**Lecture 41 Drip Irrigation**

**41.1 Introduction**

Drip irrigation also called as trickle irrigation is the method of applying filtered water (and fertilizers soluble in water) at a low discharge through the emitters or drippers directly onto or in to the soil. The pressure that need to maintained at the emitters, also called as operating pressure, is usually small operating pressure (20 to 200 kPa or 1 to 2 kg/cm2) compared to the operating pressure required at the nozzle or sprinkler of the sprinkler irrigation system. The discharge of the emitter varies from 0.5 to 12 lph depending on the soil type, discharge available at the source and the area to be irrigated. The low discharge of the emitter results in partial wetting of soil root zone.

The drip irrigation is one of the micro irrigation methods. The micro irrigation method is the low pressure irrigation system that sprays, sprinkles, mists, delivers or drips the water frequently at low discharges onto or into the soil near the plant roots and causing only partial wetting of the soil surface. The other types of the micro irrigation methods are micro-sprinkler, micro-jet, bubbler. In micro irrigation methods water is conveyed through the network of the pipes directly in to the field and applied at or near the crop root zone. Micro irrigation defers from sprinkler irrigation by the fact the only part of the soil surface is wetted in micro irrigation methods and these methods operate on low pressure and deliver low discharge.

A precise amount of water equal to daily consumptive use or the depleted soil water that change with crop growth stages and weather conditions can be applied through drip irrigation methods. In this method the soil water can be maintained near to field capacity (or within allowable depletion range) or at low tensions during the entire crop growth period. Due to regulated flow in low volumes, deep percolation losses can be completely prevented and evaporation loss is also reduced. Therefore this method is preferable in arid regions where water is scarce compared to others methods. Due to the provision of frequent water application and possibility of maintaining the soil at low tension poor quality water in respect of salt concentration can also be used. It enables application of fertilizer along with irrigation water. Due to these facts, drip irrigation ensures optimum growth, better fruiting and early maturity of crops by assuring balanced soil water, air and nutrients throughout the crop period.

41.2 Advantages and Limitations of Drip Irrigation

Due to the possibility of applying water frequently in low volumes along with fertilizer and causing only partial wetting of soil, this method offers various advantages over the surface and sprinkler irrigation methods. However at the same time, this method involves high level of technology compared to the surface irrigation method and therefore for its successful operation, the method needs to be

used carefully. This section describes the advantage and disadvantages of drip irrigation method along with its adoptability.

