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Analysis of Smart Technologies for Smart Gardening

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ABSTRACT: Plants are important for all forms of life and a great source of medicine for life-threatening diseases. In the proposed work, the amount of water absorbed by the soil, the surrounding temperature in which the plant grows, the amount of sunlight received by the plant and the major nutrients which are present in the soil were determined for efficient growth of plants. The moisture content of the soil and the amount of sunlight received by the plants are continuously monitored with help of the Soil moisture sensor and the Light Dependent Resistor respectively. The major nutrients like Nitrogen (N), Potassium (K), and Phosphorous (P) of the soil are detected with the help of Color sensor TCS3200. The surrounding temperature level also plays a major role in the growth of the plant which is monitored with the help of the temperature sensor LM35. All these information are transferred to the user's smart phones applications such as ThingView and Blynk from Node MCU via ESP8266 Wifi module. Thus the user can keep a track of the plant's growth from any remote location. This system efficiently manages both, water and nutrients level present in the soil without the presence of the user enabling the use of smart technologies for smart gardening.

KEYWORDS: Smart technologies, Smart garden, Sensors, Arduino, Cloud and Node MCU

I.INTRODUCTION

Agriculture is the backbone of India. Irrigation is one of the major concern and so are the other nutrients required for the healthy growth of the crops and plants. The objective of the proposed work is to test the soil moisture, intensity of sunlight, surrounding temperature and nutrition of the soil automatically by using Node MCU. Water contained in soil is called soil moisture[2]. Soil moisture level is a measure of how wet or dry the soil is. The water is held within the soil pores. Water is the most important component of the soil in relation to plant growth. If the moisture content of a soil is suitable for plant growth, plants can readily absorb soil water. Not all the water, present in soil, is available to plants. Most of water remains in the soil as a thin film. Soil water dissolves mineral salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants. Soil moisture act as a key variable in controlling the exchange of heat energy and water in between the land surface and the atmosphere through evaporation and plant transpiration [1]. As a result, soil moisture plays a role in the development of weather patterns and the production of precipitation. Soil moisture strongly affects the amount of precipitation that runs off into the nearby streams and rivers [9].

The second most important thing is the major nutrients available in the soil such as nitrogen, phosphorous, potassium for plant growth which varies with different types of soil. Plants also need small quantities of minor nutrients iron, manganese, zinc, copper, boron and molybdenum [3].Soil nutrients will get depleted after every harvest and hence they should be replenished[10]. To maintain the nutrient levels in the soil and also in case of deficiency, fertilizers are needed to be added to soil. Most of the farmers choose to imprecise the amount of fertilizers and try to add them manually. Right amount of fertilizers should be added in order to prevent the excess or insufficient addition that can harm the plant life and reduce the yielding process. Colour sensors are needed to decide how much extra content of these nutrients are to be added to the soil to increase soil fertility. This can improve the quality of the soil and reduces the undesired use of fertilizers to be added to the soil [11].

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Light is an essential factor in maintaining plants. The growth rate and time length of a plant remains active which depends on the amount of light it receives. Plants use sunlight as a source of energy for photosynthesis process. The number of hours of day sunlight per day directly affects flowering [6]. Also excessive light is as harmful as too little [7]. Temperature influences the plant growth in short term or long term and finally helps in crop yields. Different parts of the plants react differently to temperature [4]. Temperature will affect the plant in the short term as well as the long term basis [8].With the help of modern trends and automated techniques, we have provided a solution with the help of different sensors interfaced together with the Node MCU to determine necessary condition for the plant growth.

II.METHODS AND MATERIALS

The working model of the smart technology enabling smart gardening is as shown in Figure 1. For measuring the Sun light intensity, the Light Dependent Resistor (LDR) is used. The LDR is placed where the plant is to be planted. Thus the amount of Sun light that the plant received is obtained.

