Plant Archives Vol. 21, Supplement 1, 2021 pp. 1734-1740 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.275

NEW IRRIGATION TECHNIQUES FOR PRECISION AGRICULTURE: A REVIEW

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ABSTRACT

Precision irrigation applications are used to optimize the use of water resources, by controlling plant water requirements through using different systems according to soil moisture and plant growth periods. In precision irrigation, different rates of irrigation water are applied to different places of the land in comparison with traditional irrigation methods. Thus the cost of irrigation water is reduced. As a result of the fact that precise irrigation can be used and applied in all irrigation systems, it spreads rapidly in all irrigation systems. The purpose of the Precision Agriculture Technology System (precision irrigation) , is to apply the required level of irrigation according to agricultural inputs to the specified location , by using the variation in agricultural lands, in order to obtain more productivity with less agricultural inputs. This way ensures that the cost of agricultural inputs are reduced and environmental protection is done at the same time. In this study, the usability of precision irrigation systems in agricultural operations, as well as the use of global positioning systems with precision irrigation applications is tested.

Keywords: Precision irrigation, soil moisture, irrigation water, irrigation systems, global positioning systems

Introduction

Technological developments are increasing rapidly, because it result in achieving High productivity, lower costs, protection of environmental and natural resources in the production area. These developments, shed the light on many agricultural concepts. The most important of which are organic farming, good agricultural practices, sustainable agriculture and precision agricultural techniques (AKKAMIŞ ve ÇALIŞKAN, 2019). Precision Agriculture Technology (Precision Agriculture, PA) is an approach that allows the inputs used in agricultural production to be organized in an environmentally sensitive manner(GÜLER ve Tekin, 2005).With the development of applications that are implemented by taking into account soil properties and nutrient status of the soil, land slope, pH level, etc. The variable-level agricultural input purpose is considered among precision agricultural technologies, it aid to reduce production costs, increase agricultural efficiency and reduce environmental pollution in agricultural production areas .Precision farming techniques such as variable fertilization, spraying and irrigation applications began in horticulture. Accurate irrigation is applied to specific areas and quantities of land, thus accurate irrigation ensures a reduction in water consumption (Nagothu, 2016). The accurate irrigation method gives positive results in both, planting of vegetables and fruits alike, moreover the production of field crops, thus ensuring more efficient and productive use of limited agricultural land and water resources (Dehghanisanij ve ark., 2007). During these processes sensors are used to measure soil moisture when necessary (Nagothu, 2016). In order to increase the efficiency of the system, it is possible to measure the temperature of soil or air, obtain weather data, measure the relative humidity of the environment and determine the type of soil by sensors that work with different principles of those that which are based on semiconductors principle to those based on optical fibers (Singh ve ark Hence). More controlled irrigation operations can be performed compared to manual irrigation applications (Dehghanisanij ve ark., 2007). In this way it is possible to administer plant nutrients during irrigation whenever is necessary and to control pesticides and pests (Köycü ve Sukut, 2018).

Importance of irrigation

In the event that the water which is needed for the natural growth of plants cannot be met by rain, the lost amount is compensated for by supplying the soil and plant roots with irrigation water. The main elements of irrigation are soil, water and plants. Water obtained through the soil is essential for many chemical, physical and biological activities for plants. But the most important thing is to dissolve the nutrients and transfer them to the plant's organs, which are considered the most important element necessary for plant growth (Onur, 2002).

In order for plants to continue their normal growth, especially perennial plants, they need to constantly obtain water from the soil through their roots, except for the winter rest period. This need also increases during vegetation covering periods. For this reason, having adequate moisture in the root zone of a plant during the growing season is very important for its good growth (Li ve ark., 2011). The continuous and stable growth of the plant can be ensured by irrigation as the water needed by the plant is stored in the root zone. Meanwhile, the excess salt is washed away in the soil and the air surrounding the soil and plants cools.

On the other hand, high or low soil moisture, irrigation period and wrong irrigation times generally lead to a decrease in productivity (Ertek ve Kanber, 2002). This can be explained by the graph (Fig.1) typical of the water-productivity relationship.

