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Drip Irrigation System and Its Importance in Agriculture Sector

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There is a huge demand for irrigation today in order to obtain the needed yield and satisfy our present-day population's food requirements. Water is treated as one of the important elements of agriculture; however, its usage is hindered since there are issues like rising demands, inconsistent rainfall and depletion of groundwater reserves and climate changes. Conventional irrigation systems usually waste water through runoff, evaporation and deep percolation. One of the methods of micro-irrigation is drip irrigation wherein water is delivered to the root zone at a slow pace via emitters or drippers. Thus, it allows farmers to use water according to the needs for respective crops and create optimal moisture conditions around roots. This method can also be combined with the fertigation process to supply water with soluble fertilizers. Drip irrigation is widely applied to vegetables, fruits, plantation crops, flowers, and other high-value crops. To accomplish effective results with the drip irrigation system, the design and filtration process must be accurate as well as the governance provided with the proper pressure level.

Keywords: Agriculture, Drip Irrigation, Fertilizers, Micro-Irrigation, Water

Introduction

Freshwater is mostly used in the agriculture sector for Irrigation worldwide. This requires the proper management of irrigation systems guaranteeing sustainable food production. The issue of using groundwater, changing rain patterns and increased combat over water sources is of utmost importance in India today. Traditional surface irrigation can lead to high losses when conveying and applying water. According to ICAR, drip irrigation provides a superior water application efficiency if the system is designed and managed correctly. Drip irrigation, or trickle irrigation, is a micro-irrigation technique based on supplying water at low rates directly to the soil in proximity to the root zone of plants. FAO describes common drip emitters delivering water at low rates throughout the operation to sustain favourable moisture conditions at the root zone.

Principle of Drip Irrigation

The underlying concept of drip irrigation is to "provide the proper quantity of water at the right location and at the correct moment." Water is passed from the origin through the mainline and sub-mainline to laterals placed on the planting rows. Small devices called emitters or drippers release water slowly near the plants.

Unlike flood irrigation, the entire field does not necessarily need to be wetted. Instead, a portion of the soil containing the active root system is maintained at an appropriate moisture level. It leads to minimizing water movement away from the root zone and prevents losses due to evaporation, runoff, percolation and also promotes water conservation at other stages. According to FAO, the main methods of saving water can be defined as reduction of runoff, evaporation and percolation, while the savings rate depends on both the condition of the field and the usage of the system

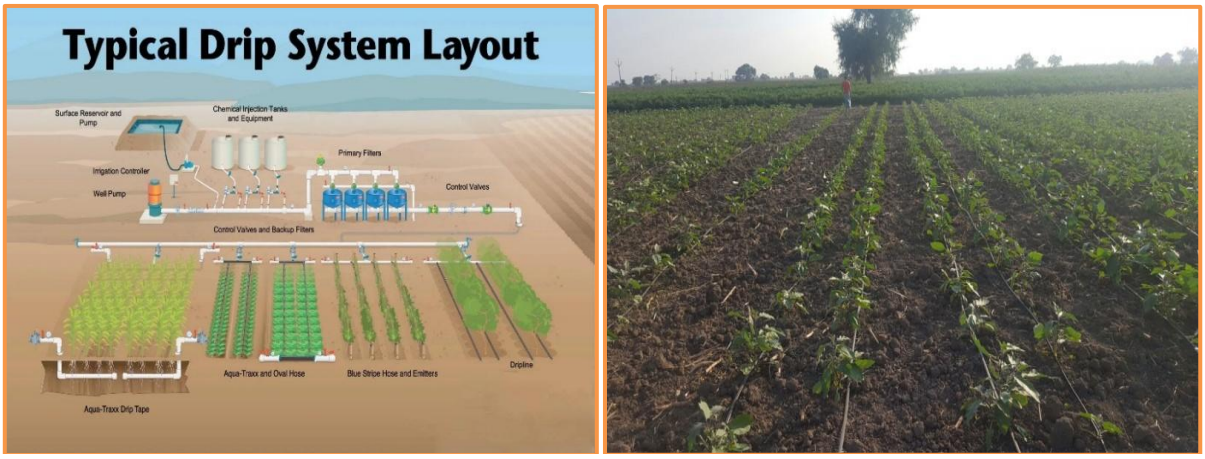

Figure 1: Typical drip irrigation arrangement and field application. *Image sources should be checked for licence/permission before publication.*

Major Parts of Drip Irrigation System

Table 1: The irrigation system is an assemblage of several parts needed to work together.

Component	Major function
Water source	Provides irrigation water
Pumping unit	Provides required pressure and flow
Filter	Removes suspended particles and reduces emitter clogging
Fertigation unit	Allows soluble fertilizers to be supplied through irrigation water
Mainline	Carries water from the source towards the field
Sub-mainline	Distributes water to different field sections
Laterals	Carry water along individual crop rows
Emitters/Drippers	Release water near the plant at a controlled rate
Pressure regulator	Maintains suitable operating pressure
Valves	Control water flow to different sections
Flush valve	Helps remove accumulated sediments from laterals

The FAO drip-irrigation system description similarly identifies the pump, control head, main and sub-main lines, laterals and emitters as important elements of a typical system.

