**Lecture 1 Introduction to Micro-Irrigation**

**1.1 Introduction**

Water is one of the most critical inputs for agriculture which consumes more than 80% of the water resources of the country. Availability of adequate quantity and quality of water is, therefore, key factors for achieving higher productivity levels. Investments in conservation of water, improved techniques to ensure its timely supply, and improve its efficient use are some of the imperatives which the country needs to enhance. Poor irrigation efficiency of conventional irrigation system has not only reduced the anticipated outcome of investments made towards water resource development, but has also resulted in environmental problems like water logging and soil salinity thereby affecting crop yields. This, therefore, calls for massive investments in adoption of improved methods of irrigation such as drip and sprinkler, including fertigation.

Various options are available for reducing water demand in agriculture. First, the supply-side management practices include watershed development and water resource development through major, medium and minor irrigation projects. The second is through the demand management practices which include improved water management technologies/practices. The micro-irrigation (MI) technologies such as drip and sprinkler are the key interventions in water saving and improving crop productivity. Evidence shows that upto 40% to 80% of water can be saved and water use efficiency (WUE) can be enhanced up to 100% in a properly designed and managed MI system compared to 30-40% under conventional practice (INCID 1994; Sivanappan 1994 cited in Kumar 2012).

The term "micro-irrigation" describes a family of irrigation systems that apply water through small devices. These devices deliver water onto the soil surface very near the plant or below the soil surface directly into the plant root zone. Micro-irrigation is a method for delivering slow, frequent applications of water to the soil using a low-pressure distributing system and special flow-control outlets. Micro-irrigation is also referred to as drip, subsurface, bubbler or trickle irrigation and all have similar design and management criteria. The systems deliver water to individual plants or rows of plants. The outlets are placed at short intervals along small tubing and only the soil near the plant is watered. The outlets include emitters, orifices, bubblers and sprays or micro sprinklers with discharge ranging from 2 to over 200lh-1.

Drip irrigation was developed originally as a sub-irrigation system and this basic idea underlying drip irrigation can be traced back to experiments in Germany in 1860's. The first work in drip irrigation in the U.S.A was a study carried out by House in Colorado in 1913. An important breakthrough was made in Germany way back in 1920 when perforated pipe drip irrigation was introduced.

During the early 1940's Symcha Blass, an engineer from Israel, observed that a big tree near a leaking tap exhibited more vigorous growth than other trees in the area. This led him to the concept of an irrigation system that would apply water in small quantity literally drop by drop. The earliest drip irrigation system consisted of plastic capillary tubes of small diameter (1 mm) attached to 1arge pipes. One of the refinements made by Blass in his original system was coiled emitter. In his early 1960's, experiments in the Israel reported spectacular results when they applied the Blass system in the desert area of the Negev and Arava. Drip irrigation unit in their current diverse forms were installed widely in U.S.A, Australia, Israel, Mexico and to a lesser extent in Canada, Cyprus, France, Iran, New Zealand, UK, Greece and India. With the increased availability of plastic pipes and development of emitters in Israel, it has since become an important method of irrigation in Australia, Europe, Israel, Japan, Mexico, South Africa and the United States (INCID, 1994).

In India drip irrigation was practiced through indigenous methods such as perforated earthenware pipes, perforated bamboo pipes and pitcher/ porous cups. In Meghalaya some of the tribal farmers are using bamboo drip irrigation system for betel, pepper and arecanut crops by diverting hill streams in hill slopes. Earthenware pitchers and porous cups have been used for growing vegetable crops in Rajasthan and Haryana. In India drip irrigation was introduced in the early 70's at agricultural universities and other research institutions. The growth of drip irrigation has really gained momentum in the last one decade. These developments have taken place mainly in areas of acute water scarcity and in commercial/horticultural crops, such as coconut, grapes, banana, fruit trees, sugarcane and plantation crops in the states of Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Gujarat.

Micro-irrigation has been accepted mostly in the arid regions for watering high value crops such as fruits and orchard trees, grapes and other vine crops, sugarcane, pineapples, strawberries, flowers and vegetables. Growers, producers and landscapers have adapted micro-irrigation systems to suit their needs for precision water application. Micro-irrigation systems are immensely popular not only in arid regions and urban settings but also in sub-humid and humid zones where water supplies are limited or water is expensive. In urban landscapes, micro-irrigation is widely used with ornamental plantings.

To bring more area under irrigation, it has become necessary to introduce new irrigation techniques viz. Micro & Sprinkler Irrigation for economizing the use of water and increase productivity per unit of water.  This technology also arrests water logging and secondary salinization problems of the canal command areas and check the receding water table and deteriorating water quality in the well command areas. Micro-irrigation is to be viewed as a total plant support system starting with planting material to post harvest management and marketing. Therefore, micro-irrigation need be promoted in a holistic manner involving appropriate cultivars, good agronomic practices, post harvest handling, processing and marketing leading to an end-to-end approach. Water source development and recharge of wells through watershed management would also form a part of the technology package (AGRICOOP, 2005).

