CHAPTER 10

WATER REQUIREMENTS AND IRRIGATION

Irrigation plays an important role in raising and stabilizing yield and maintaining quality of a crop like litchi, which is more precious than other fruit crops grown in tropical or sub-tropical climate. Water relations are very important to the function of the litchi tree, as water is the greatest component of the tree by mass and almost all critical processes can be limited by inappropriate water status. The essential role of water, however, does not mean that the water is always limiting or is regulating variations in productivity. This chapter will address natural as well as culturally imposed conditions under which the water relations may be controlling tree behaviour. Many litchi orchards are still dependent on rainfall. Trees suffer water deficit during crucial fruit development period. This is the reason why many times both productivity as well as fruit quality are not up to the level desired. Thus effective scheduling of irrigation is very important in decisions related to maximizing yields and improving fruit size and aril quality. Irrigation scheduling requires knowledge of two crop characteristics:

(1) how much water a tree needs at a particular time? and
(2) how it should be applied?

Besides these characteristics, one additional point is considered that is how efficiently the needed water is applied to the potential root zone of the tree. As regards litchi tree's water requirement it is believed that litchi is a hardy plant species able to tolerate drought fairly well during vegetative period. But once inflorescences have initiated and fruit setting is over, the best fruit yield and quality is achieved only when the trees are well watered. Similarly, younger plants (1-3 years old) are highly sensitive to drought. They require frequent irrigations particularly in hot summer months. Otherwise, mortality rate of younger plants is higher as compared to other fruit crops under neglected un-irrigated conditions.

The Root Zone

Roots of mature litchi trees, in general, extend down to 1.5 m. Root development is largely dependent on rootstock in case of grafted plants and the formation of secondary and tertiary roots in case of layering *vis-a-vis* the characteristics of the soil and water regime. Majority of the feeding roots are located in 0.0–0.6 horizon but the trees extract water from lower depths. The root water extraction pattern from 0 to 1.5 m depth is given below (Table 10.1).

Table-10.1: Water extraction from different soil depths*

Soil depth (m)	Water extraction (%)	Successive extraction (%)
0.0 – 0.3	28 %	28 %
0.3 – 0.6	23 %	51 %
0.6 – 0.9	17 %	68 %
0.9 – 1.2	19 %	87 %
1.2 – 1.5	13 %	100 %

* From article by Menzel *et al.* (1995)

It is thus obvious that mature trees are able to extract soil water from considerable depths, and that a short term drought may not necessarily reduce photosynthesis and growth. But, there must not be any water stress even for a short period at critical stage of fruit development. Since major part of the water is drawn from 0–90 cm depth, for all practical purposes, the amount of waters applied through flooding should replenish the water deficit of this layer.

It is important to mention here that the long-accepted notion that the entire volume of the root-zone must be wetted to field capacity at each irrigation has been contradicted by recent experience proving that a crop can do well when the wetted zone is restricted to a fraction of the soil volume, say 50 percent. This is on condition, of course, that supply of moisture and nutrients in the partial volume is sufficient to satisfy full crop needs. In drip or micro-sprinkler method of irrigation entire volume of the potential root-zone is never wetted and still the response of the crop is better than the conventional practice.

Monitoring Soil Moisture

As a rule of thumb, irrigation should be applied to litchi orchards when 40 or 45 % of the available water in the potential root zone (0-90 cm depth) has been depleted. If further depletion is allowed, the trees are subjected to a level of stress that might cause an appreciable reduction in fruit yield and quality. In order to keep the soil moisture above this level, regular monitoring of the available soil moisture is essential.

Tree water use, in general, is best determined by monitoring the soil moisture level in the effective or potential root–zone of the tree. The availability of soil water can be measured by a number of instruments. On–farm use is most frequently done by soil probe or tensiometers. Tensiometers are located in areas containing roots being wet by surface impounding or drip emitters. Also available are neutron probes which are portable devices which, when properly calibrated, can give information about the volume of water stored in the various soil depths. Drawing the soil samples from various depths using soil auger and analyzing their moisture content is slow and time consuming process.

