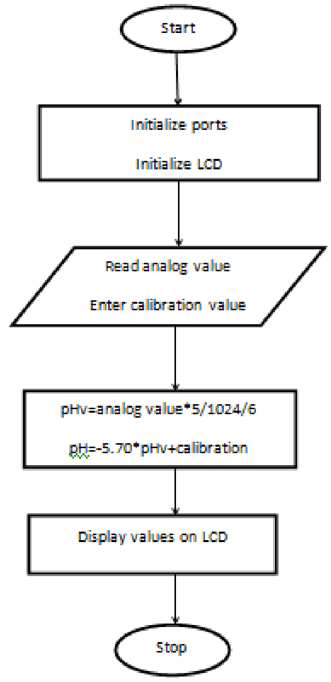

Figure 3: Flowchart of Determining Soil pH in the soil

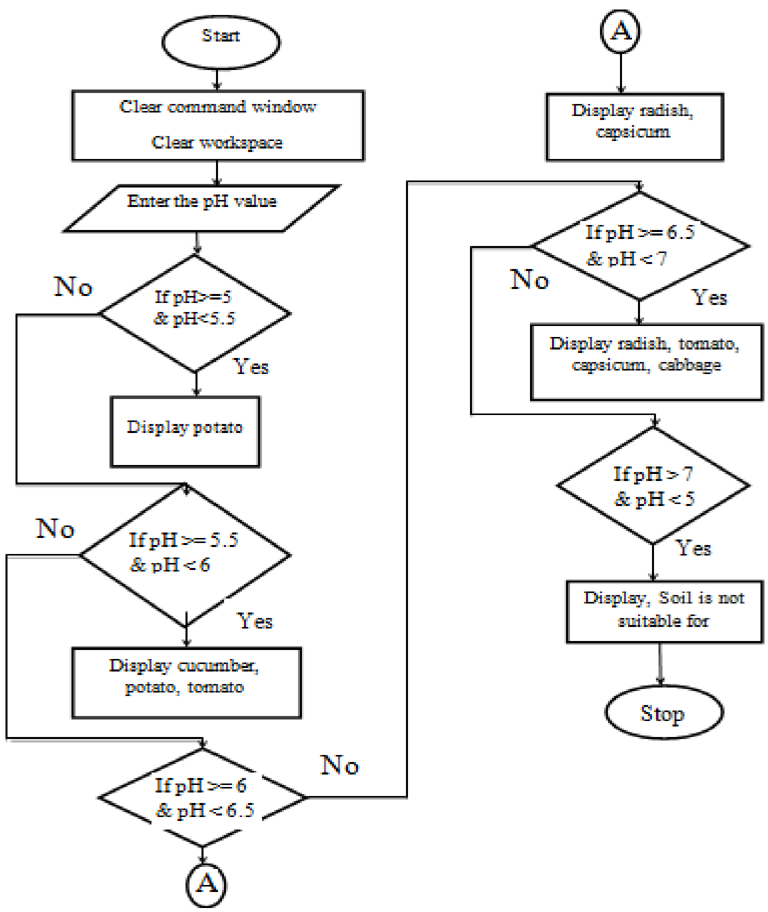

Figure 4: Flowchart for selection of crops

In soil samples, based on the pH values i.e., the crops are selected. Then the displayed datasets are feed manually to the decision software to get the specific suited crop to the site specific field. As shown in the above flowchart.

IV. RESULT

Here collected around 50 soil samples from the farm field of various regions in Mysore for the test purpose. The output of pH and moisture content in soil sample 1 are 6.94 and 63.54% respectively. Since the pH value is neutral, the selected crops are radish, cabbage, tomato and capsicum based on table 6.1.

Figure 5: output OF ph value in soil sample 1

Figure 6: output of moisture content in soil sample 1

Figure 7: selection of crops

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