MICRO-SCALE IRRIGATION SYSTEMS

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Water is considered a scarce resource in Sri Lankan agriculture. The annual water resource of the island has been estimated to 4.32 mil,ha.m and present withdrawal is about 20 per cent mainly for agricultural purposes. This is the highest among countries such as Nepal, Madagscar, Philippines, Vietnam, Bangladesh, Thailand, Japan etc. If the irrigated area is kept without expanding, rice production requirement in 2025 could only be achieved by increasing the irrigation effectiveness, yield and the cropping intensity. This brings us the message that with increasing demand for food production under limited resource situations, agriculture becomes more and more intensive and competitive. Cultivation must be geared to achieve high productivity (yield per unit land and/or water resource) in order to meet the market demand on commodity. In this context, management of all the inputs in agricultural production system is vital. Water is one of the basic requirements that plants require to obtain high productivity. The agriculture, which depends purely on rainfall, will not be a viable venture since we cannot totally rely on the rainfall, which is beyond our control. Therefore, irrigation plays an important role in modern agriculture.

Supply of water to the plant with correct amount at the correct time without creating any hazardous effect to the soil plant environment is considered as good irrigation. In most of the cases efficiency of irrigation is low due to absence of proper management of water, and the soil-plant environment is deteriorated due to absence of proper drainage. As a consequence agricultural productivity of the system would be diminished. Therefore, suitable method of irrigation and proper drainage are considered as the key factors to a successful irrigated farming system.

Irrigation can be practised by using various methods. Cheapest and most widely used method is flood irrigation (surface irrigation). Majority of the surface irrigation systems in Asian region only bears 35-50% efficiency. Apart from that, the uniformity of application in surface irrigation is very low. Therefore, surface irrigation will not be a right choice in a situation where agriculture is expanding while water resources are diminishing. Under such circumstances, strategies need to be adopted to increase the irrigation efficiency and uniformity. One of the best methods to increase the efficiency and the uniformity of irrigation is the use of micro scale or localised irrigation techniques for irrigating the agricultural lands. In micro irrigation, water will be supplied on demand to the plants with high efficiency.

In rainfed agriculture, plants grow entirely under conditions imposed by the nature, or slightly manipulated by man. The surrounding environmental factors such as soil, climate, pest, disease, human activities etc. affect the growth of plants. This fact is true at varying degrees even to the irrigated agriculture as there is a wide range of irrigation strategies which has been innovated to address the problems associated with irrigated farming in various environments. Thus, in selecting the type of irrigation to be adopted, the most important aspect to understand is why the prevalent environment and what environmental factors are to be adjusted or managed to achieve a successful crop production. Most important factors are discussed below:

Water for Irrigation

Type of water source, its supplying capacity, quality and the cost involved are the basic considerations to be made in planning an irrigation system at any scale. The elevation of the water source with respect to the field is one of the primary factors influencing the choice of irrigation method. Where water is supplied at a small static head above the level of land, surface irrigation is the most feasible. The use of a booster pump to draw water from a canal and irrigate by sprinklers is possible, but would have to be amply justified by other criteria. If the water comes from a source much higher than the field, there is a greater potential for drip and sprinkler systems in order to conserve water. In the case, where the water originates below the field and is delivered under pressure, it is logical to use pipe-distribution systems, if the additional head to operate the sprinklers or drips is a relatively small part of the total head delivered by the pumps. This situation occurs in pumping from wells and where the irrigable lands lie well above the river or reservoir. In such a case the cost of water is usually quite high and greater effort to use it more efficiently would be justified.

The distance of the water source from the field has an indirect but important influence upon the choice of an irrigation method. In cases where the water is close to the field the choice is open, and other factors govern. If the water is brought from considerable distance the type of conveyance, which is most economical for the particular terrain may often dictate the method of irrigation.

When the available discharge at the head of the field is relatively small (less than 100 cubic meters per hour or 28 litres per second), sprinkler systems can however, be operated with even smaller flows. Medium size discharges are from 100 to 400 cubic meters can be efficiently handled with normal equipment by one man for either gravity or sprinkler installations. Drip systems are the best in a situation, where both total supply of water and the discharge are small.

