



## Smart Water Management: Modernizing Irrigation for Vegetable Cultivation

(\*Imran Arshad<sup>1</sup>, Mubarak Ahmed Saleh AlMansoori<sup>2</sup>, Clea Anne Vallejera Corsiga<sup>3</sup> and Nishat Shah<sup>4</sup>)

<sup>1</sup>Agriculture Engineer, SAA Technical – (ADAFSA Project), Abu Dhabi, UAE

<sup>2</sup>Research Station Head, Dept. of R&D AIDhafra Region, (ADAFSA), Abu Dhabi, UAE

<sup>3</sup>Dean, Cebu Technological University, Barili, Cebu, Philippines

<sup>4</sup>Vice Chairman, Rural Botanical Research Foundation, Jaipur, Rajasthan, India

\*Corresponding Author's email: [enr\\_imran1985@yahoo.com](mailto:enr_imran1985@yahoo.com)

Vegetable farming heavily relies on irrigation as a foundational element, providing essential artificial water supply to ensure continuous growth and yield. This article emphasizes the importance of irrigation in maintaining optimal soil moisture levels for vegetable crops, exploring various methods encompassing both traditional and modern approaches. The efficiency of sprinkler, drip, and responsive drip irrigation systems is scrutinized with considerations for soil topography and water availability. Furthermore, the article explores into practical irrigation scheduling approaches and identifies critical periods essential for consistent water supply during key growth stages. Precision in water supply is paramount in vegetable cultivation to attain maximum yield and produce quality while minimizing water wastage. The selection of an appropriate irrigation system plays a crucial role in meeting the crop's water needs economically and efficiently, steering clear of unnecessary consumption of water, time, and energy.

### Factors Influencing Irrigation Suitability

Factors influencing irrigation suitability are diverse and play a crucial role in determining the effectiveness and efficiency of irrigation systems. These factors can vary based on geographical, climatic, soil, and economic conditions. Understanding these influences is essential for sustainable and productive agriculture. Here are some key factors:

- **Climatic factors:** Different crops have varying temperature requirements. Some thrive in warmer climates, while others prefer cooler temperatures. Areas with insufficient rainfall may require irrigation to meet the water needs of crops.
- **Soil Characteristics:** Sandy soils drain water quickly, while clayey soils retain water for longer periods. The soil's texture affects the frequency and amount of water needed for irrigation. Well-structured soils allow for better water infiltration and root penetration.
- **Topography:** Steeper slopes may lead to water runoff, making irrigation challenging. Terracing and contour farming are often employed in hilly areas to manage water flow.
- **Water Quality and Availability:** High levels of salt in water can negatively impact soil fertility and crop growth. Salinity management practices may be necessary in such cases. The presence of harmful elements in water, such as excess minerals or pollutants, can affect crop health. The proximity and reliability of water sources, such as rivers, lakes, or groundwater, influence the feasibility of irrigation. Legal frameworks and water rights impact the availability and allocation of water for agricultural use.

- **Crop Type:** Different crops have varying water needs at different growth stages. Modifying irrigation practices to specific crops optimizes water usage.
- **Economic Factors:** The financial feasibility of implementing and maintaining irrigation systems influences adoption rates. The demand and profitability of crops in the market impact the economic viability of irrigated agriculture.
- **Technology and Innovation:** Advanced technologies, such as sensors and automation, enable precise water management, reducing waste and optimizing resource use.
- **Government Policies:** Government policies promoting irrigation through subsidies or incentives can influence farmers' decisions. Water usage regulations and guidelines may impact the design and operation of irrigation systems. Efficient irrigation management contributes to food security, economic stability, and environmental sustainability.

### Modern Irrigation Methods

Modern irrigation methods have proven highly efficient not only in sustaining plant growth but also in serving additional purposes such as frost protection and preventing soil consolidation. The discussion encompasses uniform water supply considerations, considering factors like water source extraction and field distribution.