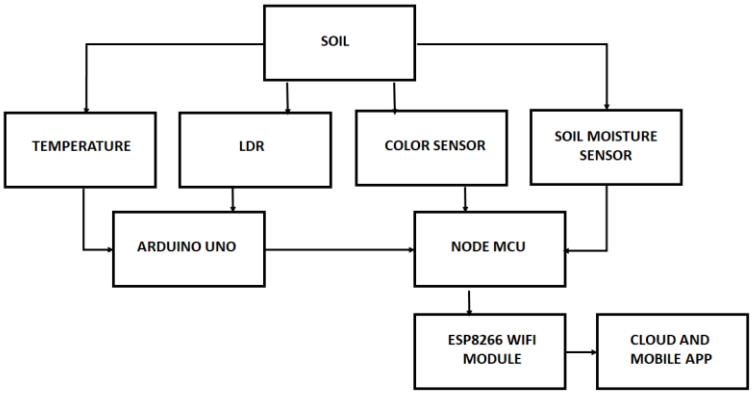

Figure 1. Working Model of Smart Technology

The output value is the resistance (Ohm), which varies according to the intensity of the light that falls on the LDR. The surrounding environmental temperature of the plant is measured by using the temperature sensor LM35. The output value is measured in millivolt which is converted into Celsius or Fahrenheit based on our requirement or user's comfort using the formulae.

The water requirement by the plant is measured by using the soil moisture sensor, which will be inserted in the soil where the plant is planted. It measures the capacitance value of the soil which in turn determines the level of the moisture present in the soil. If the soil is dry the output value of the sensor is high and vice versa. Thus based on the value obtained we can water the plant. The moisture sensor output differs for different type of the soil.The major Nutrients required for the plant growth is measured with the help of colour sensor. Each select line sets corresponding to different colour represents the different level of nutrition. The output value is obtained in terms of frequency which indicate the amount of corresponding nutrition in the soil (say.,) N, P and K. The activated photodiode in the sensor corresponds to different colour, thus when exposed to the soil, detects corresponding nutrients as given in the Table 1.

Table 1. Colour related to Nutrients

COLOUR	NUTRIENTS
Red	Potassium
Green	Phosphorous
Blue	Nitrogen

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Each sensor will be activated with the embedded C code coded in Arduino IDE platform. The LDR and Temperature sensor (LM35) is connected to Arduino UNO board and the data from this board is sent to Node MCU board via UART serial communication. The moisture sensor and the colour sensor are connected to Node MCU. The output values from both will be displayed on the serial monitor. The same value will be uploaded to the Cloud via ThingSpeak web platform through Wi-Fi module ESP8266 which is inbuilt in the Node MCU board. There the value will be displayed in either graph or numerical value or a gauge meter. With the help of the Think View mobile application the same values will be viewed in the Mobile phone if the Channel Number and Write API key of the ThingSpeak channel is provided.

III.PROCESS FLOW

The process flow applied in the smart model enabling the use of emerging technologies in smart gardening is shown in Figure 3. Moisture sensor inserted in the soil and the color sensor is kept at a certain height above the soil and is interfaced with Node MCU. If the sensor value is above the threshold value set, the message "Water is needed" is displayed, else "No water is needed" is displayed. Depending upon the select lines sets, the RGB value is obtained. Each color corresponds to three different major nutrients that is Red-Potassium, Green-Phosphorous, Blue-Nitrogen values. LM35 sensor and LDR is interfaced with the Arduino Uno. Then the result of LDR (V0) is used for calculating the intensity of the sunlight and the surrounding temperature value is obtained. The output obtained from Arduino Uno is serially communicated to Node MCU. The sensed values can be continuously observed in the ThingSpeak cloud platform and also viewed in the ThingView and Blynk Application.