**41.2.1 Advantages**

* Water Savings: In drip irrigation system, the water is not moved over the soil surface or through the air. Therefore the conveyance losses are totally eliminated. As water does not come in contact with the foliage, the interception losses are also eliminated. In addition to this as this method can wet only the desired soil root zone keeping other portion of the soil dry, the losses in application are also reduced. Due to regulated flow and application of water in low volumes, the deep percolation losses are also reduced to a great extent. All these utilities in drip irrigation method make this method to use water efficiently and reduce/eliminate the water losses in the process of conveyance, distribution, application and storage. Therefore this method can save water to the extent of 40 to 60 % without compromising the crop growth.
* Improved Plant Growth and Crop Yield: As this method allows the efficient application of water in low volumes frequently, it is possible to maintain the water content in the soil root zone near to the field capacity or within allowable depletion soil moisture. At this level the soil moisture tension is low and the plant need not to exert much to extract water from the soil. Therefore the plants are not subjected to water stress during the entire crop growth period. This also maintains the favorable air and water ratio in the soil root zone and thus improving the plant growth and in the process obtaining the higher crop yield compared to other methods. It has been reported that drip irrigation increases the yield from 10 to 60% depending upon soils and crops over conventional methods of irrigation (INCID, 1994).
* Labor & Saving: There is considerable saving in labor, as the well-designed system needs labor only to start or stop the system. This method is also adaptable to automation of low to high level in water and fertilizer application. Therefore the expenses on the manual labourer can be reduced to a great extent.
* Energy Saving: Because of high irrigation efficiency, less amount of water is required to be applied and hence less time is required to supply the desired quantity of water and therefore this, method saves energy. In addition to this the low pressure is required to operate the emitters compared to sprinkler irrigation system, therefore there is a need of low horse power pump, further causing the saving in energy.
* Suitability to Poor Soils: Very light soils are difficult to irrigate by conventional methods due to deep percolation of water. Like-wise, very heavy soils with low infiltration rates are difficult to irrigate even by sprinkler method. However, drip irrigation has been found successful in both types of soils.
* Weed Control: In drip method, due to partial wetting of soil, weed infestation is very less in comparison to other methods of irrigation. This reduces the need of expensive and environmentally hazardous chemicals and laborers for the application of these chemicals.
* Economy in Cultural Practices & Operations: Besides achieving effective control of weeds, it also increases the efficiency of other operations like spraying, weeding, harvesting etc. due to the possibility of arranging the geometry of the plantation to suit to these operations. There by reducing the operational costs even upto the extent of 50%.
* Use of Brackish/Saline Water: In this method the soil moisture can be maintained at low tension and therefore best suited to the application of brackish/saline water which is otherwise not possible in surface irrigation method due to moisture at high tension because of prolonged interval between two irrigations. As the irrigation requirement of this method is almost reduced by more than 50%, the use of water with salt loads cause the less salt accumulation compared to surface irrigation methods.
* Enhanced Fertilizer Application Efficiency: In drip irrigation system, water soluble fertilizers can be applied. As water can be precisely applied in the root zone, fertilizer can also be applied in the root zone of the crop only. Therefore the losses of fertilizers in the process of deep percolation, leaching, runoff etc can be considerably eliminated enhancing the saving of precious fertilizer and causing the minimum hazards to the environment reducing the groundwater pollution.
* No Soil Erosion: As water is not moved over the land surface, there is no soil erosion due to drip irrigation.
* No Land Preparation: Preparation of leveled bed, bund and channels is not necessary as water is not required to move on the land surface. Only land smoothening will suffice.
* Minimum Diseases and Pest Problems: In drip system, because of less atmospheric humidity minimum diseases and pest problems are observed.
* Adaptability to Application of Mulches: In water scarce region, the mulching has been found very successful for saving water. The drip irrigation method wherein the drippers can be placed below the mulch cover is suitable for the situations where the mulches are required to be used. The drip irrigation method along with the mulching has been found a very formidable option in regions where water shortage is acute.

**41.2.2 Limitations**

The limitations of drip system are

* Initial Heavy investment: The drip irrigation method involves the use of several components to apply water as per its principle compared to surface and sprinkler irrigation methods. Therefore the initial cost required for the procurement of these components of the system and its installation is high. Often farmers may not afford this investment. However realizing the importance of this method in water saving and other factors, the Central and various State government agencies including National Horticulture Mission on Micro-irrigation bear the partial expenses on this system by offering the subsidy to the farmers on the procurement of this system. Though the initial cost is high, in long term the system is beneficial as it saves water, energy, fertilizers, labor and produces more crop produce.
* Extensive Maintenance Requirement: If the proper filtration system is not used emitter clogging could be the most serious problem in drip irrigation the remedial measures on which could be expensive. Apart from this, salt and chemical deposits can accumulate at openings of the emitters partially or fully plugging the tehm. Clogging can adversely affect the flow rate and uniformity of water application, increased maintenance costs as it becomes necessary to check, replace or reclaim the clogged emitters. As the water is not applied uniformly and as per the requirement due to partial and full clogging of the emitters. As the water is not applied uniformly and as per the requirement due to partial and full clogging of the emitters, crop damage & decreased yield may occur, if not detected early & corrected timely. Other maintenance problems may include pipeline leaks and puncturing of the tubes. Rodents, rabbits, dogs, etc. can chew & damage drip line; and ants & other insects have occasionally enlarged opening in drip tubing. Drip lines can be cut or dug-up accidentally when weeding, replacing or repairing other pipelines or utilities in nearby areas. Filters, chemical injectors, pressure regulators, water meters and pumps are also subjected to malfunctioning and liable for maintenance.
* Salinity Hazards: Although drip system can be used under saline conditions, it must be managed properly. Otherwise reverse pressure gradients in the soil will cause flow of salts towards plant root with the resulting detrimental effects. It has also been found that the salts in irrigation water or soil are pushed to the fringes of the wetted area formed due to emitters, causing the accumulation of salts. This accumulation of salt could be harmful for the next seasons if not leached in rainy season or by applying water in excess of the irrigation requirement for leaching of the salts that are accumulated.
* Economic and/or Technical Limitations: Besides the initial heavy investment on the components of the drip irrigation system, the annual maintenance of these components, if not used properly, could be expensive. There are some specific requirements to operate and maintain the fertigation units, valves, pumps and filters. Often the technical limitations on the operation of these components may prohibit the proper use of the components, increasing the cost on the maintenance.
* High Skill Requirements: High skill is required for designing, installation and subsequent operation. The technical knowledge in the design of emitters, fittings, filters, etc. has been necessary. The procedures for preventing or correcting emitter clogging & rectifying equipment failure have been difficult. The use of proper methods for injection of fertilizers & other chemicals has sometimes been a problem. A higher level of design, management & maintenance is required with drip than other irrigation methods.

