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Sensor Based Automated Irrigation System

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***Abstract*— In a country like India, the agriculture plays the important role in the economy and development of the country. In the field of agriculture, use of proper method of irrigation is important and it is well known that irrigation by drip is very economical and efficient. At the present era, the farmers have been using irrigation technique in India through the manual control in which the farmers irrigate the land at the regular intervals. This process sometimes consumes more water or sometimes the water reaches late due to which the crops get dried. Over-irrigation can increase energy consumption and water cost as well as leaching of fertilizers below the root zone, erosion, and transport of soil and chemical particles to the drainage ditches. Irrigators who monitor soil moisture levels in the field greatly increase their ability to conserve water and energy, optimize crop yields, and avoid soil erosion and water pollution. The objective of this paper is to develop sensor based automated irrigation system to reduce water requirement and increase the productivity of orange orchard in Vidarbha region. This system is best suited for places where water is scarce and has to be used in limited quantity. Also, third world countries can afford this simple and low cost solution for irrigation and obtain good yield on crops.**

Keywords— Irrigation, Sensors, Soil moisture

I. INTRODUCTION

Due to increased agriculture productivity through irrigated land is being developed in arid and sub- humid zones. Agriculture has started to compete for water use with industries and other sectors. This increasing demand along with increments in water and energy costs have made it necessary to develop new technologies for the adequate management of water.

The intelligent use of water for crops requires understanding of evapotranspiration processes and use of efficient irrigation methods. The need for additional food for the world's population has spurred rapid development of irrigated land throughout the world. Vitally important in arid regions, irrigation is also an important improvement in many circumstances in humid regions. Unfortunately, often less than half the water applied is used by the crop – irrigation water may be lost through runoff, which may also cause damaging soil-erosion, deep percolation beyond that required for leaching to maintain a favorable salt balance. New irrigation systems, design and selection techniques are continually being developed and examined in an effort to obtain high practically attainable efficiency of water application.

The main objective of irrigation is to provide plants with sufficient water to prevent stress that may reduce the yield. The frequency and quantity of water depends upon local climatic conditions, crop and stage of growth, and soil-moisture plant characteristics. Need for irrigation can be determined in several ways that do not require knowledge of evapotranspiration (ET) rates. One way is to observe crop indicators such as change of color or leaf angle, but this information may appear too late to avoid reduction in the crop yield or quality. Other similar methods of scheduling include determination of the plant water stress, soil moisture status, or soil water potential. High frequency irrigation systems involve fastidious planning and complex designs, so that timely and accurate additions of water and fertilizer can result in sustainable irrigation. At the same time these production systems are becoming more intensive, in an effort to optimize the return on expensive and scarce resources such as water and nutrients.

Advanced fustigation systems combine drip-irrigation and fertilizer application to deliver water and nutrients directly to the roots of crops, with the aim of synchronizing the applications with crop demands and maintaining the desired concentration and distribution of ions and water in the soil. Hence a clear understanding of water dynamics in the soil is important for the design, operation, and management of irrigation and fustigation under drip irrigation. However, there is a need to evaluate the performance of these systems, because considerable localized leaching can occur near the drip lines, even under deficit irrigation conditions. The loss of nutrients, particularly nitrogen, from irrigation systems can be expensive and pose a serious threat to water bodies. In order to reduce these threats we are developing the completely atomized sensotronic system for irrigation and fertigation management.

II. IRRIGATION METHODS

The problem of power distribution provided an overview of wireless sensor network by managing the equal power distribution by using GSM network. The system sets the irrigation time depending on the temperature and humidity reading from sensors and type of crop and can automatically irrigate the field when unattended. There are two different way to irrigate land:

A. Traditional Irrigation Methods:

1. Level Basin Method:

In this technique the top end of the field is applied with water where it will flow over the whole field. After the water reaches the end of field it starts run of to pond. Water wastage is not good for dry area. The whole field is divided into basins according to the capacity of water.[2]

2. Furrow irrigation method:

This irrigation basin is used in the production of vegetables. The whole field is not filled with water rather than water is applied in furrows. This saves water at the same time and on the other hand the plant is not in direct contact with water as some plants like production of vegetables are very sensitive to pounded water. Furrows are sloping channels which are formed in the soil. [2]