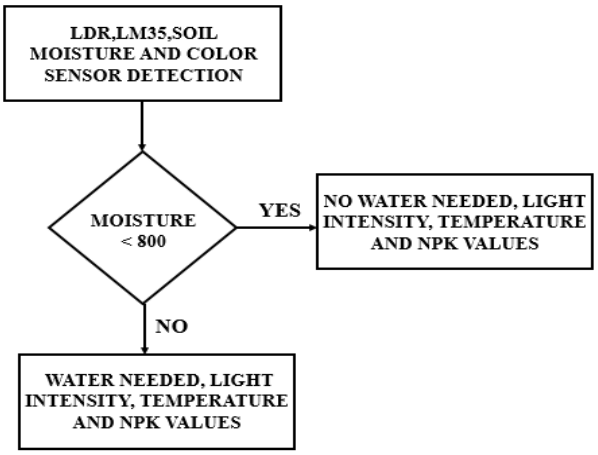

Figure 3. Process flow

IV.RESULTS AND DISCUSSION

Four different types of soil used in the analysis are Red soil, Clay soil, Coastal soil and Black soil.Different types of crops and plants are used in the analysis based on the type of the soil suitable for their growth. The output of LDR and temperature sensor are shown in Figure 4. It is observed that the light intensity value changes between 90 and 130 and the temperature value varies according to the surrounding atmospheric condition which helps in the plant growth.

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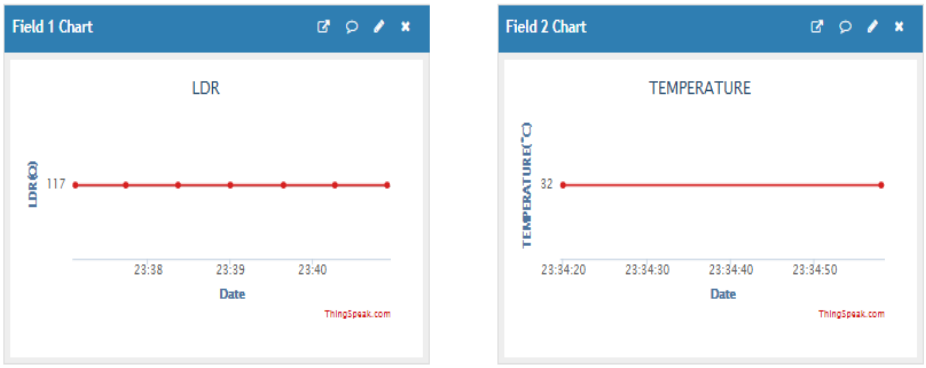

Figure 4. Output of LDR and temperature sensor

Maize is planted and tested in the red soil which provides the observations as shown in Figure 5. The moisture level varies according to the wetness of the soil, that is with water the value is between 100 and 400 while without water the value is around 1000.When water is poured, the moisture level increases gradually (than sand), indicating that the red soil absorbs water slower than the black soil. Quick dryness does not occurs in this soil, hence the plants which grows in this type of soil needs moderate amount of water for their growth. Maize, Millets, cotton, etc., are the plants which grows in this type of soil. And the figure also shows the deficiency of the nutrients such as Nitrogen, Phosphorous and Potassium in percentage.