**41.3 Critical Appraisal of the Adaptability of Drip Irrigation**

The drip irrigation system is very popular in areas of acute water scarcity due to its advantages in terms of high water use efficiency. This method adoptable to almost all types of soil and topography of land. Drip irrigation has been found to irrigate marginal soils and terrain that otherwise not possible continently  irrigate by other methods, Soils with high permeability and low water holding capacity, such as sands, desert pavement and least topical soils adopt  poorly to surface or sprinkler irrigation but can be irrigated successfully with drip systems. Drip irrigation has been proven to be an efficient and effective technique for establishing vegetation on steep slopes of abandoned mines, road embankments etc.   It is also suitable for irrigating slowly permeable soils and irregular plots.

Small irregularly shaped and narrow long and landscaped area are difficult to irrigate by sprinkler irrigation system resulting in over spray of paved surfaces and lack of uniformity. Drip irrigation enables water to be applied with high uniformity and may eliminate runoff and overspray. Sub surface drip on turf grass and sports fields does not interfere with the continuous use of area. Drip irrigation is adaptable for protected cultivation in green house, shade net and low tunnels. It provides control application of water and nutrients for each individual plant without foliage wetting, which is an important feature for high values crops such as flowers, potted plants and green house vegetables. Drip irrigation is also suitable for vegetables grown on plastic mulching under tunnels, such as strawberries and early seasons melons and other vegetable crops. Saline and poor quality water can be more safely used through drip irrigation than through any other method of irrigation. It is well adapted to variety of row crops from widely spaced fruit crops to closely spaced vegetable crops and places where commercial cultivation is in vogue of cash or horticultural crops. Numerous studies have been conducted in different parts of the country on various crops to quantify the benefits of the use of drip irrigation in terms of increased production and productivity as well as saving of water (Padmakumari and Sivanappan, 1989; Raman, 1999; Sivanappan, 1999). Kumar and Singh 2002 compiled multi locational research trial data on drip irrigation and these are reported in Table 41.1. The crops that gave relatively higher yield under drip irrigation are gherkins, mosambi, carrot, beans, mango, turmeric, popcorn, baby corn, papaya and capsicum (Table 41.1). On the other hand, chilli, coconut, radish, ridge gourd, tomato, guava, cabbage, banana, potato and beet root gave higher water use efficiency. High water saving was observed among beet root, bitter gourd, sweet potato, papaya, radish, sweet lime, mosambi, pomegranate, turmeric and cotton crops.

**41.4 Scope and Status of Drip Irrigation in India**

The drip method is an acceptable system of irrigation to many crops, yet drip irrigation should not be expected to replace other irrigation methods or in some cases to even compete with conventional irrigation methods. The potential for using less water per unit of production may provide the motivation for changing irrigation methods whenever and wherever water costs have very significant effects on profit margins. The rapid expansion of drip irrigation in southern India such as Andhra Pradesh, Tamil Nadu, Karnataka and western part of country such as Maharashtra and Gujarat where water is scarce commodity and the costs are high illustrates this point. Since drip irrigation is not economical for some crops that are surface irrigated such as wheat and paddy in particular. Vast areas under these crops underestimate the acceptance of drip irrigation over the past decade.

