Automated Irrigation System using Weather Prediction for Efficient Usage of Water Resources

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Abstract: In agriculture the major problem which farmers face is the water scarcity, so to improve the usage of water one of the irrigation system using drip irrigation which is implemented is “Automated irrigation system with partition facility for effective irrigation of small scale farms” (AISPF). But this method has some drawbacks which can be improved and here we are with a method called “Automated irrigation system using weather prediction for efficient usage of water resources” (AISWP), it solves the shortcomings of AISPF process. AISWP method helps us to use the available water resources more efficiently by sensing the moisture present in the soil and apart from that it is actually predicting the weather by sensing two parameters temperature and humidity thereby processing the measured values through an algorithm and releasing the water accordingly which is an added feature of AISWP so that water can be efficiently used.

Keywords: Drip irrigation, humidity, weather prediction.

1. Introduction

All the countries in the world are currently in a situation where they are required to use water in a very efficient manner, according to the recent studies, water is becoming more and more in short supply worldwide and more than one-third of the world population would face total water shortage by the year 2025[1]. The most affected areas are the semi-arid parts of Asia, the Middle-East and sub-Saharan Africa, all of which already have a heavy concentration of population living below poverty line. The present condition in India is also critical, where water scarcity is already affecting a considerable amount of the population and this proportion is increasing rapidly. And there is similar condition in many other countries as well so there is a need for us to improvise the way in which the water is being used [2].

Irrigation has been around for as long as humans have been cultivating plants. Different irrigation methodologies used are flood irrigation, man and tube method, drip irrigation and spray irrigation. Flood and man and tube irrigation methods may cause uneven distribution of water over the farm [3]. In sprinkler irrigation, water is pumped through a pressurized pipe network to sprinklers, nozzles, or jets which will be spraying the water into the air, to fall to the soil as an artificial “rain”. A disadvantage of sprinkler irrigation is that many crops are sensitive to foliar damage when sprinkled with saline waters. Other disadvantages of sprinkler systems are the initially high
installation cost and high maintenance cost [4].

Drip irrigation involves dripping water onto the soil at very low rates (2-20 liters/hour) from a system of small diameter plastic pipes fitted with outlets called drippers. Plants are watered such that only part of the soil which is closer to the roots grow gets wet, which differs from surface and sprinkler irrigation, which makes up the whole soil profile. With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favorable high moisture level in the soil in which plants can flourish.

Among advanced micro-irrigation techniques, drip and sprinklers are gaining special attention. Drip irrigation (DIM) and sprinkler irrigation (SIM) methods differ in many important parameters such as flow rate, pressure requirement, wetted area and mobility [5], but they have the potential of significantly increasing water use efficiency. While DIM concentrates on supplying water directly to the root zone through a network of pipes and emitters, SIM sprinkles water, into the air using nozzles which breaks into small water drops and fall on the field surface. DIM has little or no water losses through conveyance [6], and the on-farm irrigation efficiency of a properly designed and managed drip irrigation system can be as high as 90 %, compared with 35 to 40 % efficiency in surface method of irrigation [7]. However, SIM has relatively less water saving (up to 70 % efficiency), since it supplies water over the entire field of the crop [8].

2. Related Works

Tahar Boutraa and his team made a study on evaluation of effectiveness of an automated irrigation system using wheat crops and concluded that wheat plants that were irrigated automatically had higher photosynthesis rates compared to the manually irrigated ones[9]. In [10] discussed the preliminary studies of salt water drip changes by brackish water irrigation, providing theoretical and technical support for the development and utilization of water resources, and salt desert ecosystems of the rehabilitation and reconstruction. [11] discussed the design and operation of drip irrigation system using a drip tape and power from solar cell were feasible and economical for growers owning a small field in arid areas or remote areas with limited water resources and electricity, particularly for newly planted sugarcane. In addition, the designed system was easy to move and install in other sugarcane fields, therefore, it could save cost of the system. However, the system required water refilled continuously while a sugarcane field was drip irrigated.

In [12] implemented three features mainly drip irrigation, mobile network, and fuzzy technique. First it explains the drip irrigation and how it is controlled by the mobile network. The mobile network keeps the user updated and in control of the system remotely. Consequently fuzzy controller processes the real time data and calculates the amount of water required. Zhiwei Zheng has explained the change regulation of the crop coefficient of the greenhouse tomato in the growth period, which provides an important basis for the analysis and calculation of the water requirement of tomato [13]. [14] describes a mechanism to control the moisture content of the soil of cultivated land. According to soil moisture, water pumping motor turned on or off via the relay automatically. This saves water, while the water level can be obtained in a preferred aspect of the plant, thereby increasing productivity of crops.