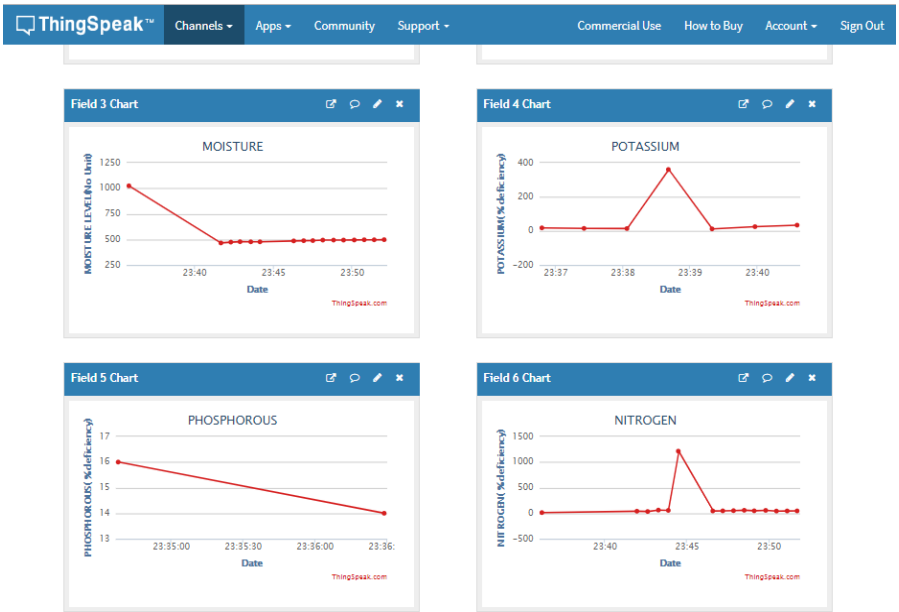

Figure 5. Output of Moisture level and Nutrition value of Red Soil

To analyze the black soil, Green grams are used. As shown in Figure 6, the moisture level varies according to the wetness of the soil, which is with water the value is between 200 and 400 while without water the value is between 900 and 1000. When water is poured, the moisture level increases exponentially, indicating that the black soil absorbs water quickly. This type of soil is suitable for plants that need more amount of water for growth. Green grams, Beans, Turmeric, etc., are the plants which grows in this type of soil. And the figure also shows the deficiency of the nutrients such as Nitrogen, Phosphorous and Potassium in percentage.

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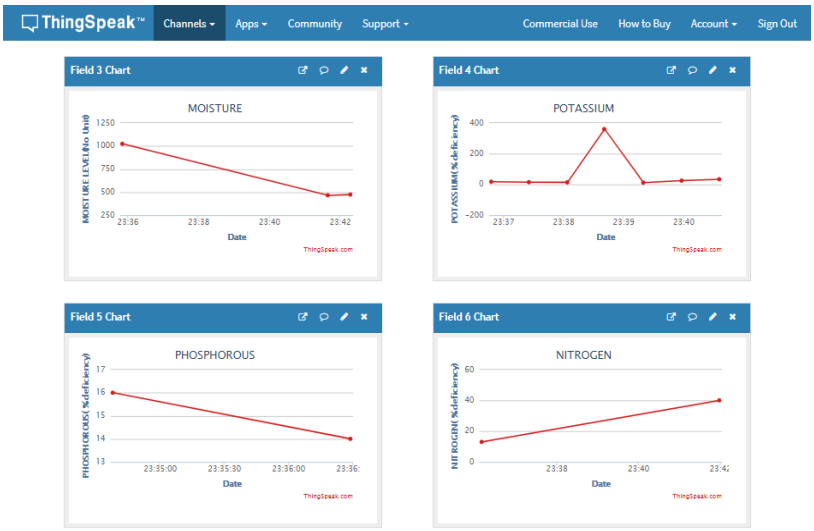

Figure 6. Output of Moisture level and Nutrition value of Black Soil

The analysis of coastal soil is done using Aloe Vera plant. The output observed is shown in Figure 7. The moisture level varies according to the wetness of the soil, which is with water the value is between 300 and 500 while without water the value is around 1024. The dryness of this type of soil is high. The moisture level increases gradually, indicating that the coastal soil i.e., sand absorbs water slowly. Cactus, lavender, etc., are the plants which grow in this type of soil. And the figure also shows the deficiency of the nutrients such as Nitrogen, Phosphorous and Potassium in percentage.