Table 41.1. Average crop yield, percentage increase in yield, water use efficiency and water saving in drip over the conventional irrigation system for various crops.

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| --- | --- | --- | --- | --- | --- | --- |
| Sl. No. | Crop | No. of references | Yield (tha-1) | Yield increases (%) | WUE(tha-1cm-1) | Water saving(%) |
| 1 | Acid lime | 1 | 78.00 | 56.00 | 1.30 | 50.00 |
| 2 | Baby corn | 1 | 9.88 | 72.40 | 0.48 | 43.80 |
| 3 | Banana | 7 | 71.52 | 29.27 | 2.95 | 42.50 |
| 4 | Bean | 1 | 10.25 | 81.80 | 0.37 | 36.90 |
| 5 | Beet root | 1 | 48.87 | 7.00 | 2.76 | 79.00 |
| 6 | Ber | 3 | 71.03 | 27.67 | 0.66 | 34.33 |
| 7 | Bitter Ground | 4 | 2.68 | 44.38 | 1.43 | 69.50 |
| 8 | Bottole gourd | 1 | 55.80 | 46.80 | 1.03 | 35.70 |
| 9 | Brinjal | 7 | 16.01 | 44.63 | 1.47 | 42.55 |
| 10 | Cabbage | 5 | 50.49 | 37.48 | 3.17 | 37.35 |
| 11 | Capsicum | 1 | 22.50 | 66.60 | 0.78 | 43.10 |
| 12 | Carrot | 1 | 26.26 | 92.30 | 0.81 | 33.60 |
| 13 | Castor | 2 | 7027 | 30.24 | 1.73 | 32.99 |
| 14 | Cauliflower | 3 | 19.50 | 39.73 | 0.68 | 37.10 |
| 15 | Chickpea | 1 | 3.80 | 66.60 | 1.60 | 42.60 |
| 16 | Chilli | 5 | 67.98 | 28.74 | 7.47 | 47.28 |
| 17 | Coconut, No/plant | 2 | 181.00 | 7.10 | 6.89 | 50.50 |
| 18 | Cotton | 3 | 36.00 | 40.00 | 0.86 | 51.10 |
| 19 | Cucumber | 1 | 22.50 | 45.10 | 0.94 | 37.80 |
| 20 | Gherkins | 1 | 4.88 | 100.60 | 2.30 | 36.10 |
| 21 | Grain corn | 1 | 6.50 | 52.90 | 2.20 | 45.00 |
| Contd… |
| S. No. | Crop | No. of references | Yield(tha-1) | YieldIncreases (%) | WUE(tha-1cm-1) | Water saving(%) |
| 22 | Grape | 5 | 29.93 | 20.94 | 0.95 | 43.00 |
| 23 | Groundnut | 2 | 3.50 | 62.50 | 1.00 | 32.40 |
| 24 | Guava | 2 | 25.50 | 63.00 | 3.53 | 9.00 |
| 25 | Mango | 3 | 19.50 | 80.67 | 2.40 | 28.93 |
| 26 | Mosambi, 1000 pcs | 1 | 15.00 | 98.00 | 0.23 | 61.00 |
| 27 | Oil palm | 1 | - | - | - | 21.00 |
| 28 | Okra | 12 | 20.05 | 20.69 | 1.94 | 44.72 |
| 29 | Onion | 3 | 17.01 | 42.60 | 1.20 | 36.70 |
| 30 | Papaya | 5 | 56.64 | 71.97 | 0.91 | 67.97 |
| 31 | Pomegranate, 100 pcs | 3 | 44.67 | 55.67 | 0.53 | 57.33 |
| 32 | Popcorn | 1 | 5.50 | 75.40 | 2.10 | 42.00 |
| 33 | Potato | 5 | 28.66 | 50.02 | 2.80 | 24.62 |
| 34 | Radish | 2 | 17.00 | 27.50 | 5.04 | 64.00 |
| 35 | Ridge gourd | 3 | 17.39 | 14.50 | 4.36 | 43.39 |
| 36 | Round gourd | 1 | 36.60 | 24.00 | 0.46 | 0.00 |
| 37 | Sapota | 1 | - | 17.20 | - | 21.40 |
| 38 | Sweet potato | 1 | 50.00 | 39.00 | 1.98 | 68.00 |
| 39 | Sugarcane | 6 | 145.87 | 43.59 | 1.19 | 46.67 |
| 40 | Sweet lime | 1 | 15.00 | 50.00 | 2.30 | 61.40 |
| 41 | Tapioca | 2 | 54.60 | 12.60 | 0.55 | 23.40 |
| 42 | Tomato | 11 | 36.57 | 46.00 | 3.82 | 37.35 |
| 43 | Turmeric | 2 | 18.44 | 76.30 | 0.56 | 53.10 |
| 44 | Watermelon | 3 | 46.80 | 64.83 | 2.13 | 46.10 |
|  |  |  |  |  |  |  |  |  |  |  |

