NEW ERA AGRICULTURE MAGAZINE

SENSOR BASED IRRIGATION SYSTEM IN HORTICULTURE

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Abstract: -

Sensor-based irrigation is an innovative approach that optimizes water use in agriculture, providing crops with the ideal amount of water while minimizing manual intervention. It offers significant benefits, including 80–90% water application efficiency and higher crop yields, addressing issues of water scarcity, outdated irrigation practices, and groundwater depletion. Integrating soil moisture, flow, rain, freeze, and wind sensors enables real-time monitoring and control, reducing water waste and preventing damage to irrigation systems. This technology allows farmers to optimize irrigation schedules, improve resource management, and support sustainable agricultural practices, particularly in semi-arid regions with limited access to powered irrigation.

Introduction

Water is crucial for plant nourishment and photosynthesis, with agriculture being the primary user, consuming 1,500 billion m³ (70%) of the 2,500 billion m³ of fresh water used annually. However, inefficient water use in agriculture is a significant issue, with around 40% of freshwater used in developing countries lost to evaporation, runoff, or deep soil absorption. This challenge is linked to broader development issues, as agricultural practices often lead to overuse, nutrient pollution, and salinization of water sources. Irrigation, the artificial application of water to

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agricultural land, is a key aspect of farming, especially in regions facing water scarcity. Efficient water use is essential, requiring precise application only where and when needed. Modern irrigation methods like spray and drip irrigation address water waste associated with traditional techniques such as furrow and flood irrigation.

The irrigation water requirement represents the gap between the agricultural water needs and effective precipitation. Tools like GIS technology and the FAO-modified Penman-Monteith equation can calculate irrigation demand and crop water needs, which are crucial for optimizing irrigation scheduling. Advanced systems can help determine when and how much water should be applied, reducing labor and maintaining optimal soil conditions for better crop yields. Soil moisture sensors offer a promising approach for real-time monitoring of soil water status, enabling precise irrigation. Their relatively low cost allows for widespread deployment, capturing soil moisture variability across fields. The primary aim of this approach is to explore sensor-based technology for an automatic irrigation system that maximizes water efficiency, reduces costs, saves energy, and minimizes time for farmers.

METHODS OF IRRIGATION

Irrigation techniques vary to meet the needs of different crops and regions, with four primary types: surface, subsurface, sprinkler, and drip/micro irrigation.

Surface irrigation, covering 85% of the world's 299 Mha of irrigated cropland, uses gravity to distribute water across the soil. China and India, irrigating over 60 Mha each, primarily rely on this method, which is less efficient than sprinkler or micro irrigation due to water losses in the soil.

Subsurface irrigation uses ditches or drains to maintain the water table near plant roots. It's less common in arid regions and often combined with controlled drainage.

Sprinkler irrigation sprays water over the soil and offers better control than surface methods but can lose water to evaporation and wind.

Drip/micro irrigation applies small, controlled amounts of water, improving efficiency and yield, especially with subsurface drip systems. Micro-irrigation use has grown, with India reporting 1.15 Mha under drip and sprinkler systems in 2005.

The choice of method depends on crop type, costs, user preferences, infrastructure, and local soil, water, and climate conditions.

Use Of Sensors in Irrigation

Soil moisture content, measured in volumetric and gravimetric forms, can be determined using classical or modern techniques, both in laboratories and in situ.

Classical techniques include thermogravimetric analysis, gypsum blocks, tensiometers, and calcium carbide neutron scattering.

Modern methods involve tensiometers, soil resistivity sensors, infrared moisture balances, and dielectric techniques such as capacitance, heat flux sensors, MEMS, Time Domain Reflectometry (TDR), and Frequency Domain Reflectometry (FDR). These advanced methods enable real-time, in-situ measurements using sensor data, offering a cost-effective approach for adjusting irrigation schedules based on specific crop needs.

Soil moisture sensors can operate independently, integrate with the FAO approach, or complement experience-based irrigation management. The system consists of interconnected components called "nodes" that perform three main functions: **Sensing**; **Communication**; **Computation.**

These functions utilize hardware, software, and algorithms. Data-gathering nodes, known as source nodes, send information to a central "sink" or gateway node, which may also process data. In cases where multi-hop routing is needed, source nodes can act as routing nodes. Additional memory may be included for local data storage if required for decision-making. In-field sensors monitor air temperature, soil temperature, and moisture levels. This data is wirelessly transmitted to a base station, where an intuitive decision-making program processes it. The processed information is then used to issue control commands to the irrigation control station.