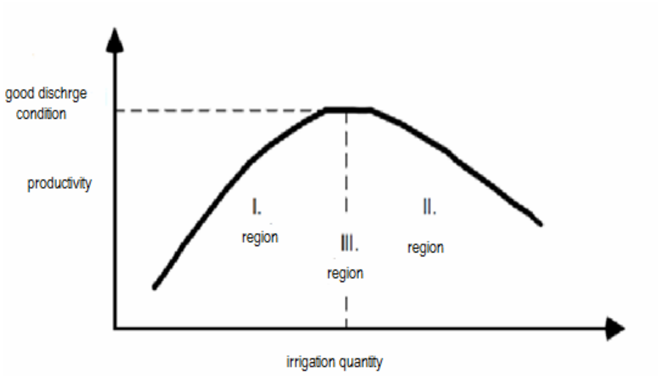

Fig. 1: Relationship between irrigation and vegetation productivity.

When good agricultural conditions, water and air balance in the soil are provided, as shown in Figure (1). Whenever the moisture stored in the plant root zone increases during the growing season, the productivity increases and reaches the highest value at a certain soil moisture level. After that, productivity remains constant even if the amount of water entering the soil increases under good drainage conditions.

Irrigation systems and methods

Irrigation systems can be basically divided into two parts according to the service area, water transmission and distribution. The second group can be classified as surface and pressurized irrigation systems. Pressure systems can also be divided into low and high pressure systems. These basic types of irrigation systems are shown in Fig.2.

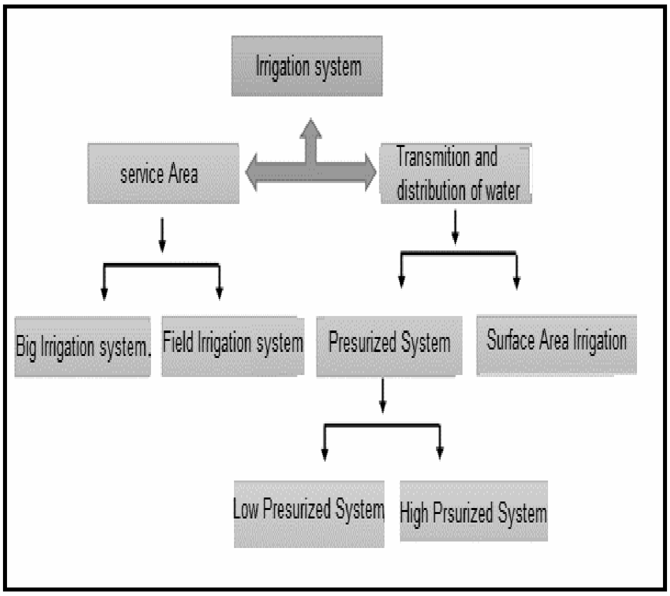

Fig. 2: Types of irrigation systems

There are many different methods in irrigation systems, the most important of which are surface irrigation, sprinkler irrigation, and drip irrigation, etc. The most appropriate irrigation method can be determined by looking at the natural and climatic conditions and the state of water resources (Johar ve ark., 2018).

Precision irrigation

The concept of precision irrigation is the accurate use of irrigation water resources according to soil moisture and plant growth periods. As irrigation water is used in different quantities according to the variation in the plant need, thus reducing the cost of irrigation water.

