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Revolutionizing Irrigation Management: Automated Irrigation System

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Irrigation accounts for more than 70 percent of the global water extraction from surface and groundwater, which is critical to the production of food in arid and semi-arid regions (Mc Dermid *et al.*,2021). In today's constantly evolving agricultural landscape, the search for efficient irrigation management is of paramount importance. Traditional methods fail to meet the demands of various agricultural ecosystems, resulting in water waste, reduced yields, and environmental degradation. However, with the advent of automated irrigation technology, farmers around the world have entered a new era of precision and sustainability. Irrigation schedules are still reliable technology for applying the necessary amounts of water at appropriate times, and automated irrigation system scans maximize the efficiency of water use, based on crop water needs (Munoz *et al.*,2003).

Ganjeer *et al.*, 2019 compared manual irrigation to wheat irrigation using humidity control sensors and reported that the highest water consumption efficiency was achieved in sensor-based irrigation and 15.85% water saving was achieved through sensor-based irrigation.

What is automation?

The Automatic irrigation system includes irrigation without manual intervention " or operation without minimum manual intervention. Irrigation automation is justified when large areas are divided into small segments called irrigation blocks, and the segments are irrigated to match the flow of water available from the water source (Rajakumar *et al.*, 2008).

Types of automation

Semi-automatic

- Semi-automatic systems and controls require manual attention at each irrigation and are usually simpler and less costly than fully automatic systems. Most semi-automated systems use mechanical or electronic timers to activate control structures at pre-determined times.
- The irrigator usually determines when to begin irrigation and its duration and manually resets or returns the devices to their original positions or moves them from one location to another before the next irrigation. The parts of a given system may be automatic while other parts are semi-automatic or manually operated. Such systems require communication between the controller and system components located in the field.

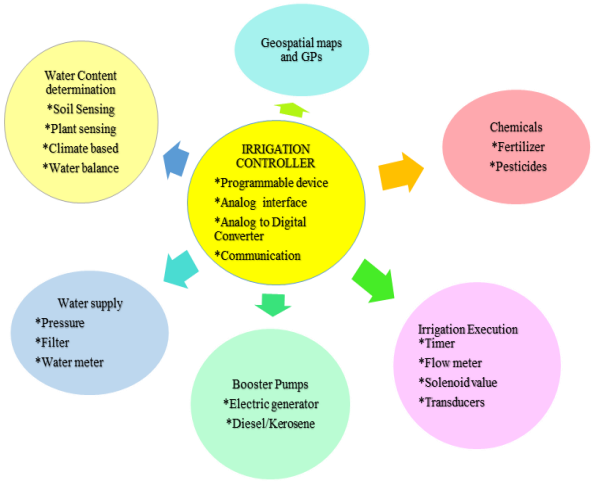

Fig 1: Basic structure for irrigation control system with different functional model (Wang *et al.*, 2013)

Fully automatic

Fully automatic systems normally operate without operator attention except for periodic inspections and routine maintenance. The irrigator may determine when and how long to irrigate and turn water into the system or start programmed controllers to initiate the automated functions. Fully automatic systems may use soil moisture sensors, such as tensiometers or electrical resistance blocks to

activate electrical controls when soil water is depleted to predetermined levels. Fully automatic systems require a water supply available on demand such as from wells or farm reservoirs. Most farm systems however do not have the flexibility required for complete automation.

Component of automated irrigation system

Sensor

- A sensor is an object that **detects changes in energy input to change the output of that energy in either a different form or the same** form.
- The following are the various kinds of sensors used to track soil and plant factors include the ones listed below:
    - Electrochemical
    - Airflow
    - Mechanical
    - Electromagnetic
    - Optical
    - Infrared sensors for plant temperature monitoring
    - Climatological parameter monitoring

Water monitoring sensors for soil plants

The following are the numerous sorts of instruments used to monitor the water condition of soil plants and to automate irrigation systems:

- Resistance block
- Tensiometer
- Time Domain Reflectometry (TDR) based soil moisture sensor
- Gypsum block
- High-frequency capacitance type soil moisture sensor
- Granular matrix sensor
- Infrared sensors for leaf air temperature

Sensors used in automated irrigation system

Automatic controllers

- Micro irrigation systems use automatic controllers, which can simply be mechanical clocks that open/close a single valve on the pre-set timetable of micro-computers. They can be programmed to check soil moisture and/or climate sensors, determine when irrigation is to be started and stopped, start/stop pump, open/close valves to carry out irrigation, and apply exact amounts of water and fertilizers to each block in the field.

