**Lecture 2 Scope and Applications of Micro-irrigation**

**2.1 Potential and Applications of Micro Irrigation**

The water use efficiency under conventional flood method of irrigation, which is very low due to substantial conveyance and distribution losses. Recognizing the fast decline of irrigation water potential and increasing demand for water from different sectors, a number of demand management strategies and programmes have been introduced to save water and increase the existing water use efficiency in Indian agriculture. One such method introduced relatively recently in Indian agriculture is micro-irrigation, which includes both drip and sprinkler method of irrigation. Micro-irrigation (MI) is proved to be an efficient method in saving water and increasing water use efficiency as compared to the conventional surface method of irrigation, where water use efficiency is only about 35-40 percent.

Studies carried out across different countries including India have confirmed that irrigation plays a paramount role in increasing the use of yield increasing inputs and enhancing cropping intensity as well as productivity of crops. Apart from benefiting the farmers, irrigation development also helps to increase the employment opportunities and wage rate of the agricultural landless labourers, both of which are essential to reduce the poverty among the landless labour households. However, water is becoming increasingly scarce worldwide due to various reasons. With the fast decline of irrigation water potential and continued expansion of population and economic activity in most of the countries located in arid and semi-arid regions, the problems of water scarcity is expected to be aggravated further. Macro-level estimate carried out by the International Water Management Institute (IWMI), Colombo, indicates that one-third of the world population would face absolute water scarcity by the year 2025 (Seckler, et al., 1998; Seckler, et al., 1999). As per this estimate, the worst affected areas would be the semi-arid regions of Asia, the Middle-East and Sub-Saharan Africa, all of which are already having heavy concentration of population living below poverty line. In spite of having the largest irrigated area in the world, India too has started facing sever water scarcity in different regions. Owing to various reasons the demand for water for different purposes has been continuously increasing in India, but the potential water available for future use has been declining at a faster rate (Saleth, 1996; CWC, 2005). The agricultural sector (irrigation), which currently consumes over 80 percent of the available water in India, continues to be the major water-consuming sector due to the intensification of agriculture (Iyer, 2003). Though India has the largest irrigated area in the world, the coverage of irrigation is only about 40 percent of the gross cropped area as of today. One of the main reasons for the low coverage of irrigation is the predominant use of flood (conventional) method of irrigation, where water use efficiency is very low due to various reasons. Available estimates indicate that water use efficiency under flood method of irrigation is only about 35 to 40 percent because of huge conveyance and distribution losses (Rosegrant, 1997; INCID, 1994).

Considering the water availability for future use and the increasing demand for water from different sectors, a number of demand management strategies and programmes (water pricing, warabandhi, waters users’ association, etc) have been introduced since late seventies in India to increase the water use efficiency, especially in the use of surface irrigation water. One of the demand management strategies introduced relatively recently to control water consumption in Indian agriculture is micro-irrigation (MI), which includes mainly drip and sprinkler irrigation method. Under micro-irrigation, unlike flood method of irrigation (FMI), water is supplied at a required interval and quantity using pipe network, emitters and nozzles. Therefore, the conveyance and distribution losses are reduced completely which result in higher water use efficiency under MI. Though both drip and sprinkler irrigation methods of irrigation are treated as MI, there are distinct characteristics differences between the two in terms of flow rate, pressure requirement, wetted area and mobility (Kulkarni, 2005). While drip method supplies water directly to the root zone of the crop through a network of pipes with the help of emitters, sprinkler irrigation method (SIM) sprinkles water similar to rainfall into the air through nozzles which subsequently break into small water drops and fall on the field surface. Unlike flood irrigation method, DIM supplies water directly to the root zone of the crop, instead of land, and therefore, the water losses occurring through evaporation and distribution are completely absent. The on-farm irrigation efficiency of properly designed and managed drip irrigation system is estimated to be about 90 percent, while the same is only about 35 to 40 percent for surface method of irrigation (INCID, 1994). In sprinkler irrigation method, water saving is relatively low (up to 70 percent) as compared to drip irrigation since SIM supplies water over the entire field of the crop (Kulkarni, 2005).