In a study on cotton plants, sensors were used to measure the variability in the terrain, whereby a smart model sensor was developed, that simultaneously measures soil moisture and temperature. The sensors were placed in specific points in the ground. Hence It has been reported that the irrigation process can be done by determining the irrigation time and its quantity simultaneously by combining the data of these sensors with accurate irrigation techniques (Vellidis ve ark., 2008). In another study, soil moisture and temperature were measured using a system developed in a way that is cost-effective, easy-to-use and reliable effect, by applying the right amount of irrigation water. In order to increase productivity (Nandurkar ve ark., 2014). The amount of water used in mobile irrigation systems (central axis, linear movement) is controlled by changing the speed of the system or by changing the rate of sprinkler discharge (Pierce, 2010). The sprinklers operate in the system at a certain flow and pressure. Whereby, an increase in the speed of movement in the system reduces the amount of irrigation whereas a decrease in the velocity can increase the amount of irrigation (Hezarjaribi, 2008). However, these precise systems that are applied with changing velocity are not used in variable rate irrigation applications. Global positioning systems are preferred rather than previously used routing and positioning methods in linear motion irrigation systems. Underground and above ground cables are used to guide irrigation in linear systems. This equipment can be damaged by rain, lightning, and tillage equipment. It may be possible to eliminate this problem by using wireless networks. In addition, the irrigation is repeated in the turns/ corners in the same line again at the end of the irrigated land, which results in using more water. This problem can be solved by means of wireless systems that can decrease the travelling on these lines which eventually lead to reducing the amount of irrigation. In this way both water and energy are saved by using less water on the ground.

Variable ratio techniques in irrigation

Water needs depend on the type of soil. Accordingly, after preparing application and maps of irrigation water, different percentages of water are irrigated by smart irrigation machines (Figure 3). Depending on the stage of the plant growth, variable irrigation applications are performed using sensor-based systems, whereby soil moisture is monitored. These technologies could achieve significant savings of irrigation water (TÜRKER ve ark., 2015).

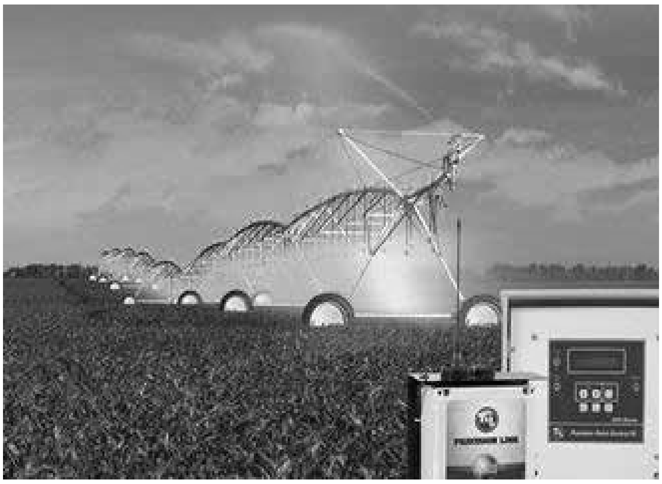

Fig. 3: The system of variable proportions in irrigation.

Nowadays, mechanization is developing in agricultural applications, new methods and techniques are being searched and studied for automated systems of irrigation operations. unlike of the traditional / manual irrigation methods, Automatic irrigation methods are preferred over the old methods due to labour requirements, cost, inefficient use of water resources, incomplete irrigation, low productivity and quality ... etc. (Dehghanisanij ve ark., 2007). According to modern studies and techniques, we try to prevent the unnecessary use of irrigation thus the efficient use of water resources. In addition, high productivity is obtained from finely irrigated land (Burunkaya).

Positioning systems

The values of the longitude, width and height of a specific object can be specified as well as its location. Location information is required in precision farming technology applications. These systems are divided into two main systems based on location and satellites. In the ground-based system, at least three transmitters are placed at the corners of the area. The receiver located at the specified point, receives the signals from the transmitters and calculates the distance to each transmitter. The location of the receiver is the intersection of the circle plotted from the centre of the three transmitters (AKKAMIŞ ve ÇALIŞKAN, 2019)