In recent past significant advancement has been made in developing devices to monitor soil moisture. Non-portable capacitance probes are now available to measure the volumetric soil-water content by determining the dielectric constant next to an access tube. For most of the soils, the dielectric constant is proportional to its water content. The equipment consists of multiple sensors mounted on probes with slots every 0.1 m to accommodate snap-in sensors. The probes are placed within vertical PVC access tubes installed throughout the orchard. These are left in place for the season and can be shifted to other sites as required. To record measurements, sensors are linked to a data logger via a cable. These informations are downloaded to a computer to map daily tree water use. However, the equipment cost is high (nearly Rs. 4-5 lakhs) and it seems beyond the reach of a common litchi grower in India.

Plant Based Measurement

In addition or as an alternative to monitoring the soil, it is possible to monitor the water status of the plants. This can be done visually, as well as instrumentally, to detect early sings of thirst (incipient stress) very well in time to irrigate the plants and prevent any significant reduction in yield. Numerous methods have been proposed to monitor the physiological state of the water in the plant. Important among these are techniques to estimate transpiration using excised leaves, determination of leaf tissue hydration (relative water content) with punched disks or intact leaves, observations of stomatal aperture, monitoring stem diameter, pressure cell and psychrometric measurements of leaf water potential, determination of free prolin or ABA accumulation in the leaves and more. Perhaps the most comprehensive measurements are of total plant transpiration and photosynthesis, using portable tents with transparent (plastic) walls. Nearly all of these techniques require specialized instrumentation and trained personnel and are difficult to carry out on a routine basis in fields. Hence, there is need to develop a gadget based on these technique which can be used in field for ordinary irrigation management.

Since perennial fruit trees, owing to their large canopies have a marked capacity for passive and active adjustment of cell solute concentration in response to varying water status, in the soil and air, leaf water potential is often not a good measure indicating the exact nature and degree of stress experienced by the plants. Significant osmotic adjustment has been reported in many temperate and subtropical fruit trees.

Still the most common way to monitor the crop is by the well tried and tested method of direct visual inspection. An experienced orchardist can detect early signs of thirst by the appearance of the foliage especially during the period of peak transpiration demand (generally at mid day). Young leaves are the most sensitive organ in this regard. They begin to curl or become flaccid or change their angle of orientation. When that happens, an irrigation is indeed needed, so it is good to irrigate the tree before such signs are too evident, that is to say before the stress becomes severe enough to reduce the yield potential.

Meteorological Observations

These methods are more or less directly based on the evaluation of the so-called evaporation power of the atmosphere and aim at inferring from it and eventually other parameters like the time and depth of water application. The idea here is to follow the meteorologically imposed evapotranspirational demand as it varies over time and to set the quantity of irrigation accordingly. Conceptually, it is supposed that there ought to be a definable rate of ET for the special case, in which, the field is maintained perpetually wet, and this rate should depend only on the meteorological regime. The concept of "potential evapotranspiration" (PET) is an attempt to characterize the climatic environment in terms of its evaporative power, i.e. the maximal evaporation rate which the atmosphere is capable of extracting from a well watered field under given climatic conditions. PET is thus said to represent the externally imposed "evaporative demand".

Soil moisture determination also helps in estimating crop evapotranspiration through water balance technique. In this, an account of all quantities of water added to, subtracted from and stored within the root zone during a given period of time is maintained. ET is then calculated as $ET = (P + I + U) - (R + D) \pm \Delta ASM$; where P = precipitation, I = irrigation, U = upward capillary flow into the root zone from below, R =runoff, D = downward drainage out of the root zone and $\pm \Delta ASM$ = change in soil moisture over a given time interval. Adopting the technique crop ET, water requirements of many fruit crops have been estimated, but no work has been done for litchi on these lines.