**1.2 Overview**

In micro-irrigation, water is carried to the actual root of the plant and not just to the surrounding dirt. It uses pipes, tubes, and a dripper to slowly deliver the water. This method uses much lesser water than normal irrigation and is more efficient and ecological.

In ancient times, a clay pot with holes were filled with water and buried in the ground. Then, a clay pipe was used, which eventually changed into the more common perforated plastic tubing. Even newer developments include a plastic water emitter located where the root sits in which the water drips out. Newer and newer methods make this a valuable contribution to the agriculture world, especially those areas lacking rain and water. Other types of micro-irrigation include the bubbler, where the drip is more spread out, and the micro sprinkler, which is used overhead where the water is emitted in micro-sprays. This is usually in a closed setting such as a greenhouse.

Ideally, the irrigation tube is buried in the dirt, close to the surface. At each plant, the emitter is placed into the tubing (which is perforated). A pump pressurizes the water slowly through the emitters. If drip irrigation is combined with mulching, this form of watering would actually reduce surface evaporation and be quite effective in conservation methods. Drip irrigation can also help reduce foliage diseases that come about with wet and moldy leaves because the water goes directly down to the main root.

Micro-irrigation is used in farms as well as commercial greenhouses. It has proven successful in a commercial sense due to automation. Also, with piping and pressurized pumps, fertilizer can be added to the water. This automates the watering and feeding of plants and is less labor intensive. On land that is hilly or sloped, micro-irrigation can be the answer in avoiding run-off. The cost of micro-irrigation would cost less than leveling the land for any type of farming and can help control erosion. On farms growing crops spaced closely together, such as strawberries, micro-irrigation can help in more direct watering methods. For crops grown under cover, requiring more water, micro-irrigation can help control the flow.

**1.3 Status**

About 42 million ha area is potential under drip and sprinkler in the country (Raman 2010). Out of this, about 30 million ha are suitable for sprinkler irriga­tion for crops like cereals, pulses and oilseeds in addition to fodder crops. This is followed by drip with a potential of around 12 million ha under cotton, sugar cane, fruits and vegetables, spices and condiments; and some pulse crops like red gram, etc.

The percentage of actual area against the potential estimated under drip irrigation in different states varied between nil in Nagaland to as much as 49.74% in Andhra Pradesh, followed by Maharashtra (43.22%) and Tamil Nadu with 24.14%. In case of sprinkler irrigation, the percentage of actual area against the potential estimated was as much low as 0.01% (Bihar) and the highest of 51.93% (Andhra Pradesh). Compared to the potential of 42.23 million ha in the country, the present area under MI accounts for 3.87 million ha (1.42 million ha under drip and 2.44 million ha under sprinkler) which is about 9.16% (Table 1). The present figures thus reflect the extent of MI sys­tems covered under different government programmes as well as own investment by the farmers. However, the actual area under MI may vary according to the extent of use by the farmers. (Palanisami et al., 2011)