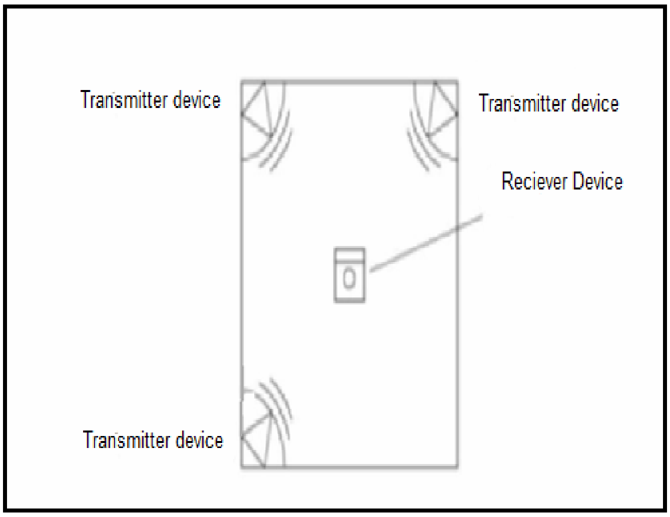

Fig. 4: Determining the location on the basis of geographical location .

PLC irrigation system control

The general schematic diagram of a PLC automatic irrigation system is shown in Fig.5. The irrigation system consists of a PLC controller and computer units, along with humidity and temperature sensors. PLC control can be provided from a computer using the TIA portal v 13 software on a computer. The irrigation system works either manually or automatically via PLC. The operating system can be monitored and controlled at every stage through TIA gateway. Meanwhile, immediate system changes, can be displayed on the SCADA (Supervisory Control and Data Acquisition) screen, as a beginning and an end of the irrigation. Then the process can be seen on the computer screen, whereby the system gives a warning in the event that an error occurs in the irrigation system. This warning is displayed on the computer screen in the real time. Below is a description of the parts of the control system (Ali ve BAHAR, 2018).

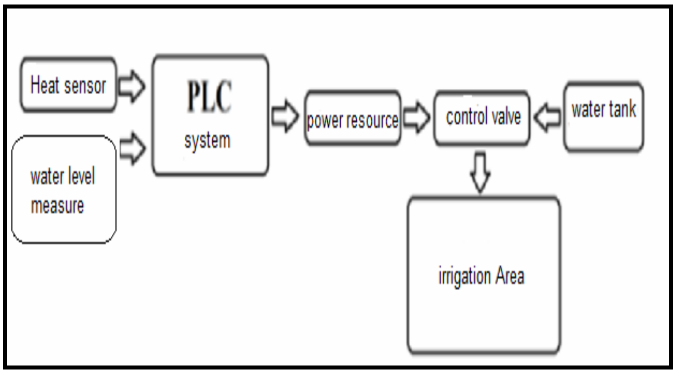

Fig. 5: Diagram of automatic irrigation system

Sensor devices

One of the important parts of automation systems are sensors. In the control system the sensor may also be referred to as a part of the system. The sensors we use in the PLC irrigation system are described as follows (Ali ve BAHAR, 2018):

Temperature Sensors: Platinum PT type is used as temperature sensor. The 100 PT temperature sensor was selected and used to detect the temperature difference between 0 and 100 PT

Humidity sensor: In this system, the degree of humidity is measured with the help of connecting rods placed at the beginning and the end of the furrows in the area to be irrigated.

Level sensors: The amount of water in the tank is measured by determining the height of the water using electrodes to measure the liquid level placed in specific areas in the water tank.

Solenoid valve: Electric powered solenoid valves are electromechanical valves that control the passage of liquids such as gas, air, water, steam and oil. To move the piston inside the valve, electric current is applied to the coil inside the valve. When the solenoid receives the electrical signal, the inlet channel allows the fluid to pass directly to the outlet. When the electrical signal is cut off, the valve returns to its previous state and prevents the passage of liquids. The solenoid valve is located in the tap portion of the tank and is used to control water drainage. A 24V KL223-08-E-NC type valve was used as the solenoid valve.

The experimental work

The study relied on the automatic irrigation system that is linked to the SCADA screen to monitor and control data. SCADA Supervisory Control and Data Acquisition can be expressed as a central unit for auditing and collection of data. The irrigation system is controlled by a PLC (Programmable Logic Controller) to monitor the potential developments related to the irrigation system on SCADA at the same time. The SCADA screen of the study can be viewed from Figure 6 below.