Soil-Plant-Atmosphere Continuum

In the last two decades, new concepts of irrigation management have been evolved. A fundamental change has taken place in the old concept of soil-plant-water relations, leading to more dynamics and holistic approach. The field is not perceived to be unified system in which all processes are inter-dependently linked, as a chain. This unified system has been called the SPAC, for "Soil-Plant-Atmosphere Continuum". Accordingly, the availability of soil moisture is not a property of the soil alone but indeed a combined function of the plant, the soil and climate. Now, several mathematical models exist which attempt to describe almost all the aspects of SPAC. With the help of a computer, it is possible to correlate or combine more than one hundred characters of the three components of SPAC to reach a more precise and better controlled irrigation schedule for a particular crop. This has greatly helped in attaining maximum water use efficiency (i.e. maximum yield per unit of water transpired).

Determining Water Requirement

Water requirement for litchi crop (WR), is a function of surface area covered by plants, evaporation rate and infiltration capacity of soil. The irrigation water requirement for each plant is calculated first and thereafter for the whole plot of 1 ha based on plant population for the different seasons. The maximum discharge required during any one of the three seasons is adopted for design purposes. The daily water requirement for fully-grown plants can be calculated as under.

WR = A x B x C x D x E
Where : WR = Water requirement (l p d /plant)
A = Open Pan evaporation (mm/day)
B = Pan factor (0.7); this may differ area wise
C = Spacing of plant (m^2)
D = Crop factor (factor depends on plant growth-for fully grown plants = 1)
E = Wetted Area (0.3 for widely spaced crops)
The total water requirement of the farm plot would be WR x No. of Plants.

The irrigation water requirement is determined using average season wise pan evaporation data for the area. The average figure of 20 or 30 years is taken into account while doing the calculations.

Stress Before Flowering

There are several evidences to show that flower induction in litchi is promoted by water stress during the preceding autumn and winter. High moisture prior to floral initiation promotes vegetative growth and suppresses flowering. However, the desired response is only achieved if the water deficit is followed by cool weather. Drought cannot be used to induce flowering in tropical environments. It has also been observed that drought during actual flower development or anthesis reduces yields. Furthermore, shoot growth is more sensitive to drought than photosynthesis or fruit growth. Leaves cease to expand once leaf water potential falls below -2.5 MPa, whereas dry matter accumulation in fruit continues. Mild water deficits after flowering shift resources in favour of the fruit, whereas severe drought sharply reduces yield and fruit quality. These observations must be kept in mind while deciding irrigation schedules for litchi trees.

Irrigation Scheduling

Young trees up to 3-4 years are irrigated frequently from October to June. The period from July to September receives sufficient rain to fulfill the water needs of the trees. If the rain during this period is scanty, the trees are irrigated at 15 days interval during October–November, at one month interval during December-February and at 7 or 10 interval during March–July. This schedule favours rapid vegetative growth and induces the trees to bear in the 4th or 5th year of planting. When the trees come into bearing, the irrigation schedule is changed. The bearing trees are seldom irrigated from November to March i.e. till flowering and fruit setting are over. Thereafter trees are irrigated at weekly intervals till harvesting of the crop in last week of May or early June. Thus, localities which have a consistently dry period from November to March are more congenial for litchi cultivation.

The period from flowering to early fruit development is particularly sensitive to water supply. If moisture is inadequate at this stage, poor fruit setting and abnormally high fruit dropping result in poor crop yield. If the moisture stress continues further, fruit size is reduced appreciably. As stated earlier in sandy loam soil irrigation is normally applied when 40 or 50% of the available soil water in the root zone (0-60 cm) has been depleted. If further depletion is allowed, the trees may be subjected to a level of stress that might cause an appreciable reduction in yield. However, heavy irrigation at the time of fruit setting leads to shedding of fruits. So only light application is required when fruit-setting process is just completed. Once the fruits start growing and attain 1 cm size, water application should be increased to high rates to prevent any stress. Litchi fruits approaching maturity are subject to splitting, if rainfall occurs. This condition is greatly aggravated if early fruit development is retarded by water stress. Retarded development also results in a lower flesh to seed ratio, a feature particularly evident in the big seeded cultivars like Shahi, Mandraji. Suggested water application rates for trees of different age groups are shown in Table 10.2 and 10.3.