3. Basin Irrigation Method:

This method is generally known as Border Strip Irrigation Basin. Here land is formed into strips which is leveled across the Narrow dimension i.e. width and the sloping is done in long dimensions i.e. length, is Formed. During irrigation, water is poured at the upper end of the border strip, and it is advanced down the strip. It is suitable to irrigate all growing crops like wheat, barley, fodder. This irrigation method is more suited for horticulture development. [2]

Disadvantages of using traditional irrigation methods:

Large amount of water is used in above irrigation techniques. Efficient and welfare use of fertilizers is not possible. Requires large man work. Net yield or productivity is also not high. Problems related to soil erosion are major problem. Substantial amount of ground water goes waste. Problem of water logging in fields. [2]

B. Modern Irrigation Methods:

1. Sprinkler Irrigation Method:

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then spread into the air through sprinklers so that it breaks up into small water drops which fall into the ground. The pump supply system and operating condition must be design to enable a uniform application of water.

2. Drip Irrigation Method:

Drip irrigation also known as trickle irrigation or micro irrigation is an irrigation method which minimizes the use of water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitter. In this irrigation system, a small amount of water is applied at frequent intervals in the form of water droplets through perforations in plastic pipes or through nozzles attached to tubes spread over the soil to irrigate a limited area around the plant. A precise amount of water equal to the daily consumptive use or the depleted soil water needs to be applied. The soil water can be maintained at the field capacity during the crop growing period. Deep percolation losses can be completely prevented and the evaporation loss is also reduced.

Drip irrigation requires about half of the water needed by sprinkler or surface irrigation. When compared with overhead sprinkler systems, drip irrigation leads to less soil and wind erosion.

3. Pot Irrigation Method:

Pot irrigation method is more suitable for areas having scanty rainfall. In saline areas where flow irrigation is not suited, pot irrigation method is successful.

III. PROPOSED AUTOMATED IRRIGATION SYSTEM

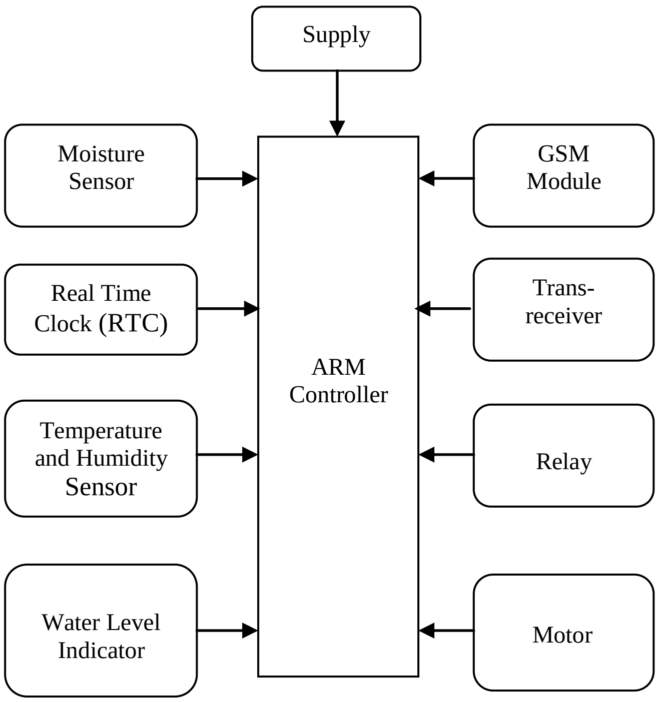

Fig.1. Proposed automated irrigation system

The sensors are mounted at a depth of 1 feet near the root zone of the bell pepper plants in the farm. The supply is connected to a 5V battery. The moisture sensor after sensing the output provides the analog output in the range of 3.3 to 5V. These measured values then are fed to the controller in the form of voltages. An average threshold value will be calculated by the help of conduction charts and thus the water requirement will be defined. This sensed value is averaged and compared with the predefined average value whose results will determine the further course of action. Further a message will be sent to the user via the GSM modem wherein the time of sensing, water status and necessity of water would be mentioned with the starting of the motor. Placing of water level detectors in the water body like tanks, wells etc. will be done with indications of high, medium and low values. If the

value is below medium level, the pump will not start and indicate a necessity of water to the user through a text message on his cell phone. This will thus warn the user to arrange a separate water source for watering before the plant wilts within 5 hours which is its stress sustainable limit beyond which it will start wilting.
The different conditions required are follows:
1. If the moisture level is below threshold value
2. Whether the water level is adequate.
3. If yes then the motor will start otherwise user will get the message of failure due to scarce water resources with a deadline of 4 hours