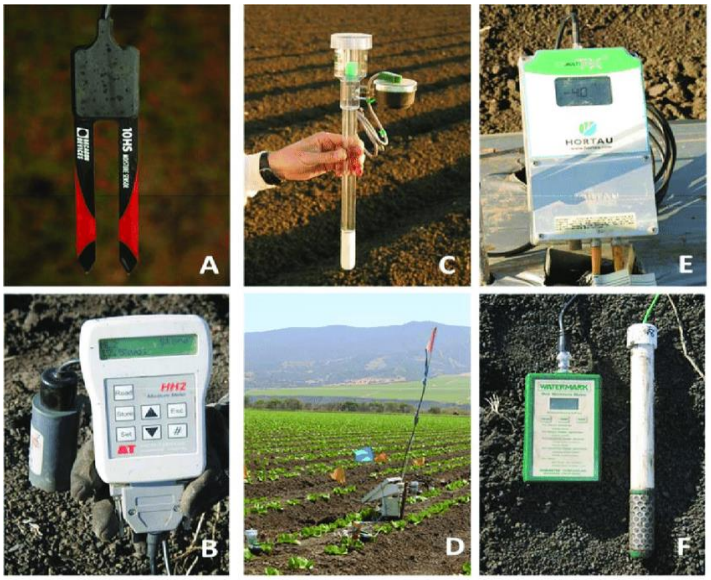

Fig 2: (A, B) capacitance sensors; (C) tensiometer with an electronic gauge; (D) tensiometers with electronic gauges installed in a lettuce field and interfaced with a datalogger and radio communications; (E) tensiometer integrated with pressure transducer, datalogger, and radio communications; (F) granular matrix sensor and reader

- A timer controller uses a clock (solid state or motorized electric) and is programmed to start and sequence irrigation. The controller supplies electrical or hydraulic power to activate remote solenoid valves located in the individual lateral or sub-main(manifolds). Electrical cable, hydraulic or pneumatic cable, or radio telemetry are used to communicate between the controller and the valve.
- Microprocessor-based controllers can be programmed to control pumps, fertilizer injection devices, filters, etc., and activate or deactivate solenoid valves by using data from sensors such as accelerometers, pyranometers, evaporator pans, thermocouples, humidity meters, anemometers, flow meters, pressure transducers, etc. These controllers receive soil and/or climate sensor data according to the irrigator's schedule.

- The controller program uses these data to determine the need for irrigation in each field and block. Then it uses the pumps, filters, injection equipment, and valves needed to complete irrigation. The data of flow meters and pressure sensors are used to determine the need for fluids and detect system malfunctions.
- Some controllers can also identify system errors and correct them. Some even shut down the system during rainy seasons and restart it after the storm ends (James *et al*.,1988)

Merits and demerits of automated irrigation system

Merits

- Water savings
- Water efficiency
- Low application rates
- Uniformity of water application
- Energy saving
- Improved tolerance to salinity
- Improved quality and yield
- Reduced labor cost

Demerits

- High initial cost
- Pressurized irrigation water
- Management and maintenance
- Clogging
- Salt accumulation near the root zone
- Moisture distribution/restricted root zone

Conclusion

Automated irrigation systems represent a paradigm shift in irrigation management, offering precision, efficiency, and sustainability across diverse agroecosystems. As we navigate the complexities of modern agriculture, it is imperative to embrace innovative solutions that enable us to maximize productivity while minimizing environmental impact. Through collaboration between scientists, engineers, and farmers, we can harness the power of automation to create a more resilient and sustainable future for agriculture.

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