Table-10.2: Water requirement of young litchi plants (l/plant /week)

Month	1st year	2nd year	3rd year
March – June	9.0	30.0	175.0
July – October	5.4	18.0	105.0
November – February	3.0	9.0	60.0

It is obvious that irrigation in the 4-5 months before fruit set is managed with light applications to prevent severe stress occurring while limiting conditions for vegetative growth are also important. Once the fruit setting is over and fruits attain 1 cm size, watering is done at the rate of 1350 litres per tree per week (Table 10.3).

Table-10.3: Quantity of water to be applied (l/plant/week) through irrigation to litchi trees of various age groups at different phenological stages

Phonological stage (Duration)	4-6 years	7-12 years	>12 years	> 12 years	
				Crop factor * (kg)	Average water use mm/week
Preflowering (Nov. – Feb.)	120	200	550	0.60	9
Flowering (March- April)	400	600	1350	0.80	25
Fruit growth (April – June)	500	800	1650	0.80	32
Vegetative flushing (July – Oct.)	270	450	900	0.80	17

***Crop factor = water use / evaporation**

Irrigation Methods

There are four main methods to apply water to the litchi plants: (1) surface irrigation, (2) sprinkle irrigation, (3) drip irrigation and (4) sub-irrigation. Each system has advantages and disadvantages. Physical factors involved in the system selection include soils, climate, topography, water quality and availability, water table depth, orchard size, system performance, maintenance and repair etc. Human and economic factors involved are labour and management skills, availability and cost, as well as capital and energy costs in relation to expectable returns. Not all of the relevant factors can be defined or weighed quantitatively in each case, so often the decision as to which system to select rests in part on personal judgment and subjective preference rather than on completely objective analysis.

The most traditional way to irrigate orchard consists of flooding the land around the tree trunk to some depth with a large volume of water so as to saturate the soil completely, to a certain depth thereafter waiting for some days until the moisture thus stored in the soil profile is nearly depleted before flooding the land once again. In this low-frequency, high volume, total-area pattern of irrigation, the typical cycles consist of repeated periods of excess soil moisture and alternating periods of likely insufficiency. Optimal conditions occur only briefly in transition from one extreme condition (i.e. excessive supply or over saturation) to other (i.e. drought or stress). The optimization of soil moisture is difficult to achieve with the traditional method of flooding but still this is a predominant method of irrigation for most of the litchi orchards in India.

In contrast, the never low volume, high frequency irritation systems supply a small, measured volume of water at frequent intervals by means of drip emitters, or under-canopy micro-sprinklers or soil embeded porous emitters to the root zone of the tree. The purpose is to reduce fluctuations in moisture content of the root zone by maintaining moist but unsaturated conditions continuously, without subjecting the crop to oxygen stress (from excess moisture) or water stress (from lack of moisture). Moreover, applying the water at spatially discrete locations rather than over the entire area has the effect of keeping much of the soil surface dry, thus helping not only to reduce evaporation but also to suppress proliferation of weeds.

Since a high-frequency irrigation system can be adjusted to supply water at very closely to the exact rate required by the crop, the irrigator no longer needs to depend on the soil's ability to store water during long intervals between two flood irrigations. A skilled orchardist can control the moisture content of the root zone as well as the rate of internal drainage by adjusting the rate and quantity of application according to soil's infiltrability, the soil solution's concentration, and the climate imposed evaporative demand of the tree. Thus, the orchardist can manage the system optimally so as to increase yields and conserve precious ground water.

One should also bear in mind that the newer irrigation methods are not free from shortcomings. With only a fraction of the potential root zone wetted, there is less moisture storage in the soil. So the crop depends vitally on the continuous operation of the system. Any short-term interruption of the irrigation (whether caused by neglect, mechanical failure or water shortage) can quickly result in severe distress to the crop. The imperative to maintain continuous operation is difficult to meet if the system depends on costly and vulnerable sophisticated equipments. The system must therefore be simplified to make the local growers self-reliant. Many Indian firms are now supplying drip and micro-sprinkle installations at fairly moderate prices.