The water supply will be provided at night as the rate of evapotranspiration is the lowest at that time i.e. between 10p.m-5a.m. Thus this sensing will be monitored after every 5 hours. This monitoring will be done through RTC which will store the given dates and time of the last sensed output and previous data also. It thus gives us a chance to monitor these values over a period of certain days depending on plant growth and thus provide the requisite amount of water to the plants to prevent stress. The watering will stop after the plant is adequately watered and thus ensure a maximum crop yield with meticulous use of water resource and preserving soil nutrients.

IV. IMPLEMENTATION

Fig. 2. Soil moisture sensor mounted near roots

Fig. 3. Slave card

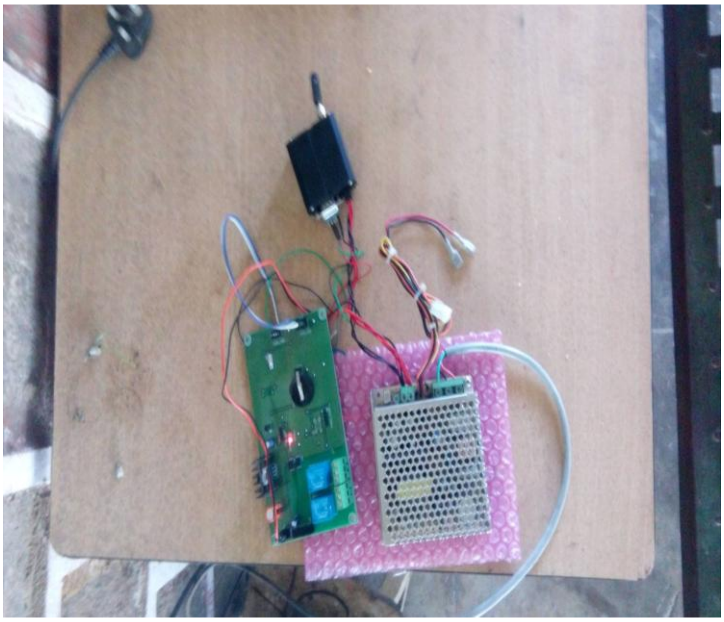

Fig. 4. Master card

EXPERIMENTAL RESULTS AND DISCUSSIONS

TABLE I. IRRIGATION TO WATER RECOVERY LAG

Sr. no.	***Age of tree (years)***	***Water lag (cm)***	***Water required (ltr)***
1	1	6.9	3.72
2	2	9.2	4.968
3	3	11.04	5.961
4	5	13.8	7.452
5	6-10	27.6	14.904
6	10-20	46	24.84
7	20 above	55.2	29.808

TABLE II. EFFECT OF EVAPORATION ON NET MOISTURE CONTENT

Sr. No.	*Age of tree (years)*	*Daily Water requirement (ltr)*	*Evaporation of soil moisture*	*Depth of root zone (cm)*	*Depth of dry zone (cm)*	*Depth of dry zone from top surface (cm)*
1	1	8	4.32	15	8.1	6.9
2	2	15	8.1	20	10.8	9.2
3	3	24	12.96	24	12.96	11.04
4	5	35	18.9	30	16.2	13.8
5	6-10	80	43.2	60	32.4	27.6
6	10-20	108	58.32	100	54	46
7	20 above	140	75.6	120	64.8	55.2

TABLE III . AFTER APPLYING THE SYSTEM ON THE ORANGE

Sr. no	**Soil moisture in terms of voltage**	**Time at which moisture is recorded**
1	3.102	10:00 AM
2	2.981	11:00 AM
3	2.619	12:00 PM
4	2.486	01:00 PM
5	2.318	02:00 PM
6	2.286	03:00 PM
7	2.151	04:00 PM

After the detailed analysis of employed irrigation system and other environmental conditions, water requirement per acre can be calculated as below