Micro-irrigation is introduced primarily to save water and increase the water use efficiency in agriculture. However, it also delivers many other economic and social benefits to the society. Reduction in water consumption due to drip method of irrigation over the surface method of irrigation varies from 30 to 70 percent for different crops (INCID, 1994, Postal, 2001). According to data available from research stations, productivity gain due to use of micro-irrigation is estimated to be in the range of 20 to 90 percent for different crops (INCID, 1994). While increasing the productivity of crops significantly, it also reduces weed problems, soil erosion and cost of cultivation substantially, especially in labour-intensive operations. The reduction in water consumption in micro-irrigation also reduces the energy use (electricity) that is required to lift water from irrigation wells.

**Table 2.1 Water saving and productivity gains under drip method of irrigation in India**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Crop’s Name | Water consumption (mm/ha) | Yield (t/ha) | Water Saving over  FIM (%) | Yield Increase over FIM (%) | Water Use Efficiency (yield/ha)/(mm/ha) |
| Vegetables: | FIM | DIM | FIM | DIM | FIM | DIM |
| Ash gourd | 840 | 740 | 10.84 | 12.03 | 12 | 12 | 0.013 | 0.016 |
| Bottle gourd | 840 | 740 | 38.01 | 55.79 | 12 | 47 | 0.045 | 0.075 |
| Brinjal | 900 | 420 | 28.00 | 32.00 | 53 | 14 | 0.031 | 0.076 |
| Beet root | 857 | 177 | 4.57 | 4.89 | 79 | 7 | 0.005 | 0.028 |
| Sweet Potato | 631 | 252 | 4.24 | 5.89 | 61 | 40 | 0.007 | 0.023 |
| Potato | 200 | 200 | 23.57 | 34.42 | NIL | 46 | 0.118 | 0.172 |
| Lady’s finger | 535 | 86 | 10.00 | 11.31 | 84 | 13 | 0.019 | 0.132 |
| Onion | 602 | 451 | 9.30 | 12.20 | 25 | 31 | 0.015 | 0.0277 |
| Radish | 464 | 108 | 1.05 | 1.19 | 77 | 13 | 0.002 | 0.011 |
| Tomato | 498 | 107 | 6.18 | 8.87 | 79 | 43 | 0.012 | 0.083 |
| Chillies | 1097 | 417 | 4.23 | 6.09 | 62 | 44 | 0.004 | 0.015 |
| Ridge gourd | 420 | 172 | 17.13 | 20.00 | 60 | 2 | 0.030 | 0.075 |
| Cauliflower | 389 | 255 | 8.33 | 11.59 | 34 | 39 | 0.021 | 0.045 |
| Fruit Crops: |   |   |   |   |   |   |   |   |
| Papaya | 2285 | 734 | 13.00 | 23.00 | 68 | 77 | 0.006 | 0.031 |
| Banana | 1760 | 970 | 57.50 | 87.50 | 45 | 52 | 0.033 | 0.090 |
| Grapes | 532 | 278 | 26.40 | 32.50 | 48 | 23 | 0.050 | 0.117 |
| Lemon | 42 | 8 | 1.88 | 2.52 | 81 | 35 | 0.045 | 0.315 |
| Watermelon | 800 | 800 | 29.47 | 88.23 | Nil | 179 | 0.037 | 0.110 |
| Mosambi\* | 1660 | 640 | 100.00 | 150.00 | 61 | 50 | 0.060 | 0.234 |
| Pomegranate\* | 1440 | 785 | 55.00 | 109.00 | 45 | 98 | 0.038 | 0.139 |
| Other Crops: |   |   |   |   |   |   |   |   |
| Sugarcane | 2150 | 940 | 128.00 | 170.00 | 65 | 33 | 0.060 | 0.181 |
| Cotton | 856 | 302 | 2.60 | 3.26 | 60 | 25 | 0.003 | 0.011 |
| Coconut | --- | --- | --- | -- | 60 | 12 | --- | --- |
| Groundnut | 500 | 300 | 1.71 | 2.84 | 40 | 66 | 0.003 | 0.009 |

Notes: \*-yield in 1000 numbers

Sources: INCID (1994) and NCPA (1990)

India has enormous potential for both DIM and for SIM. Two of the INCID (1994 and 1998) reports, which present an overview about the development of drip irrigation and sprinkler irrigation in India, indicate that about 80 crops, both narrow and widely spaced crops, can be grown under micro-irrigation. Although DIM is considered to be highly suitable for wide spaced and high value commercial crops, it is also being used for cultivating oilseeds, pulses, cotton and even for wheat crop (INCID, 1994). Closely grown crops such as millets, pulses, wheat, sugarcane, groundnut, cotton, vegetables, fruits, flowers, spices and condiments have been found to be suitable to cultivate under sprinkler irrigation. Importantly, an experimental study suggests that sprinkler irrigation can also be used successfully even for cultivating paddy crop (Kundu, et al., 1998).