Surface Irrigation

Surface irrigation has four main techniques e.g. (i) normal flooding, (ii) basin irrigation, (iii) border irrigation, and (iii) furrow irrigation. All these methods are employed to irrigate litchi orchards. This type of irrigation is recommendable only in those regions where low-cost labour and abundant water are available or where rainfall distribution is adequate is meet litchi requirements and only occasional irrigation is necessary. It is suited to land that is almost flat.

Normal flooding is the least controlled of all surface irrigation techniques. Water is delivered to the orchard and allowed to spread over the entire orchard surface in a continuous sheet. Since the degree of control over the flowing water is minimal, the resulting distribution of water is usually highly uneven. Despite its obvious disadvantages, flooding is still prevalent in many areas for irrigation of litchi orchards. In basin irrigation, low earth dikes are made around each tree or a group of trees, within which water can be impounded for irrigation. Young litchi plants are usually irrigated by basin irrigation because at this stage the plant are irrigated individually through a channel connecting the basins made around their trunks. Old trees can also be irrigated by this method in those area where the natural land surface is nearly level. In sloppy land, basin irrigation can be carried out in conjunction with terracing. Border irrigation is followed in large leveled litchi orchards where the slope of the surface does not exceed 0.5%. Here the entire orchard area is divided into elongated plots confined to low earth bunds. Depending upon the slope and the size of the land, the number of border strips can be decided. In furrow irrigation, the water runs in small furrows between the tree rows. The furrows vary from 30 to 60 cm in depth, 20 to 60 cm in width and 200 to 300 cm in length and follow the contours of the land. Slopes along the furrow may range from 0.2 to 2% but some times may be as high as 5%. This system is more suitable for irrigating young litchi orchards as one furrow running along side of each tree row may suffice to supply water to the limited zone of rooting. When the trees develop, several furrows are needed between the rows in order to wet the greater volume of soil occupied by the extensive root system.

High Frequency Irrigation

Under continuously favourable moisture conditions, improved cultivars can attain their high yield potential and can respond to great amounts of fertilizer and more intensive management practices. The advent of new irrigation system (sprinklers, drippers or ticklers, micro-sprayers, bubblers etc.) has made it possible to establish and maintain soil moisture conditions at a more nearly optimal level. Since a high frequency irrigation system can be adjusted to supply water at very nearly the exact rate required by the crop, one no longer needs to depend on the soil's own ability to store water during long interval between irrigations. The consequences of this fact are far-reaching. New lands, until recently considered very unsuited for irrigation, can now be brought into production. One outstanding example is the case of coarse sand and gravels, where moisture storage capacity is minimal and where the conveyance and spreading of water by surface flooding would involve inordinate losses by excess and non-uniform seepage. Such soils can now be irrigated quite readily even on sloping around without expensive leveling, by means of drip or micro-sprayer systems.

With high frequency irrigation, the orchardist need no longer worry about when available soil moisture is depleted or when plants begin to suffer stress. Field capacity and permanent wilting point indeed loose their relevance in the present context of high-tech irrigation. It has been suggested that the best the pressurized irrigation systems is almost continuous irrigation during the period of peak water demand because it costs little more to use a system once it is permanently installed.

Sprinkler Irrigation

This type of irrigation is highly recommended for use in frost-prone or low-moisture areas in order to offset the very unfavourable effects of this type of climate. In sprinkler irrigation, there is usually one sprinkler for every tree. This is because in order to obtain good cover an overlap of more than 200 per cent is necessary. Sprinkler irrigation, also called overhead irrigation is the application and distribution of water on the trees in the form of a spray, or a jet which breaks into drops or droplets, created by expelling water under pressure from a nozzle. In effect, it is a simulated series or range of drop sizes. If run-off occurs, this means that the system has not been correctly set up and it will be necessary to check that the right type of sprinkler is being used. Rate of discharge and sprinkler size are suitable/or whether some adjustment to the sprinklers is required. A system of sprinkler irrigation consists of water source, pumping unit, a pressurized conveyance system (pipe network) and a set of nozzles to eject the water into the air and spray it on the litchi trees. There are many different systems of sprinklers. They may be classified as over-tree or under tree sprinkler (Fig. 10.1) and fixed or portable sprinkler system. Where cost of water is expensive and wind conditions are severe, it is preferable to use the fixed under tree type sprinkler. Where atmospheric humidity is low and wind speed is usually normal, the productivity of litchi trees can be improved by overhead intermittent misting or sprinkling as it decreases leaf air water vapour concentration gradient. In recent years, increasing number of litchi growers in developed countries have abandoned the old-fashioned surface irrigation in favour of overhead sprinklers. Some farmers, however, do not favour this system as it causes some injury to plant parts, flowers and fruit. This happens