BENIFITES OF SENSORS BASED IRRIGATION

The main goal of sensor-based irrigation is to provide crops with the ideal amount of water, enhancing both economic and water-use efficiency. This method reduces manual intervention compared to traditional irrigation, potentially lowering input costs and increasing output. Key benefits include:

A. Water Savings: Studies show that sensor-based irrigation, especially with sprinkler and drip systems, can achieve water application efficiency of 80–90%, compared to 40–45% with surface irrigation.

B. Yield and Profit: Proper irrigation scheduling is crucial for productivity, with delays potentially causing losses from $62 to $300 per hectare. Research in Egypt demonstrated that using wireless sensor networks for potato farming increased yields and recovered significant financial losses.

In semi-arid regions like Rajasthan, where groundwater is the main irrigation source but depleting annually by about 1-meter, outdated methods such as furrow irrigation lead to inefficient water distribution.

Farmers often rely on traditional practices without considering factors like soil type, crop water requirements, or weather. Sensor-based irrigation can improve water use efficiency, provide better irrigation scheduling, increase crop yields, and help meet food security goals.

How Do Irrigation Sensors Work in Smart Irrigation Systems?

The ability for farmers to integrate irrigation sensors into their current system is a crucial aspect of all irrigation sensors. Irrigation sensors are simple to install, need little upkeep, and can endure for many years while reducing water usage and conserving resources and improving crop quality.

Soil Moisture Sensors

Prior to the development of smart irrigation, soil tension was measured using soil moisture meters as sensors. After manually connecting the wires of the gypsum block soil sensors with the data reader, a farmer would read the results. Even though these sensors are often used today, there is a rising need for others that are more efficient.

Capacitance Sensors

Liquids, gases, and solids make up soil, and these substances have the capacity to hold electrical charge. The dielectric constant is the name given to the electrical charge. Although the dielectric of liquids, gases, and soils varies, it is simple to distinguish water from other substances.

The reason this kind of soil moisture sensor works so well is that water has the biggest electrical charge, which makes it easy to detect when the soil is dry. Growers can respond promptly because the software is alerted as soon as reduced moisture levels are detected.

Flow Sensors

Flow meters or flow sensors monitor any indication that the irrigation system is using too much water. This sensor will turn off the irrigation system if there is a problem and the crops don't require that much water. To stop additional damage, a flow sensor will notify the person in charge of managing the water supply. The sensor will alert the person in charge and prevent the controller from initiating another water cycle. Farmers can detect potential damage without physically being present on the spot by using flow sensors.

Rain Sensors

Appropriate watering of the soil is one of the best aspects of precision irrigation. Among the earliest irrigation sensors, rain sensors are here to stay. The sensors will halt the subsequent watering cycle when they detect rain. Farmers have a considerable degree of control over how much water they use. Rain sensors come in a number of varieties. Sensors that depend on a cup being filled to a specific level with water are not trustworthy. The sensor will cease adding more moisture to the soil when a cup is filled with water. However, if trash or insects penetrate the cup, false-positive readings may be detected by the sensor.

install freeze sensors to prevent the irrigation system from freezing and shattering. Freeze sensors are frequently found in conjunction with rain or soil moisture sensors. When the temperature drops below 32 degrees