 **2.2 Micro-irrigation applications: Hills, arid lands, coastal and wastelands**

 Micro-irrigation for hills :

The cultivation of horticultural crops is more remunerative on the small terraces of upland areas, due to favourable climatic conditions. However, due to the non-availability of irrigation water, farmers grow rainfed cereals with very low yields. A check basin irrigation method involving high water losses is commonly used in the valley areas. Plant-to-plant hand watering, as used on a small scale in water-scarce upland areas, is commonly used water application method, but it requires a huge amount of labour. Drip irrigation can replace the hand watering system with minimum water losses and labour. Due to topographical advantages, the gravitational head may be used to operate the system, thus eliminating the initial and operational cost of pumping. Different aspects of the design of drip irrigation systems have been discussed in detail by Keller and Bliesner (1990) assessed the drip irrigation system for the relative effects of hydraulic design, manufacturer’s variation, grouping of emitters, and plugging. However, these designs are developed for plain areas and the high water pressure is built up by pumping. Some modifications in the design criteria are essential in order to design drip irrigation systems on hilly terraces. Most of the conventionally available long path turbulent flow emitters require an operating water pressure head of 10 m or more for optimum performance. Additional pressure head is required to meet the friction losses in different components of the system, whereas the elevation difference between two adjacent terraces mostly ranges between 0.5 and 5.0 m. This pressure was found to be insufficient to operate the system using turbulent flow emitters. Bhatnagar et al. (1998) obtained low emission uniformity (64–72%) for emitter operating at pressure head of 4.0–6.5 m. However, replacing the emitters with microtubes (1.0 mm diameter) improved the emission uniformity to 94–98% for the same conditions. Another problem encountered is the large variation in emitter discharge, as the system has to be laid on several terraces having varying elevations, sizes and slopes, and irregular shapes.

Micro-irrigation for arid lands:

Establishing plants in arid lands is a challenging task even with supplemental irrigation. The low relative humidity, extreme temperatures, lack of consistent rainfall, tremendous rate of evaporation, and high wind speeds common in desert environments all play important and interrelated roles in water loss from soil and plants. Deterioration of water quality, drying up of groundwater and salt accumulation in the soil due to inadequate irrigation with saline water problems are often caused by irrigated agriculture in arid lands. Two methods seem to be effective to avoid those problems.  One is to irrigate crop with drip irrigation with limited water and the other is to drain the excess water away. These factors make it critical that use of drip irrigation system to deliver water at the root zone of plants in order to maximize survival and growth.

 Micro-irrigation for coastal lands:

Coastal regions have problems of cultivating crops due to excess amount of salts in these regions. Research experiments have been conducted to store fresh rainwater in ponds and use this water for irrigating crops with drip system. Cultivation of short duration vegetable crops and salt tolerant crops are found to be successful in these areas.

Micro-irrigation for wastelands:

Wasteland is an important land resource for agriculture and the area where salt-affected soil is widely distributed is usually abundant in resources of light and heat, and therefore has great potential to develop agriculture.  Soil salinization is one of factors of soil degradation in the world, and it tends to become increasingly serious. The formation of salt-affected soil is not only related to soil parent materials, climate, and topography, but also induced by anthropogenic activities particularly improper irrigation and drainage. Inappropriate irrigation leads to ground water table rise and makes the salts to get accumulated on the upper soil layer through capillary rise. Drip irrigation was thought to be an effective method to reclaim salt-affected soil. Many research results showed that the leaching efficiency with drip irrigation was higher than other irrigation methods (Bresler et al. 1982).  The distribution of soil water and salts under drip irrigation is beneficial for crop growth. The soil water content in the inner of wetted volume is higher than that in the outer where salts accumulate. The key issue of the salt-affected soils reclamation using drip irrigation is that a reasonable irrigation regime needs to be made to ensure not only the normal crop growth but also surplus water for salts leaching.