Water moves through micro-outlets in drip and sprinkler systems, therefore presence of sediments, silt, algae, or other suspended material is not desirable to use in sprinklers and drips, unless special desilting or filtration processes are employed. When the water contains salts there is a possibility of clogging the outlets and development of high salt concentration in soil. In such cases most suitable method is to use large size sprinklers or border flooding.

The cost of water is a vital factor in the ultimate economic analysis and has a direct bearing upon the need for selecting a method that gives the highest irrigation efficiency under given conditions. High water costs would favour sprinkler or drip irrigation systems. Irrigation efficiency should not, however, be considered simply as the amount of available moisture added to the root zone of the plants, as compared to the amount delivered to the field. Equal consideration must be given to the highest possible yield per unit area resulting from a certain water application. In cases of very costly water with less limited land resources an even more important criterion is the yield per unit volume of water applied.

Soil condition

At present, the trend towards intensive and profitable agriculture calls for high input practices, therefore, it is important to understand characteristics of soil especially those affect irrigation and fertigation. Although we expect high productivity from the soil, when it is cultivated continuously the fertility gradually declines. If the soil is deteriorated it will be expensive to move to another soil or to transport good soil

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from elsewhere. Therefore, it is of utmost importance, that those soils that are utilized for micro scale irrigated farming warrant high economic returns. Some important soil characteristics are described below:

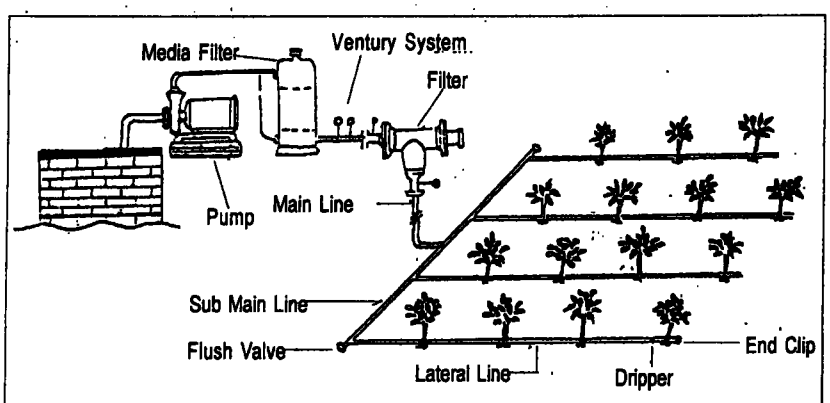
Soil texture is the composition of solid materials in the soil. It determines absorption, movement and holding capacity of water. It will also influence the inherited soil fertility. Medium to fine textured porous soils (sandy loam to friable clay) are good for irrigation. Coarse textured soils (sandy loam to friable clay) are moderately good and loamy sand to friable or very fine clay soils are marginal for irrigation.

Depth of soil available for plant growth is a main factor, which determines the available soil moisture content, allowable irrigation depth and the supplying capacity of nutrient. It is generally, the depth at which gravel, laterite or rock is encountered. This factor determines irrigation and fertigation frequencies and also the type of crops, which could be grown without any limitation for the root development. The effective depth should be above 90 cm for a soil to provide a favourable soil environment whereas soil is considered marginal when soil depth is 30 – 60 cm.

Infiltration rate of water into soil is influenced by texture, structure, type of clay and any disturbance to the soil such as compaction caused by cultivation. This factor is important for any type of irrigation because if the rate of water supply exceeds the infiltration rate then excess water moves out without any use for the crop. Higher infiltration rates will cause more percolation and such water would no longer be available to the plant. Therefore, soils that bear final infiltration rate between 10-25 mm/hour are considered favourable for irrigation.

The degree of land slope affects the infiltration rate, available moisture capacity, erodibility, external drainage and consequently the length of runs and field layout. Land levelling procedure for preparing the land to reduce slope and make a uniform bed is to be carefully undertaken because heavy soil movement will lead to expose the subsoil, which is less fertile both physically and chemically. When the effective soil is too shallow it is advisable to avoid any soil movement and select the type of irrigation system suitable to the sloppy land.

Crop growth is severely affected if the soil – water environment hears high concentration of salts. Such situation can occur due to high water tables, impeded water movement through soil due to poor land and water management and high concentration of salts in irrigation water. The situation may be further aggravated with high evaporative demanding conditions. Alkalinity occurs due to high content of Na cations etc. in the soil and salinity is due to build up of salts of Ca, K and Na. Irrigation can also be used to reduce the soil salinity or be used as an alternative to create a favourable soil environment in salt affected soils (drip irrigation).