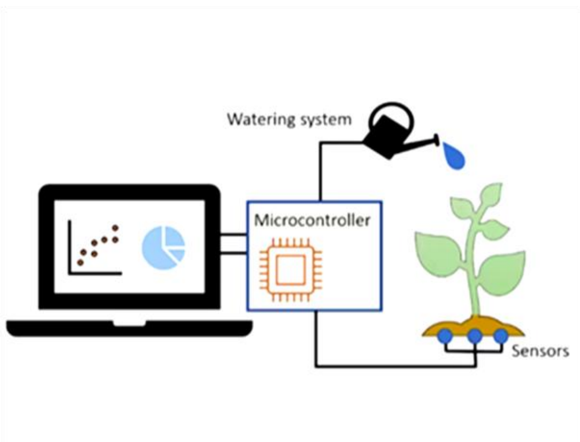

Fig 1: Sensor system in horticultural crops

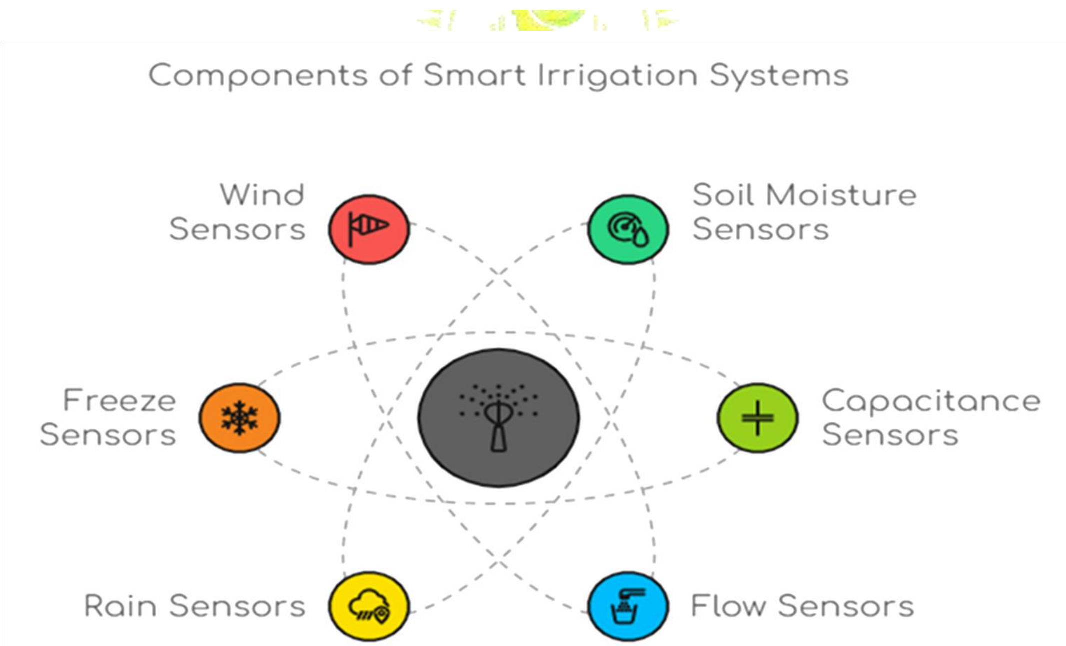

Fig 1: Sensor system in horticultural crops

Freeze Sensors

Sprinklers can be used to shield plants from frost, however this technique isn't always appropriate. For this reason, it seems sense to Fahrenheit, they are meant to halt the irrigation. Irrigation systems are susceptible to failure in cold weather, therefore stopping the irrigation cycle can extend its lifespan and help prevent damage.

Wind Sensors

With sensors that lessen the impact of wind on irrigation, the highest levels of farm irrigation efficacy can be attained. Strong gusts can spread water all across the terrain, but it won't properly hydrate the crops. Because there is an uneven distribution of water, not all crops get the right amount of moisture. When wind speeds exceed a predetermined threshold, wind sensors cut off the irrigation cycle.

CONCLUSIONS

Marginal and small farmers (holding 2–4 hectares of land) in semi-arid regions of developing nations, who lack the financial means to purchase powered irrigation, rely mostly on rainfall to sustain their crops. It has been noted that inaccurate weather forecasts and improper irrigation techniques cause farmers to suffer significant financial losses. The goal is to create an intelligent irrigation scheduling system that will allow irrigation farmers to optimise water use and only irrigate where and when necessary for the necessary amount of time, in light of the pressing need to increase irrigation system efficiency and prevent non-optimal water use.

These sensors detect changes in the surrounding air temperature and humidity and send out an interrupt signal to water when necessary. These sensor technologies have been shown to be useful for gathering data in real time for various weather, crop, and soil factors. This data aids in the development of solutions for most agricultural activities linked to irrigation and other agricultural processes. The advancement of wireless sensor applications in agriculture enables farming operations to become more profitable, productive, and efficient.