Importance of Drip Irrigation in Agriculture

❖ Improved Water-Use Efficiency

The most important advantage of drip irrigation is the precise application of water. Water is supplied close to the crop root zone instead of being distributed over the entire soil surface. This can reduce losses associated with runoff, evaporation and excessive percolation. ICAR reports water application efficiency of approximately **90–95%** for drip irrigation under appropriate conditions. Nevertheless, high efficiency at the field level does not imply that the results will yield the same level of water saving in all cases. Some critical factors continue to operate in all the fishing operations such as water management, irrigation scheduling, the choice of crops, and practices of the farmer.

❖ Better Crop Growth and Productivity

Regular and appropriate watering ensures uniform moisture in the soil surrounding the roots of a crop, which helps to reduce the time period for which a crop experiences excessive

moisture deficit. A study published in the Indian Journal of Agricultural Sciences has shown that an efficient irrigation system can affect the yield of a rice crop and its water-use efficiency.

Fertigation and Efficient Nutrient Management

One of the greatest benefits of using drip irrigation systems is their ability to perform fertigation, or supplying soluble fertilizers with irrigation water. Nutrients can be supplied in small quantities and in volumes required by the crop at its growing stages.Recent ICAR research reports that drip fertigation can improve nutrient-use efficiency and, depending on crop and location, may increase crop yield and water productivity.

Reduction in Weed Growth

Since water is concentrated around the crop root zone rather than uniformly distributed across the entire field surface, portions of the inter-row area may remain relatively dry. This can reduce the favourable environment for some weeds and consequently decrease competition between crops and weeds.

Suitability of Drip Irrigation for Various Crops

Drip irrigation is highly appropriate for application in:

- Vegetables
- Fruit and tree crops
- Grapes • Sugarcane
- Cotton • Flowers
- Plantation crops
- Nursery crops
- Commercial horticultural crops

It can also be adapted for some field crops when appropriate irrigation scheduling and system design are followed.

Drip Irrigation and Crop Productivity

In addition, there are more advantages to drip irrigation beyond saving water. Correct irrigation scheduling may help to find balance between amount of water available and production of crops. For instance, an ICAR research paper on coriander proved that irrigation and fertigation systems had great influence on growth, yield and water use efficiency of crops. The study identified an appropriate combination of irrigation and fertigation for improving production and resource-use efficiency under the experimental conditions. Likewise, studies examining rice crops cultivated with irrigation via a drip technique have shown that an irrigation scheme can strongly affect crop yield as well as water consumption efficiency. The studies show that drip irrigation should not only be thought of as a means of saving water, but also as an agricultural technology, which is based on understanding the demand of crops, irrigation scheduling, soil characteristics, and efficient management of the irrigation system.

Economic and Environmental Importance of Drip Irrigation

Drip irrigation can influence agriculture in a positive way through unnecessary irrigation reduction, efficient use of inputs and fertigation opportunities. Reduced irrigation period can also cause reduced energy consumption in some instances.

From the perspective of environmental impact, efficient irrigation can save water and nutrients. Drip fertigation may also reduce excessive fertilizer application when nutrient doses and timing are properly managed. ICAR has highlighted the potential of drip fertigation for improving both water and nutrient productivity.

Table 2: Major impacts of drip irrigation

Aspect	Potential benefit
Water management	Precise root-zone application
Crop growth	More uniform soil moisture

Aspect	Potential benefit
Fertilizer management	Suitable for fertigation
Weed management	Reduced wetting between crop rows
Labour	Potential reduction in irrigation labour
Energy	Potential reduction in pumping requirement
Soil conservation	Less surface runoff and erosion
Productivity	Better water and input productivity
Sustainability	Supports efficient resource management

Limitations and Challenges

Despite its advantages, drip irrigation also has certain limitations. The initial installation cost can be higher than conventional surface irrigation. Small emitters can become clogged if water is not adequately filtered. Pressure variation can result in non-uniform water application, while poor-quality installation may reduce system life. Regular filter cleaning, flushing of laterals, checking pressure and monitoring emitter discharge are therefore essential. FAO specifically highlights emitter blockage as an important operational problem associated with suspended materials, algae and certain dissolved substances in irrigation water. Another important consideration is that water saved through improved irrigation efficiency should be managed carefully. FAO notes that "water saving" at the field level can have wider hydrological implications, particularly where saved water is subsequently used to expand irrigation.

Future Prospects

Precision agriculture, automation, digital irrigation scheduling and sensors make for the future of drip irrigation. Soil moisture sensors, flow meters, automated controllers and weather information help to find out when to irrigate and the volume of water to be applied, according to ICAR. The organization has talked about the role of technologies and automation in drip irrigation, like wireless sensor networks or IoT, in improving water productivity. Therefore, drip irrigation + fertigation + soil moisture monitoring + automation brings changes to irrigation practice characterized by the shift from a regular operation to the deman-based crop management.

Conclusion

Drip irrigation is a vital innovation to contribute to efficient and sustainable agricultural water management. Drip irrigation allows farmers to directly deliver water to the root zone of crops, thereby minimizing any loss of water, while at the same time ensuring optimal soil moisture levels for irrigation. Its compatibility with fertigation enhances the possibilities of efficient fertilizer and nutrient management. However, the performance of drip irrigation is contingent on proper design, high-quality water filtration, proper emitter selection, proper irrigation timing and regular servicing. Thus, farmers must adopt drip irrigation depending on the requirements of crops, field characteristics, water quality, soil conditions and economic viability rather than see it as a panacea solution.

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