Irrigation factor = 0.55
Daily evaporation = 0.4
Irrigation interval = 1 day
Diameter of drip outlet = 3mm
Thus,
Water=(irrigation factor)*(daily evaporation)*(irrigation interval)*(diameter of drip)*10/2.54*0.001 required
= 0.55*0.4*1*10*3/2.54
= 10.39 Cubic-meter/Acre

Water holding capacity for medium grade soil = 189 lit/24 hr
Water requirement of bell pepper above 2 months in summer = 108 lit to 124 lit
Daily evaporation = (Water holding capacity)*(Evaporation factor in summer)
= 189*0.54
= **102.06 lit**
Active wet zone in summer = Depth*Evaporation factor
= 4ft * 0.54
= 2.16 ft

As per the above calculations the wet zone occurs below 2.16 ft of soil and the active root zone occurs between 0.5 ft to 2.16 ft of orange tree measured from top surface of soil. Hence for maintaining the constant soil moisture in summer season the soil should be irrigated at constant interval of 24hr. if requirement is not fulfilled due to extreme heat concentrated on top surface of soil. Due to convection and solar radiation. In summer days when the peak temperature rises up to 48 degree in Nagpur region the sensotronic control is to be engaged for maintaining the soil moisture so as to keep the root zone wet and greenery on orange tree is established.

After application of the said system on the Bell Pepper plants the following results were obtained.

TABLE IV. AFTER APPLYING THE SYSTEM ON THE BELL PEPPER

Sr. no	**Soil moisture in terms of voltage**	**Time at which moisture is recorded**
1	1.638	10:00 AM
2	1.593	11:00 AM
3	1.323	12:00 PM
4	1.261	01:00 PM
5	1.086	02:00 PM
6	0.992	03:00 PM
7	0.938	04:00 PM

The major aspect of discussion at the rudimentary level included the basic necessity of rural India especially the farmer class and their problem of vagaries climatic conditions and irrigation problems. So the first part of our discussion included the various ways to increase productivity through automation in irrigation. Secondly the basic point of research was to search for an optimal irrigation system which intelligently conserves water and makes irrigation easy, efficient and crop enhancing with minimal wastage which after much research we zeroed to Drip Irrigation being the most efficient after studying the pros and cons of other types of irrigation. Third was the study of rainfall patterns with a keen view on scarcity of water and drought frequency and frequently affected regions with it. The topology of Maharashtra especially Vidarbha is a typically drought prone zone which requires efficient water management for its bell pepper plants.

The second part of our discussion was then to select the key aspects in the design of system which would optimize efficient use water according to crop requirements to avoid stress and also overwatering to create salt imbalance. The flow rate to be determined with duration cycles of irrigation for black regular soil a specialty of Vidarbha also known as “Cotton Soil” and manage to avoid over irrigation thus saving salt imbalance and water. Thirdly the necessity of automation was to reduce human effort and make an accurate soil assessment and watering needs with variations in temperature according to seasons.

The basic discussion traverses to the use of controller which can optimally handle these soil moisture sensors with low power requirements calculate the threshold using conduction charts and thus decide the need to irrigate. Then the various modules to connect it with GPS modem to receive the data of irrigation with time of start and time of end.

Lastly the power requirements with a view of sustaining the working with power cuts and failure issues. This discussion then covered the topics of credibility and future applications and advancements in the current scenario and cope with recent water needs and satisfy the criteria of minimal cost and maximum benefits and crop productivity.

CONCLUSION

The automated irrigation system implemented was found to be feasible and cost effective for optimizing water resources for agricultural production. This irrigation system allows cultivation in places with water scarcity thereby improving sustainability.

The irrigation system can be adjusted to a variety of specific crop needs and requires minimum maintenance. The modular configuration of the automated irrigation system allows it to be scaled up for larger greenhouses or open fields. In addition, other applications such as temperature monitoring in compost production is easily implemented. Besides the monetary savings in water use, the importance of the preservation of this natural resource justify the use of this kind of irrigation systems.

As the demand for water increases, along with the need to protect aquatic habitats, water conservation practices for irrigation need to be effective and affordable. Precision irrigation will optimize irrigation by minimizing the waste of water, and energy, while maximizing crop yields. The most effective method for determining the water demands of crops is the based on the real time monitoring of soil moisture, and direct water application used in conjunction with the information about soil hydrological properties and evapotranspiration.

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