### Irrigation Methods for Vegetable Crops

- **Surface Irrigation:** Surface irrigation involves the movement of water over the land using gravity flow to wet the soil. This method includes various subtypes such as furrow, border, strip, or basin irrigation. When the cultivated land experiences flooding or near-flooding, it is commonly referred to as flood irrigation—a historically prevalent approach in agriculture. Surface irrigation offers a range of techniques for irrigating vegetable crops, each with its specific advantages and suitability based on factors like topography and soil characteristics.
1. **Flood System:** This method involves the uniform application of water across the entire field, resembling a natural flood. Water is allowed to flow over the surface, saturating the soil and reaching the root zone of crops. It is a simple and cost-effective method, suitable for level terrain. However, the level to water wastage due to excessive runoff; may result in uneven distribution.
  2. **Border Method:** In this method fields are divided into strips or borders separated by ridges, and water is applied to these borders. The ridges enable controlled water distribution. It improves the water control compared to flood irrigation, suitable for slightly sloping terrain. However, it may still lead to some water wastage, not ideal for highly irregular terrains.
  3. **Furrow Method:** Ridges or furrows are created between rows of crops, allowing water to flow through these furrows and irrigate the plants. Suitable for areas with varying slopes; efficient water use. However, the use of this method increased risk of salt build-up on beds, where water does not reach. In addition to this a larger volume of surface runoff is generated in furrow systems.
  4. **Basin Method (Ring and Basin):** In this method water is directed into level plots enclosed by small ridges or embankments, creating basins around individual plants or groups of plants. Ideal for heavy or sandy soils; prevents runoff and allows for efficient water utilization. However, it is generally not suited to crops which cannot stand in wet or waterlogged conditions for periods longer than 24 hours.



Fig.01. Surface irrigation methods (A) basin irrigation, (B) border irrigation, and (C) furrow irrigation.



- **Sub-Surface Irrigation Method:** Sub-surface or pipe irrigation offers a methodical approach to delivering water directly to the root zones of vegetables. The use of specialized pipes and capillary action enhances water efficiency and provides a consistent water supply for optimal crop growth. Sub-surface or pipe



Fig.02. Sub-Surface Irrigation Method

irrigation involves the burial of perforated or porous pipes, including clay pipes, beneath vegetable beds, positioned below the root zone. Water is directed into these pipes through suitable means, utilizing capillary movement to raise the water level. Perforated or porous pipes, as well as clay pipes, are employed in this system. Pipes are buried beneath vegetable beds to ensure water delivery below the root zone. Water is directed into the pipes through appropriate mechanisms. The system relies on capillary movement to gradually raise the water level. One end of the pipe is blocked, while the other end is tilted out of the soil to facilitate filling. Water gradually escapes through cracks between pipe sections and pores in the clay, ensuring a continuous water supply to the vegetables. The recommended pipe size is 75mm inside diameter and 300mm in length. Minimizes water wastage through evaporation or runoff; efficient water use; reduces weed growth. However, it requires careful management to prevent clogging of perforations; initial installation costs may be higher than some surface methods.

- **Modern Methods of Irrigation:** These methods of irrigation involve the delivery of water under low pressure through a network of pipes in a predetermined pattern. This method focuses on providing water in specific locations, either drop by drop or in the form of a spray through emitters. The commonly used modern techniques of localized irrigation are sprinkler irrigation, drip irrigation, and responsive drip irrigation.

1. **Sprinkler Irrigation Method:** Sprinkler systems disperse water over the vegetable crop, representing natural rainfall. This method offers uniform water distribution, reduces labor requirements, and has a cooling effect on plants. This method is more efficient than surface irrigation, minimizing runoff and deep percolation losses while ensuring uniform application. The system comprises sprinkler heads or nozzles mounted on raisers in lateral pipelines connected to the main pipeline, which is linked to a pumping unit. Water,



pressurized by the pumping unit, is sprayed through the sprinklers. Overlapping ensures coverage, and the sprinklers are moved to the next point after sufficient irrigation. Researchers suggest water savings of 30-50% compared to surface irrigation. Evaporation losses limited to 2-8% of the total sprinkler discharge. Highly suitable for sandy, shallow, and steep soils.

2. **Drip Irrigation Method:** Drip irrigation delivers water directly to the root zone through a network of tubes, pipes, and emitters, providing precise control over water application. This method reduces water usage and minimizes weed growth. This system delivers water drop by drop near the plant. Water travels through plastic pipes and is pressurized through emitters designed to release water in drops, ensuring direct and continuous wetting of the root zone. The drip irrigation system includes main pipelines, sub-mains, laterals,

drippers or emitters, a rise valve, pressure gauges, filters, venturis, pressure regulators, etc. It is costly method; however, it is most useful in areas with scanty rainfall and high-density plantations. It requires regular water supply for optimal operation. The evaporation and soil erosion are



Fig.04. Drip Irrigation Method

near to negligible, but considerable percolation and seepage losses occurs. It is a most efficient method for providing irrigation water and fertilizers near plants as it enables effective utilization of fertilizers, pesticides, and water-soluble chemicals. However, due to its high operational costs, pipeline damage due to clogging, and potential disease infestation in underground plant parts starting from collar regions farmers still have reservations for adopting this method.