The irrigation control system needs to know the environment temperature from the beginning and that's done by using temperature sensors PT 100 in order to know and use the different temperature values according to the types of the plants that will be irrigated. The average temperature coming to the irrigation system, if it is within the temperature of the type of plant, the irrigation system begins to work. If the temperature value of the plant is higher or lower, the irrigation system will not work, and in this case the "temperature outside the range" will appear on the SCADA screen. Secondly, the water level in the water tank is checked with the help of the signals coming from the PLC sensor. If the water tank is empty, it warns the user with the warning light "Empty tank" on the SCADA screen. If the water percentage in the tank is sufficient in this case, the system checks the moisture content in the groove/furrow by means of sensors installed at the beginning and at the end of each groove/furrow in the irrigation area. After the system verifies the presence of moisture at the beginning and end of the furrows, the system does not start irrigation, but rather gives an instruction and lights a lamp that appears on the SCADA screen as "The system does not work." If the humidity is absent in the beginning and end of the furrows, the control system activates the irrigation process and the irrigation process continues until the water reaches to the beginnings and ends of the grooves/furrows (Ali ve BAHAR, 2018).

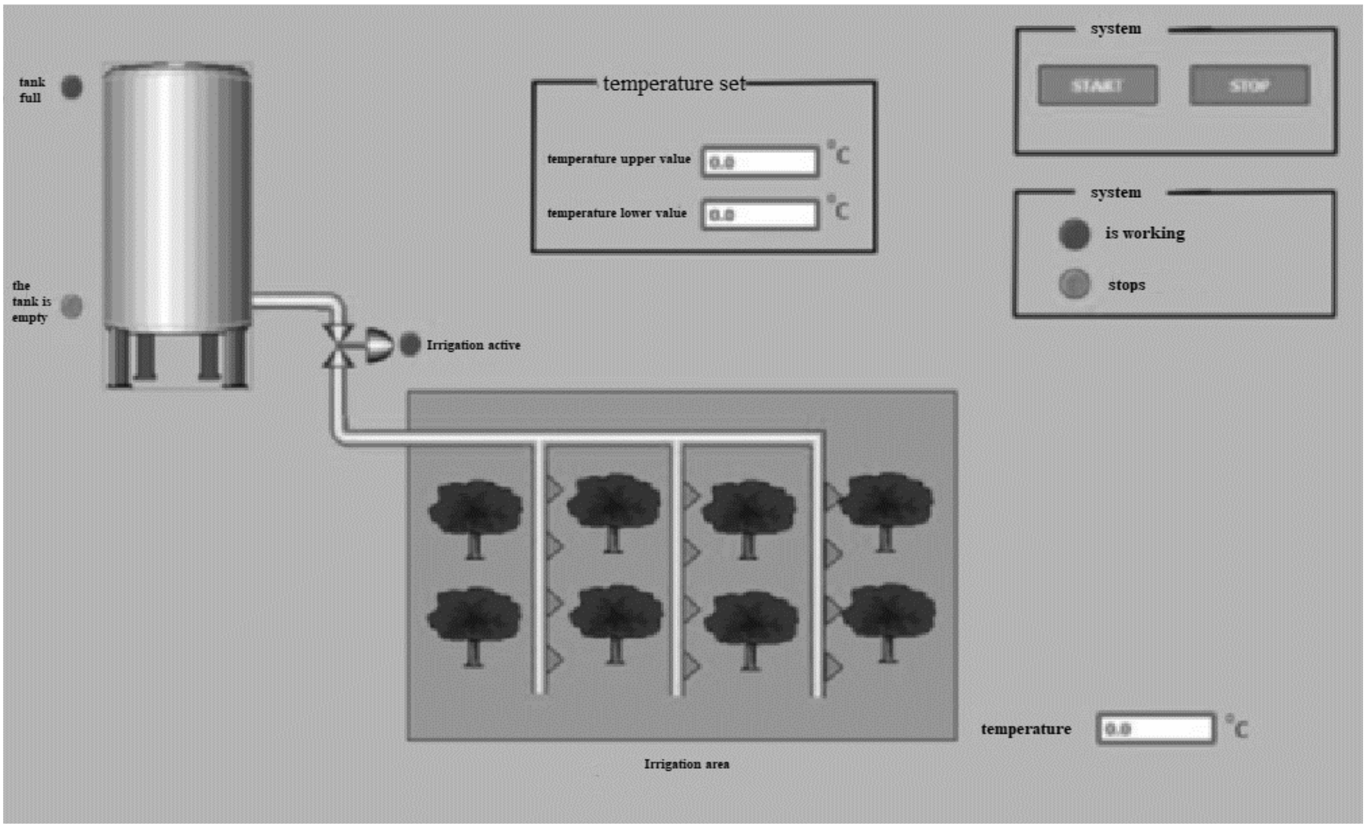

Fig. 6: An illustration of the SCADA screen.

In drip irrigation system that measures the content of the moisture in the soil by using soil moisture sensor. By measuring the value with the DC magnifier 0 volts and 5 volts are obtained respectively for 0% and 100% humidity. The resulting numerical value is displayed on a LCM screen comprised of 2x16. In comparison with the previously entered precise value, and According to the results of the comparison, a 12 V electromechanical valve is switched on and watering starts or stops when vice versa. In this study, the climate, plant and soil type were relied upon, etc. Instead of determining plant water consumption hence irrigation using predictive equations based on the data. The direct method was adopted using (Burunkaya) measurement. Figure 7 illustrates the system architecture.