Layout of a Drip Irrigation System

Climatic environment

Growth of a plant is directly proportional to the rate of evapo-transpiration from the plant environment. This is determined mainly by climatic factors and the type of plant. Most important climatic factors with respect to micro-scale irrigation are briefly discussed below:

Radiation energy available for plant growth in Sri Lanka is very favourable in terms of total annual amount, its seasonal distribution and its direction of incidence. However, intra-plant shading or shading from any structure should be avoided. This aspect is important especially in planning structures for micro-scale irrigation.

There are little or no regional temperature variation in Sri Lanka due to difference in latitude. However, there are regional and seasonal variations due to altitudes and seasonal shift of the sun northwards and southwards. Temperature increases towards lower altitudes. Relatively high temperatures are recorded in July and it drops to a minimum in January. Three elevation zones defined in Sri Lanka is lowland (<330m), midland (330 – 1000 m), and upland (>1000m) can effectively be considered as three temperature zones as hot lowland, warm midland and mild upland. However, these temperature variations alone do not affect much the crop growth, but diurnal variations alter other growth performances such as flowering, fruit setting etc. and incidence of pest and diseases.

In a country like Sri Lanka where the rainfall pattern divides the year into two distinctive periods, irrigation has an important part to play in agricultural crop production. Even during the rainy season there may be a period of several weeks when rainfall is inadequate and may cause crop failures. Such droughts are unfortunately a common occurrence and are of the major limitation to our agriculture. Therefore, micro scale irrigation is an important strategy to overcome our rainfall uncertainty problem as it assures a great security to valuable crops.

There are two monsoonal and two inter monsoonal seasons in the rainfall pattern of Sri Lanka. The regional distribution of rainfall is determined by the interaction between this seasonal weather pattern and the configuration of mountainous highlands in the country. Agricultural is adjusted in different regions of the country according to the distribution of rainfall. There are excessively wet periods in the dry zone and excessively dry periods in the wet zone. Crops in the open fields under rainfed conditions are affected both by excess and deficit of soil moisture due to these rainfall variations. Therefore, both irrigation and drainage are equally important and planned accordingly in open field irrigated farming. By understanding the rainfall pattern it can be possible to plan micro scale irrigation in the open field, protected houses and semi-protected areas. Humid conditions of the atmosphere follows a seasonal pattern which closely follows the rainfall pattern, but with a diurnal variation caused by warming effect of the sun during the day and cooling during the night.

In designing sprinkler irrigation systems, wind direction and velocity are important factors to be considered. For the island as a whole the seasonal wind pattern is largely determined by the monsoons. The presence of strong and varying winds decreases greatly the uniformity of distribution of sprinkler systems, and may consequently reduce the irrigation efficiency. This can be partly overcome by means of closer spacing of the sprinklers and by irrigating only by during those hours of the day or night when the winds are known to lower. Most recent development to overcome the wind problem is the innovation of micro-sprinklers, which have very low riser heights and wetting diameters. Such micro sprinklers are suitable for irrigating both field crops and orchards.

Cost and Benefit

In general, micro-scale irrigation systems are expensive therefore, return should compensate the additional cost. However, economic analysis of irrigation methods becomes very complex as it is based upon a variety of factors, which are constantly changing. The final analysis, however, should be reached by a simple comparison of the cost of each method of irrigation with the value of the irrigated crop.

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The actual cost of installing an irrigation system varies greatly from time to time and place to place, and no specific figures can be quoted which have general application. In the case of sprinkler or drip irrigation planning, the cost includes the well or other water supply, pump and motor, permanent pipes and fittings, portable pipes, sprinkler or drip outlets (emitters, nozzles, risers etc.) and filtering and controlling devices. In highly developed installations there may also be the cost of machinery to move the pipes around the fields.

For sprinkler and drip irrigation systems the maintenance costs include wear and tear on the pump, motor, pipes and sprinkler and drip outlet devices, replacement of corroded or calcified pipelines, and maintenance of other structures. Operating costs include energy for pumping water and the labour for setting up and moving the portable lateral lines. The depreciation for the various parts of each system needs to be calculated on the basis of the initial cost and the useful life span of the system. The cost for labour in micro-scale irrigation can be greatly reduced by the use of less portable and more permanent pipes, but such installation can be more costly than the labour use.