In AISPF [15] drip irrigation method is used, in which the land is divided into smaller units, and moisture sensors are placed in the divided areas to measure the moisture content in those areas and watering the farm whenever required but there lies a serious issue which have not been considered in AISPF, the weather at that particular place is not taken in to account. If the farm has been watered without weather prediction and after few hours if it starts raining heavily there are chances that the sand can get completely saturated which might damage the plants. We would like to add on
that particular feature in our algorithm AISWP, so that it can be more efficient and be much helpful to people in saving the crop and water which is very crucial at the present situation.

3. Automated Irrigation System using Weather Prediction (Aiswp) Algorithm

The steps involved in our protocol are as follows:

Step1: Sensors i.e., moisture sensor placed in the soil, temperature sensor, humidity sensor senses the current values and sends the data to data acquisition system.

Step2: These data will be processed using some code which will help us for the weather prediction and the output is passed to the microcontroller.

Step3: According to the input received by the microcontroller it starts taking the following actions:

- If the moisture sensor reading is less than a critical value called SMD (Soil Moisture Deficit) for a specific crop the motor related to that particular sector of the land is turned on.
- If the weather prediction turned out to be a sunny day, the pump motor and the solenoid valves are turned on till the moisture sensor reaches the set point value.
- If the weather prediction gives us the information that the possibility to rain is less than 50% then the motor will be turned on and the solenoid valves are opened till the moisture sensor reads that value of moisture content is in between 20% and 50% so as to avoid damage to the crop.
- If the prediction is pretty sure that it is going to rain i.e., if the possibility is higher than 50% then the motor will not be turned on and similarly the solenoid valves will not be opened.

This process keeps on repeating for every one hour. The flow diagram is as shown in Fig.1; it shows the control loop for each sector for different values of m, where m is the sensor measured value.

Fig.1 Flow diagram
4. Circuit Diagram

The main elements to be used when designing a model are,

A. Flow: The output of water supply can be measured with a one or five gallon bucket and a stopwatch. How much time it takes to fill the bucket and use that number to calculate how much water is available per hour. Gallons per minute x 60 = number of gallons per hour.

B. Pressure (The force pushing the flow): Most products operate best between 20 and 40 pounds of pressure. The usual household pressure ranges 40-50 pounds.

C. Water Supply & Quality: City and well water are easy to filter for drip irrigation systems. Pond, ditch, and some well water require special filtering methods. The quality and source of water will describe the type of filter necessary for your system.

D. Soil Type and Root Structure: The soil type tells us how a normal drip of water on one spot will spread. Sandy soil requires closer emitter spacing as water moves vertically at a fast rate and slower horizontally. While in clay soil, water tends to spread horizontally, this gives a wide distribution pattern. Emitters can be spaced further apart with clay type soil. A loamy type soil will produce a more even percolation dispersion of water. Deep-rooted plants have the capability to handle a wider spacing of emitters, while shallow rooted plants are required to be watered slowly (low gap emitters) with emitters spaced close together. On clay soil or on a hillside, short cycles should be repeated frequently to work best. On sandy soil, applying water with higher gap emitters helps to spread the water horizontally compared to a low gap emitter.

E. Elevation: Variations in elevation can cause a change in water pressure within the system. Pressure changes by one pound for every 2.3 foot change in elevation. Pressure-compensating emitters are designed to work in areas with large changes in elevation.

F. Timing: Watering at regular cycle is required. On clay soil or hillsides, these cycles should be repeated at short durations to prevent runoff, erosion and wasted water. In sandy soils, the method of using slow watering low output emitters is recommended. Timers help prevention of too-dry/too-wet cycles that stress plants which retards their growth. They also allow for watering at optimum times such as early morning or late evening.

G. Watering Needs: Plants with different water needs may require their own watering circuits. For example, orchards that get watered weekly need a different circuit than a garden that gets watered daily. Plants that are drought tolerant will need to be watered differently than plants requiring a lot of water.
Fig. 2 Block diagram of the methodology used

5. Comparison

| Old Model                                                                 | Proposed Model                                                                 |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1. Efficiency of water supply is limited as weather prediction is absent. | Efficiency of water supply has been increased by 20 percent by introducing weather prediction into our proposed model. |
| 2. Photosynthesis rate has been improved by 20 percent with the usage of automated irrigation system. | There has been a slight increase in the photosynthesis rate than the above mentioned model i.e., by 22 percent. |
| 3. Properties of each crop differs which leads to a different SMD values which have been neglected. | Properties of each crop differs which leads to a different SMD value which have been taken into consideration |
6. Conclusion

We clearly observe that this automated irrigation system which not only lets the water supply based on moisture in the soil, but also it takes weather conditions into consideration has made the usage of water more efficient. Further work is necessary to make these type of investigations to make the usage of water more efficient by using automatic irrigation systems.

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