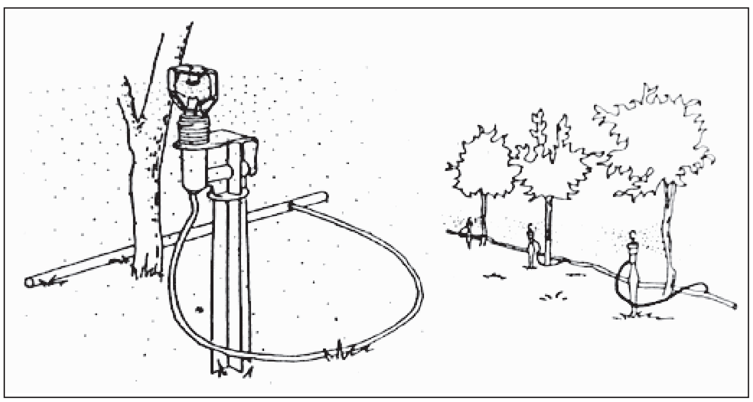

Fig. 10.1: Micro-sprinkler irrigation

probably due to poor installation of the irrigation system. Under canopy micro-sprinklers are now very common for orchard irrigation as this system requires lesser cost on installation than the overhead sprinkler system.

Drip Irrigation

Drip irrigation is the slow localized application of water drop by drop, at a point or grid of points on or just below the soil surface. Water is delivered to the plants via a set of plastic lateral tubes laid along the ground or buried just beneath it for protection (Fig. 10.2). The lateral lines are connected to a buried main line that receives water from a head source. The trickling rate, generally in the range of 4-8 litres/ hour per emitter, must not exceed the soil's infilterability if run off is to be avoided. The operating water pressure is usually in the range of 1 to 3 atmospheres. This system is specially successful in the regions where water supply is scarce. Although it is highly efficient, it presents certain management problems, particularly when the trees reach adulthood, because a large number of drippers are needed per tree, especially in light soils. In soils with a low water infiltration capacity, problems relating to salt concentration in the topsoil could arise. This system, like the micro-sprinkler method, is very suitable for both flat and steeply sloping land.

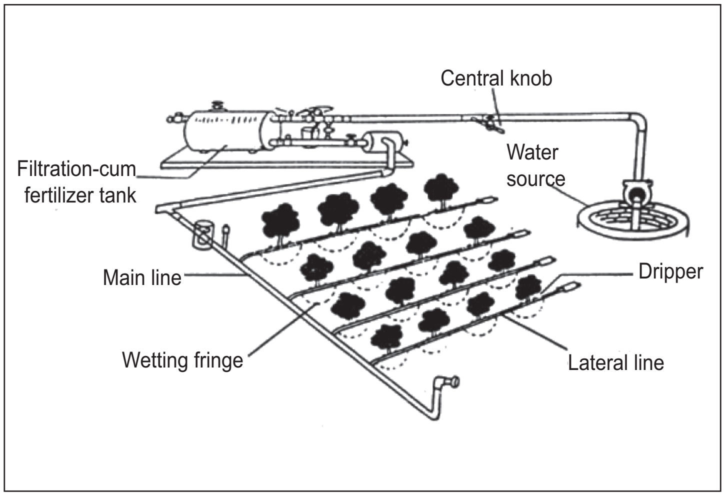

Fig. 10.2: Schematic diagram of drip irrigation system in litchi orchard

A general problem which arises with drip irrigation systems is that the pipes and drippers are likely to become blocked by mineral or organic particles. It is therefore indispensable to have a good filtering system, especially where drip irrigation is concerned. There is also the risk that pipes exposed on the soil surface may be damaged by rodents and dogs. Added advantage of this system is that plant nutrients can also be applied to the trees through irrigation water (fertigation). Some of the problems of drip or sprinkler irrigation include the high cost of installation and difficulties in keeping equipment operational.