**Table 1. Potential and actual area under MI in different states (Area in ‘000 ha)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| State | Drip | | | Sprinkler | | | Total | | |
| P | A | % | P | A | % | P | A | % |
| Andhra Pradesh | 730 | 363.07 | 49.74 | 387 | 200.95 | 51.93 | 1,117 | 564.02 | 50.49 |
| Bihar | 142 | 0.16 | 0.11 | 1,708 | 0.21 | 0.01 | 1,850 | 0.37 | 0.02 |
| Chattisgarh | 22 | 3.65 | 16.58 | 189 | 59.27 | 31.36 | 211 | 62.92 | 29.82 |
| Goa | 10 | 0.76 | 7.62 | 1 | 0.33 | 33.20 | 11 | 1.09 | 9.95 |
| Gujarat | 1,599 | 169.69 | 10.61 | 1,679 | 136.28 | 8.12 | 3,278 | 305.97 | 9.33 |
| Haryana | 398 | 7.14 | 1.79 | 1992 | 518.37 | 26.02 | 2,390 | 525.50 | 21.99 |
| Himachal Pradesh | 14 | 0.12 | 0.83 | 101 | 0.58 | 0.58 | 115 | 0.70 | 0.61 |
| Jharkand | 43 | 0.13 | 0.31 | 114 | 0.37 | 0.32 | 157 | 0.50 | 0.32 |
| Karnataka | 745 | 177.33 | 23.80 | 697 | 228.62 | 32.80 | 1,442 | 405.95 | 28.15 |
| Kerala | 179 | 14.12 | 7.89 | 35 | 252 | 7.19 | 214 | 16.64 | 7.77 |
| Madhya Pradesh | 1,376 | 20.43 | 1.48 | 5,015 | 117.69 | 235 | 6,391 | 138.12 | 2.16 |
| Maharashtra | 1,116 | 482.34 | 43.22 | 1,598 | 214.67 | 12.53 | 2,714 | 697.02 | 25.68 |
| Nagaland | 11 | 0.00 | 0.00 | 42 | 3.96 | 9.43 | 53 | 3.96 | 7.48 |
| Orissa | 157 | 3.63 | 2.31 | 62 | 23.47 | 37.85 | 219 | 27.10 | 12.37 |
| Punjab | 559 | 11.73 | 2.10 | 2,819 | 10.51 | 0.37 | 3,378 | 22.24 | 0.66 |
| Rajasthan | 727 | 17.00 | 2.34 | 4,931 | 706.81 | 14.33 | 5,658 | 723.82 | 12.79 |
| Tamil Nadu | 544 | 131.34 | 24.14 | 158 | 27.19 | 17.21 | 702 | 158.52 | 22.58 |
| Uttar Pradesh | 2,207 | 10.68 | 0.48 | 8,582 | 10.59 | 0.12 | 10,789 | 21.26 | 0.20 |
| West Bengal | 952 | 0.15 | 0.02 | 280 | 150.03 | 53.58 | 1,232 | 150.18 | 12.19 |
| Others | 128 | 15.00 | 11.72 | 188 | 30.000 | 15.96 | 316 | 45.00 | 14.24 |
| Total | 11,659 | 1,428.46 | 12.25 | 30,578 | 2442.41 | 7.99 | 42,237 | 3,870.86 | 9.16 |

P= Potential; A=actual area

Source: Raman(2010) and Indiastat 2010.

**1.4 Merits and demerits of micro-irrigation**

Merits of micro-irrigation over other irrigation systems

Micro-irrigation systems have many potential advantages when compared to other irrigation methods.

1. Water savings: Irrigation water requirements can be much smaller when compared with other irrigation methods. This is due to irrigation of a smaller portion of the soil volume, decreased evaporation from the soil surface and the reduction or elimination of the runoff. Since the micro-irrigation system allows for a high level of water control application, water can be applied only when needed and deep percolation can be minimized or avoided.

2. Water efficiency: Micro-irrigation can reduce water usage by 25-40% compared to overhead systems, and 45-60% compared to surface irrigation, because do not wet the entire field, less -evaporation, deep percolation and the runoff minimized, too.

3. Low application rates: A low application rate means a less expensive irrigation system and more efficient utilization of pumps, filters and pipelines because these system components may be sized for lower flow rates and used for longer periods of time. Micro-irrigation systems are designed to supply an individual plant's water requirement by a daily application.

4. Uniformity of water application: Micro-irrigation systems have an excellent uniformity of water application; therefore all plants receive the same amount of water. Good uniformity results in more efficient irrigation, which leads to savings of water, power and fertilizer. An even, consistent application of water also results in better, more uniform yields, because each plant is given exactly as much water and nutrients as it needs for optimum growth.

5. Energy saving: A smaller power unit is required compared to other irrigation systems. Usually, the delivery pipe systems operate under low pressure (2 - 4 bar) and hence it requires less energy for pumping.

6. Improved chemical application: Micro-irrigation systems allow for a high level of control of chemical applications. The plants can be supplied with the exact amount of fertilizer required at a given time. Since they are applied directly to the root zone, a reduction in the total amount of fertilizer used is possible (average 25-50% cost savings in chemicals and fertilizers). This application method is more economical, provides better distribution of nutrients throughout the season and decreases ground water pollution due to the high concentration of chemicals that could ordinarily move with deep percolated water. Other chemicals such as herbicides, insecticides, fungicides, growth regulators and carbon dioxide can be efficiently applied through micro-irrigation systems to improve crop production.

7. Weed and disease reduction: Due to limited wetted area, weed growth is inhibited and disease occurrences reduced.

8. Field operations are more flexible: Micro-irrigation can be applied on windy days and during operations, can function without interruption when harvesting.

9. Improved tolerance to salinity: Micro-irrigation reduces the sensitivity of most crops to saline water, soil-water conditions due to the maintenance of high moisture levels in the root zone. The frequent application of water continually replaces moisture removed by the plant and moves salts away from the plant out to the edges of the root zone. These salts precipitate out of the water at the edge of the wetted parameter. This process prevents the harmful combination of high soil salinity and low moisture from occurring. Therefore, crops under micro-irrigation systems are more tolerant of saline water and soil conditions.

10. Improved quality and yield: Crop quality and yield under micro-irrigation is improved because of the slow, regular, uniform application of water and nutrients. In addition damage and losses due to water contact with fruit or foliage are eliminated.