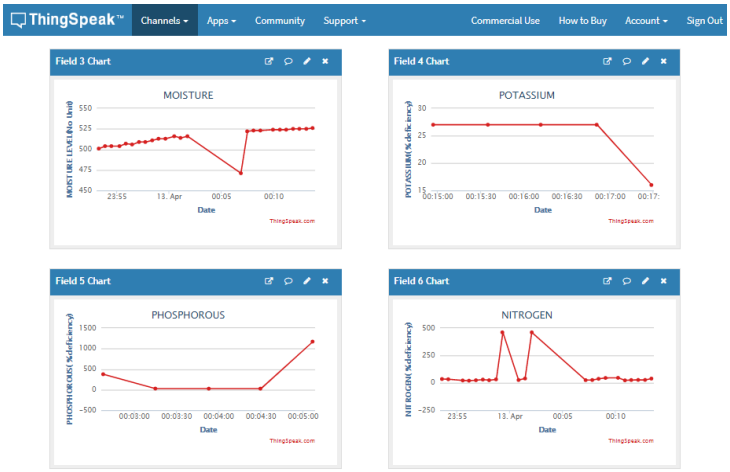

Figure 7. Output of Moisture level and Nutrition value of Coastal Soil

Fenugreek is used to analyze the clay soil which provides the observations as shown in Figure 8. The moisture level according to the wetness of the soil, which is with water the value is between 200 and 400 while without water the value is around 1000. When water is poured, the moisture level increases gradually, indicating that the clay soil absorbs water slowly. Quick dryness occurs in this soil hence this type of soil is suitable for plants that need more amount of water for its growth.Broccolis, Cabbage etc., are the plants which grow in this type of soil. The figure also shows the deficiency of the nutrients such as Nitrogen, Phosphorous and Potassium in percentage. The obtained parameter values from the Node MCU are uploaded into the ThingSpeak cloud platform and continuously observed with the help of ThingViewand Blynk mobile application.

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Table 2 and Table 3 shows the output of various sensors used in the analysis.

Table 2. Temperature for different plants

SOIL	PLANTS	TEMPERATURE
BLACK	GREEN GRAMS	25-35 °C
RED	MAIZE	18-27 °C
CLAY	FENUGREEK	15-32°C
COASTAL	ALOEVERA	30-60°C

Table 3. Soil Moisture and Nutrients value for each soil

SOIL TYPE	SOIL MOISTURE		NUTRIENTS		
	WET	DRY	NITROGEN	POTASSIUM	PHOSPHOROUS
BLACK	200-400	900-1000	460-490	380-410	570-600
RED	100-400	around 1000	400-520	550-650	600-700
CLAY	200-400	around 1000	around 430	around 410	around 570
COASTAL	300-500	around 1024	around 350	around 300	around 420

Table 4. Comparison table of results of soil tested and soil used in experiment

Soil (10 gm)	Weight of Salt(gm)	Output Wavelength(nm)			Experimental Output wavelength of the Nutrition value of the soil with no salt added (nm)		
		KNO3		H2KO4P			
		Potassium	Nitrogen	Phosphorous	Potassium	Nitrogen	Phosphorous
Black Soil	1	218	224	371	280	320	450
	3	131	120	347			
	5	107	74	317			
Red Soil	1	281	339	447	322	422	520
	3	237	304	367			
	5	190	178	300			
Clay	1	180	312	312	225	281	373
	3	147	306	306			
	5	108	212	212			
Sand	1	284	330	469	365	361	481
	3	259	275	344			
	5	218	235	235			

Table 4 shows the output obtained from testing the soils with different Salts using colour sensor. For 10 gram of each type of soil, different weight (in grams) of salts say, Potassium Nitrate (KNO_3) and Potassium Di-hydrogen Orthophosphate (H_2KO_4P), is added. It is observed that with an increase in the salt weight, corresponding output of the nutrition observed from the colour sensor decreases. Thus it shows that the absorption of the wavelength by the soil sent by the sensor will be high, if the corresponding nutrition is high in the soil, respectively reducing the output wavelength value.

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V.CONCLUSION AND FUTURE SCOPE

The moisture sensor measures the moisture level (water content) of the plant which is the essential need for plant growth. If the moisture level goes above or below the desired level, the moisture sensor sends the signal to the Node MCU Board. This sensor continuously monitors the soil moisture level. The sunlight is another important thing to make plant grow which is detected with the help of Light Dependent Resistor. LDR value varies according to the presence of sunlight. This is initially monitored and sends to the microcontroller to make sure that the plant can grow at that particular area. With this measurement we can determine which type of plant can be planted at that particular place. The major nutrients are detected by using colour sensor which ensures the healthy growth of the plant. The surrounding temperature where the plant grows is obtained with LM35 Temperature sensor. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit of each component. Thus, the working of the system has been tested thoroughly and it is said to function properly andsuccessfully.

The development of wireless sensor applications in agriculture makes it possible to increase efficiency and profitability of farming operations as well as the maximum crop yield with minimum usage of irrigation water. By fusing all the sensors into a single module, we can monitor regularly by placing it in the required area of the agricultural land. The estimation of nutrients present in the soil is to be scaled for large farms; hence containers of appropriate size are to be designed with a capacity of a few quintals.

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