WUE = Water use efficiency

(Source: Kumar and Singh, 2002)

If the gross value per unit land area of the various crops that are drip irrigated are compared with those irrigated with conventional systems, the importance of drip irrigation may be seen. Most of the crops irrigated by the drip method yield higher cash returns per unit area compared to some of the crops under conventional irrigation. Developments in the future will probably continue to be concentrated on high value crops. Extending limited water supplies and on the utilization of relatively low quality water.

**Adoption of Drip Irrigation in India**

In India, drip irrigation was introduced in the early seventies at the Agricultural Universities and research institutions. Significant development of drip irrigation has taken place in since 1980s. The growth of micro-irrigation has gained momentum in recent years. From a mere 1500 ha in 1985, the area under drip irrigation has grown to 462,300 ha in 2003 (ICAR, 2003). These developments have taken place mainly in areas of acute water scarcity. As on in year 2003 the area-wise distributions of drip irrigation in different states of India are Maharashtra (1,94,000 ha), Andhra Pradesh (59,500 ha); Karnataka (58,500 ha); Tamil Nadu (46,500 ha); Rajasthan (41,500 ha); Gujarat (20,500 ha); Madhya Pradesh (8800 ha); Kerala (8500 ha); Uttar Pradesh (4500 ha); Orissa (3900, ha) Haryana (3400 ha); Punjab (2200 ha); West Bengal (800 ha); Assam (800 ha) and other (8900 ha). (Kumar and Singh, 2002)

 During the year 2004, the area under drip irrigation in India increased to 5,40,000 ha covering majority of horticultural crops, coconut 19%, banana 11% ,grapes 10%, mango 9.4%,citrus 7.9% and pomegranate 6.2% (Rajput and Patel, 2004).

Efforts have been made at research level by Indian Council of Agricultural Research, Agricultural Universities, National Committee on Use of Plastics in Agriculture, Ministry of Water Resources of the Government of India to promote the use of drip irrigation method, Various State governments have sponsored promotional activities for adoption of drip irrigation.

 **Promotional Efforts by the Government**

Many State governments facing water shortage for irrigation. Have been taking efforts to motivate farmers in adopting drip irrigation. In India, Ministry of Agriculture Govt. of India provides subsidies to the farmers of different social communities under the National Mission Micro Irrigation. The Government of India acknowledged the importance of micro-irrigation and announced subsidy schemes in a few selected states in year 1991. Encouraging results and positive response from farmers, the Govt. of India announced a subsidy scheme of Rs.250 cores during VIII plan (1992-1997). In the IXthplan, plasticulture got a major thrust with an outlay of Rs. 375 crores. Recognizing the importance of plasticulture in horticulture in particular, the Government of India reconstituted the National Committee on Plastics in Agriculture (NCPA) to National Committee on Plasticulture Application in Horticulture (NCPH) in May 2001.Till early 2005,the assistance of the Government of India under the “Centrally Sponsored Scheme” on development of horticulture through “Plasticulture interventions” was available for all types of micro-irrigation system. The assistance covers all farmers growing horticulture through “plasticulture interventions” and is available for all types of micro-irrigation systems. The assistance covers all farmers growing horticultural crops like fruits, vegetables including potato, onion and other root and tuber crops, spices and medical and aromatic plants- (Rajput and Patel, 2005). Fig. 41.1. shows the crop coverage under drip irrigation in India.



Fig. 41.1 Area of different crops under drip irrigation in India.

(Source: Rajput and Patel, 2005)