11. Adoption to any topography and soils: Micro-irrigation systems can operate efficiently on any topography, if appropriately designed and managed. The low application rate with micro-irrigation systems is ideal for heavy clay soils with low infiltration rates as the water can be applied slowly enough for the soil to absorb it without surface runoff occurring. On the other hand, very sandy soils frequently cannot store large amounts of water. Micro-irrigation is ideal for these soils too, because of its ability to frequently provide small amounts of water to the crop.

12. Automation: A micro-irrigation system can be easily automated using electrical solenoid valves and a controller. This allows the system to be operated any time of the day or night and for any desired length of time enabling irrigation managers to take advantage of available crop water use information in determining optimum irrigation time.

13. Reduced labour cost: One of the major advantages of the micro-irrigation system is labour savings. Labour requirements are low because of the low application rates allow larger areas to be irrigated at one time and because the systems can be fully automated. In addition to the direct savings in labour, there are often indirect labour savings due to the reduced number of cultivations, the elimination of fertilizer application as a separate operation.

Most of the sprinklers, sprayers and jets are insect protected nozzles are closed after operation to avoid any clogging caused by insects or other debris.

If these benefits are not achieved, the investment in a micro-irrigation system is not worth it. Product life with good quality equipment, good operation and management can last upto 15-20 years.

**Demerits of micro-irrigation systems**

1. High initial cost: The initial investment and maintenance cost for a micro-irrigation system maybe higher than for some other irrigation methods, but the growers should weight the cost against benefits. Filters, pumps, regulators, valves, gauges, chemical injectors and possible automation components add to the cost of a micro-irrigation system. The emitter itself (drip tube/tape, sprayer, and sprinkler) represents only approximately 35 - 37% of the initial system cost. Actual cost will vary considerably depending on the selection of a particular micro system. The growers must understand that a well designed, installed and managed system has water saving and important agronomic, environment and economic benefits.

2. Pressurized irrigation water:  The irrigation water must be pressurized, resulting in energy costs. The required pressures are generally less than those needed for sprinkler systems, but they are higher than those of flood irrigation systems.

3. Requires some management and maintenance: Farming with micro-irrigation systems typically requires a change in cultivation, planting and harvesting practices. Educating growers of these changes is required before and during the first season of the micro-irrigation. These new practices can quickly become a standard part of the farming operation. Micro-irrigation systems normally have greater maintenance because of the small orifice characteristics which are susceptible to clogging from particulate matters, organic matter, and chemical precipitates. Therefore additional maintenance including filtration, injecting chlorine or acid and flushing lateral lines may be necessary to ensure best performance. Machinery, animals, insects or food traffic in the field can cause leaks in the drip tape. Also in order to realize the many benefits discussed, the grower must constantly be monitoring the growing environment and scheduling irrigation to meet the plant's needs.

4. Clogging: One of the biggest problems encountered in micro-irrigation is clogging of emitters. The small openings can be easily clogged by soil particles, organic matter, bacterial slime, algae or chemical precipitates. The micro-irrigation system requires very good filtration (most often recommended 200 mesh filtration degree) even with a good quality water supply. The filtration system should be chosen based on physical, chemical or biological characteristics of the water.

5. Salt accumulation near the root zone: Unlike surface and sprinkler irrigation systems, which can flush salts below the crop root zone, micro-irrigation systems tend to move salts to the outer edge of the wetted volume of soil and soil surface. Insufficient rainfall can move the salts back into the root zone and cause damage. Careful management is necessary to ensure that the salts do not migrate back into the active root zone. If the need to leach salts from the root zone becomes critical a sprinkler or surface irrigation system may have to be used to accomplish this purpose effectively. In areas, with heavy rainfall the salts will be washed out of the root zone before significant accumulation occurs.

6. Seed germination: Some crops do not germinate well with micro-irrigation systems (usually under drip tube/tape). In these cases portable sprinklers are often used for germination. Once started the crop can be irrigated with micro-irrigation to optimize plant growth.

7. Moisture distribution/restricted root zone: Moisture distribution depends largely on the soil type being irrigated by the micro-irrigation system. In some soils, i.e. deep sands, very little lateral water movement (low capillary forces) can create many problems. Under these conditions it is difficult to wet a significant portion of the root zone. It is also more difficult to manage the irrigation without deep percolation since only a small amount of water can be stored in the wetted volume desired. Increasing the number of emitters per plant may improve water distribution in the soil. Therefore, coarse sands will require much closer spacing of emitters than fine soils. In general, for any soil the amount of emitters and their spacing must be based on the geometry of wetted soil volume. Particularly in regions of low rainfall, plant root activity is often limited to the soil zone wetted by the emitters. The irrigator must remember that the micro-irrigation system is meant to apply small, frequent irrigations. Cover crops cannot be grown year-around due to the localized nature of the water applications.