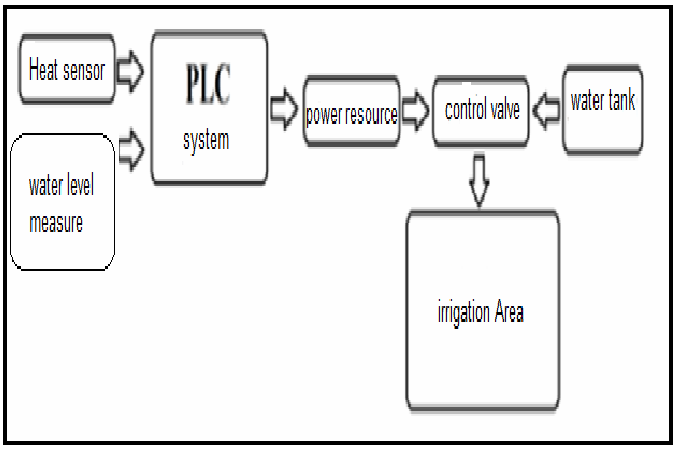

Fig. 7: Structure of a drip irrigation system

Previous Experiences

When the irrigation system is programmed according to the soil moisture content, the moisture changes in the soil should be monitored using various sensors. For this purpose, wireless sensors such as the TDR Time Domain Reflect meter, EC (Electrical conductivity), and GMS (Granular Matrix Sensor) have been developed. These sensitive sensors can quickly and accurately measure soil moisture, suitable for precision farming.

Schmitz ve Sourell (2000), investigated the accuracy of measuring three different soil moisture sensors (TDR, EC and GMS sensors) in field conditions. The researchers clarified that measuring soil moisture with the required accuracy using the aforementioned sensors, it is necessary to take care of a calibration in order to determine the places in which the sensors will be installed. Otherwise, the same sensor can give different levels of measurement in the same soil conditions.

(Thompson ve ark., 2006), searched in providing electronic tension meters with a special sensor (watermark 200ss sensor) that measures the potentials of soil matrix (layers) for irrigation programming purposes, for both pepper plants and watermelon that were irrigated by drip irrigation. The researchers stated that both types of sensors can be used to monitor the change of moisture in the soil through proper calibration.

Sönmez ve ark. (2008), studied the values (degrees) of reflection and quality of turf in grass plants that are watered at different levels using a spectrophotometer. In the field experiment irrigation was done at levels of 100%, 75%, 50% and 25% of daily evaporation. The best quality of grass is obtained in parcels/packages irrigated by 100% and 75%. They found that the quality of the lawn decreased as the amount of irrigation water decreased, and the reflection values changed according to the different irrigation levels.