3. **Responsive Drip Irrigation (RDI):** Responsive Drip Irrigation (RDI) GrowStream™ revolutionizes conventional irrigation practices by introducing an innovative method for delivering water and nutrients to plants. The system utilizes a microporous tube that responds directly to signals emitted by plant roots. Operating on a demand-driven principle, RDI releases water and nutrients precisely when the plant

needs them, eliminating



Fig.05. Responsive Drip Irrigation Method

issues like evaporation and percolation. This results in a highly efficient and sustainable irrigation approach that provides optimal conditions for plant growth. RDI recognizes the dynamic nature of plant life beneath the surface, responding to natural chemical signals released by roots in reaction to environmental factors. The heart of RDI lies in its microporous tube, responding to root signals and allowing for precise water and nutrient delivery. Unlike traditional systems, RDI puts plants in control of their hydration needs, minimizing wastage and optimizing resource utilization. This intelligent system ensures perfect irrigation by providing resources exactly when needed, promoting vigorous and healthy plant development. The seamless integration with natural root processes minimizes waste, enhancing sustainability in agriculture. The precision of RDI not only optimizes plant growth but also contributes to environmental conservation by reducing water and nutrient wastage. This eco-friendly approach aligns with the global focus on sustainable agriculture.

### Irrigation Scheduling

Determining when and how much to irrigate is crucial for preventing water stress in plants and achieving high-quality vegetable yields. The irrigation schedule, influenced by soil, climate, and plant factors, plays a key role in successful vegetable cultivation. Several practical approaches are employed to establish irrigation schedules, including monitoring soil moisture depletion, cumulative pan evaporation, and sensory observations. These methods help tailor irrigation practices to the specific needs of the crop.

### Critical Periods for Irrigation

Certain growth stages, such as seed germination, flower initiation, and fruit development, require consistent water supply. Failure to provide water during these critical periods can

reduce crop yield potential. Essential irrigation periods include seed germination, flower initiation, and fruit development. In the early stages, ensuring water availability is crucial for seed germination. During later stages, such as flower initiation and fruit development, maintaining consistent irrigation is vital for optimal yield potential in various vegetable crops. Critical stages for specific crops include head/curd development in cole crops, fruit formation in solanaceous vegetables and okra, pod development in peas and beans, tuberization in potatoes, bulb development in onions and garlic, and root development in root crops. By understanding and adhering to these critical periods, farmers can maximize the yield potential of their vegetable crops and enhance overall crop quality.

### Conclusion

Optimizing water use in vegetable cultivation is imperative to maximize crop yield and quality. Modern irrigation methods, notably sprinkler, drip, and responsive drip irrigation systems, exhibit efficacy in meeting diverse crop water requirements while minimizing wastage. The selection of an appropriate irrigation system necessitates alignment with specific field conditions, encompassing factors such as soil topography and water availability. Additionally, implementing precise irrigation scheduling methodologies and identifying critical water supply periods during distinct growth stages are paramount. Integration of these insights into agricultural practices enables sustainable water management, enhances overall crop quality, and fortifies the resilience of vegetable farming amid evolving environmental conditions.

### References

1. Ahadi, R., Samani, Z., Skaggs, R., 2013. Evaluating on-farm irrigation efficiency across the watershed: A case study of New Mexico's Lower Rio Grande Basin. *Agric. Water Manag.*, 124(1): 52–57.
2. Arshad, I., Farooqui, O., Ali, W., 2017. Impact of Agricultural Engineering Practices on Farm Management: A Case Study of Gharo Model Farm. *PSM Biol. Res.*, 2(1): 40-45.
3. Arshad, I., 2020. Importance of Drip Irrigation System Installation and Management - A Review . *PSM Biol. Res.*, 5(1): 22-29.
4. Berbel, J., Gutierrez-Marín, C., Expósito, A., 2018. Impacts of irrigation efficiency improvement on water use, water consumption and response to water price at field level. *Agric. Water Manag.*, 203(1), 423–429.
5. Maina, k., Singh, O.P., Dinesh, C.M., 2017. Crop Water Requirement, Water Productivity and Comparative Advantage of Crop Production in Different Regions of Uttar Pradesh, India. *Int. J. Curr. Microbiol. App. Sci.*, 6(7): 2043-2052.