Micro-scale irrigation systems are more suitable for high value crops. The value varies not only with the crop and variety but also with quality, seasonality, total supply and demand and marketability. These complex factors are variable and often difficult to predict. With respect to the choice of an irrigation method, however, it can only be stated that where any of these price factors are favourably influenced by a certain method of irrigation, a relatively greater expense for that method can be justified. For example, if the tomatoes, which can be raised under a system of permanently installed sprinkler pipes are of better quality and can be matured in a season of relatively scarce supply, the profit would justify the high cost of installing the said irrigation system. If, on the other hand, high value crops can be raised almost as well by a lower cost surface irrigation system, use of sprinklers would be unjustified.

Advantages and limitations

Drip/Trickle Irrigation Systems

Drip or trickle irrigation is a method to apply water to soil through emitters (or applicators) located at selected points along the water delivery lines. Emitters have orifices through which a limited volume of water is discharged. Emitted water moves within the soil as an unsaturated flow. Wetted soil area of an emitter is normally elliptical in shape, and real shape is determined by textural composition of the soil.

Drip irrigation is not suitable for broadcasted crops. It is recommended for fruit trees, grapes, flower plants, vegetables and other high value crops cultivated in rows. When irrigation water is of poor quality drip irrigation can be used to avoid the yield reduction in salt sensitive crops.

Drip systems can control the rate of water application to achieve application efficiency as high as 90-95%. It could reduce evaporation from soil as well as evapo-transpiration from the crop. As the entire soil surface does not get wet, weed growth is not promoted by drip systems. The system is excellent for soils with low infiltration rates. Unlike surface and sprinkler irrigation, the drip systems can keep the water content always near the field capacity without creating any soil moisture deficit to the crop. Drip or trickle irrigation systems are designed to apply only the required amount of water, therefore, it would minimize water losses as runoff, percolation and seepage. Land levelling or grading is not an essential component in this system, and it requires very low labour for operation and maintenance. Most important advantage of this system is that fertilizer can be injected to the irrigation water (fertigation). Further, it avoids high concentration of salt due to frequent application of water.

However, there are limitations too in drip irrigation systems. Most serious problem is clogging (blocking) of emitters due to insufficient filtration of water. During irrigation, excess salt accumulates near the soil surface and moves towards the edges of the wetted soil. Rain can bring these into the root zones. Investment cost is high and technology is sophisticated. Conveying pipes or tubes can be easily damaged.

Micro-sprinkler irrigation systems

Sprinkler irrigation is the transport of water through a system of pipelines under pressure and the release of water in the form of spray. Water dynamically moves from the water source through the pump to the pipe network and is released through sprinkler nozzles into the air at a high velocity, where it breaks up into droplets and falls to the soil or crop surface. Micro-sprinklers are also similar to sprinklers but riser height is low with comparable application radius.

Sprinklers are suitable for a wide range of crops – field crops, vegetables, orchards etc. but some crops are affected as the entire crop gets wet usually. This is an advantage in one way because it reduced the insect damage.

Micro-scale irrigation systems can be selected when one or more of the following conditions prevail:

- Land bears undulating topography and soil is shallow,
- Land slope is too steep and levelling or grading is not economical,
- Soil is coarse textured and surface irrigation would cause high losses,
- Water is scarce and expensive therefore should be efficiently utilized,
- When labour cost is high many parts of the micro-scale irrigation systems can be permanently installed,
- When water supply needs high assurance especially for high value crops micro-scale irrigation is the best.

Finally, it is worthwhile to note that the adoption of micro-scale irrigation systems should not be a fashion or a sign of modernization. If the investment costs are not economically justified; for example in case of low income generating crops, it is useless to think of expensive micro-scale irrigation systems. However, there are low head, simple drip systems are available in the market and these small units are recommended for backyard cultivation. If the condition for surface irrigation is favourable (water and labour are not limiting) micro-scale irrigation systems are not economical. Energy for lifting and pressurising to apply water is very high in micro-scale irrigation. Most important point is that the user of the micro-scale irrigation systems should have an adequate knowledge on how to operate, maintain and service and repair the system.