Karataş ve ark. (2006), they demonstrate the application of the SEBAL method used to determine ET by remote sensing. For this purpose, the researchers processed the image from the NOAA-16 / AVHRR satellite covering the Gediz lower irrigation system on August 14, 2004 and identified inference maps related to true yield (ETa) and potential evapotranspiration (ETp), the Gökkaya Irrigation Association as an example. ETa values set for a given period. The researchers stated that ET calculations can be made on a system and basin basis with UA and that more accurate, objective and reliable information can be provided compared to traditional methods of agricultural and hydrological conditions of the Earth's surface and the sustainability of water resources will be preserved by observing spatial and temporal changes of water use.

Gündogdu ve ark. (2001), worked on the SUGIS model to create a database supported by geographic information system for monitoring and evaluation of irrigation projects. It consists of 4 sections: Form Data Entry, Project Information, Water Use Method and Evaluation, these sections have different submenu options. The researchers stated that the comprehensive projects implemented with great efforts and expenditures with their work will contribute to solving the problems that will arise practically in the short term, however forming new policies in the long term with this type of M&E information system that includes all types of activities.

(Babayiğit ve Büyükpatpat), indicated that when studying a specific area of irrigation, first a design for remote monitoring of the irrigation system was obtained. The Arduino Uno, ESP8266 Wi-Fi module and Thing speak that is used in the system, these all have the potential to achieve water savings by keeping water under control and spotting irrigation lines. It was found that they can access the irrigation system from anywhere using the Internet by monitoring various environmental variables such as soil moisture, air temperature, air humidity, UV rays and rain.

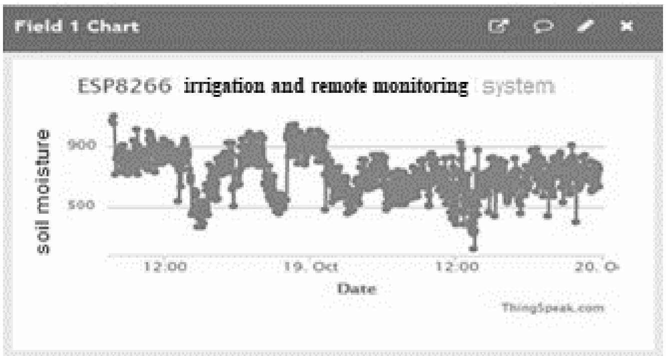

Fig. 8: Soil moisture measurement system.

This model represents a soil moisture measurement system. Remote water depends on soil moisture through irrigation during the month of October, for a period of three weeks. The soil moisture levels were recorded between 500-900 degrees and the lowest soil moisture was recorded at less than 500 degrees at 12 o'clock.

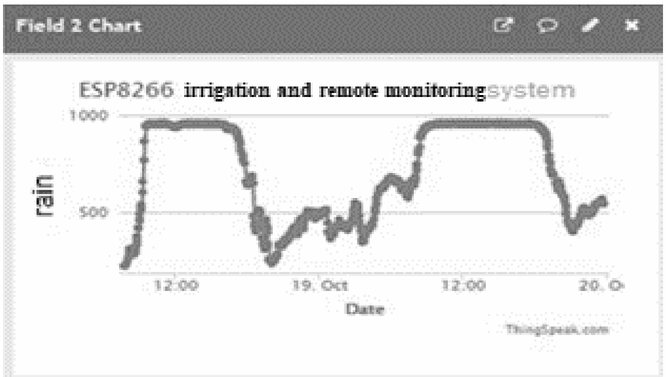

Fig. 9: Rain measurement system with rain sensors.

Rain is one of the important factors that affect the remote irrigation system, as it forces the system to continuously intervene in the event that its degree changes. The change was obvious during daylight hours continuously with its fluctuation reaching a maximum of 1000.

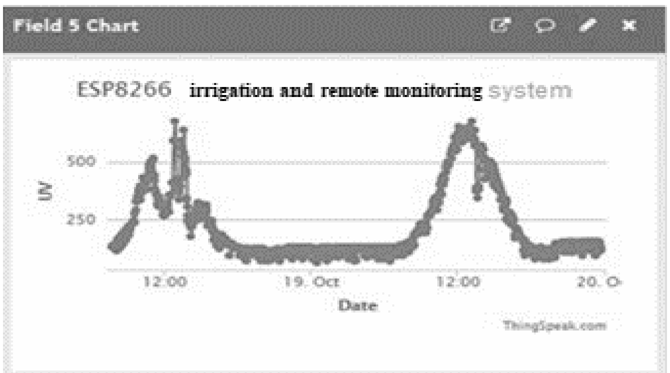

Fig. 10: UV rays measurement system.

In the previous figure we observe the UV rays. Looking at the figure, we see that the UVV rays are below 250 degrees, and that escalation suddenly returns to higher than 500 degrees, and then falls back to below 250 degrees.

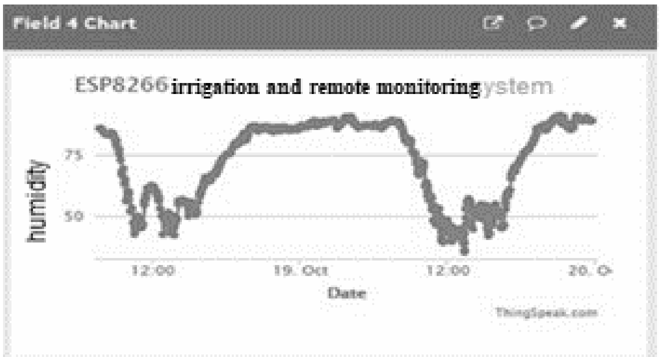

Fig. 11: Air Humidity measuring system.

The air humidity drops below 50 in the middle of the day and rises again at the beginning and end of the daylight hours.

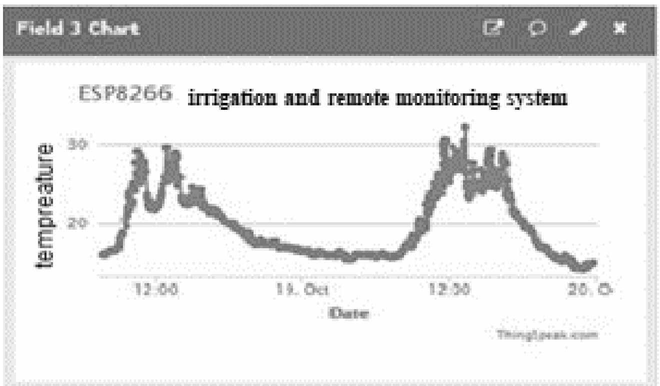

Fig. 12: Temperature measurement system.

Through the previous figure, we see that the high and low temperature affects the remote irrigation system, as we see that the lowest temperature drops at the beginning and end of the daylight hours, while the highest temperatures, which exceeded 30 degrees, were recorded during the noon hours.

Conclusion

The satellite-based geo-location system is used in many agricultural operations, including productivity monitoring, harvesting, fertilization, and controlling of pests ... etc. With these precise technologies, the processes are applied in specific locations so that the energy, fuel, fertilizer, irrigation water and chemical pesticide consumption is lower than conventional processes. Recently it has been proven that satellite based positioning systems can be used in irrigation systems. It is essential to use water effectively in all kinds of activities. Therefore, it may be necessary to switch to the use of agricultural mechanization and automatic irrigation systems instead of traditional methods in irrigation activities, Due to the continuous development in plant growth, never the less when a sufficient moisture in the root zone during the growing season is present, the lost quantity is quickly replaced by the soil, into The root zone of the plant regularly, hence, the importance of careful irrigation is obvious. For this purpose, the characteristics of the sensor used in the measurements are determined. Afterwards, control operations are executed by using specific programs. Therefore, we recommend using precision irrigation instead of traditional irrigation methods to reduce irrigation water and increase productivity.

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