As is mentioned with respect to sprinkler irrigation, special attention must be paid to the design of drip irrigation systems based on the soil type, emitters/dripper characteristics and tree development patterns and each individual case must be examined by qualified technical staff. For uniform distribution of water to the entire root zone of litchi plants hydrogoles can be attached with laterals which has flexibility of adjustment as the root zone is expanding.

Some farmers prefer both drip and micro-sprinkler below the canopy to increase the humidity in the orchard at the fruiting time. This reduces fruit cracking.

Improving Water-Use Efficiency

When the ET of litchi orchard is worked out for a particular set of climatic conditions, the task of an irrigator becomes easy. The irrigator needs to make up the ET losses through irrigation allowing 20-30% more water to compensate for deep drainage and conveyance losses. But, this will happen in area where water is plentiful and cheap in comparison with other production inputs. The orchardist is free to select any method of irrigation or any time interval to satisfy the crop's need. He must, however, be aware of the dangers of excessive irrigation. In areas where irrigation water is limited, the question of its efficient use arises. How the water is to be distributed on the entire orchard area. Should the litchi orchard have part of its area irrigated, leaving other parts un-irrigated? Should partial wetting of the root zone be sufficient enough? Some other similar questions may also boggle the mind of a litchi grower. Answer to these questions lies in allowing flexibility in irrigation scheduling. For example, in areas where water unavailability is unpredictable, a safety factor or buffer of several days is needed to protect the crop. Wetting zone of roots in two methods of irrigation in litchi are explained in Fig. 10.3.

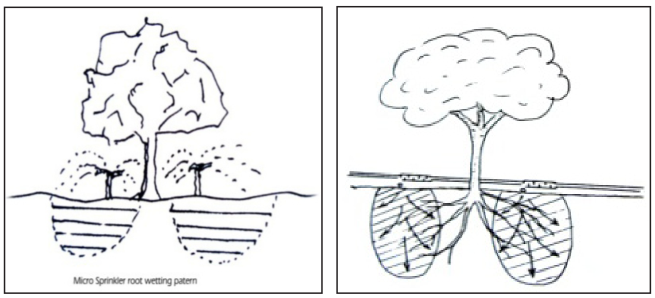

Fig. 10.3: Soil/root wetting pattern in drip and micro-sprinkler

System of Irrigation

Since soil and climate of different places are highly diverse, there is a wide variation in plant growth or fruit yield *vis-à-vis* the number of irrigation applied to the litchi trees. Where annual rainfall is more than 125 cm and is well distributed throughout the year, litchi can be grown without irrigation. The young plant neither establishes well nor make optimum growth if there is a shortage of water. Adequate and frequent watering is also essential for the bearing tree as the atmospheric humidity is very low during the course of fruit development.

Method of irrigation that minimized evaporation (but not transpiration) is likely to increase the efficiency of water utilization by the litchi trees. Drip or under-canopy micosprinklers are capable of doing this. They introduce water directly into the potential root-zone without wetting the entire soil surface. Water conservation practices like mulching also reduce evaporation from the bare soil and enhance water-use efficiency.

Even with the best irrigation practices, field application efficiency values cannot attain 100 per cent target. Nor should that be the aim, since certain fraction of the water applied must be allowed to seep downwards and leach the salts that would otherwise accumulate in the root-zone. However, with the careful management, field water application efficiency values approaching 90% are possible and values of 80% are practicable by drip or micro-sprinkler irrigation. This is why these systems are gaining ground gradually and different Govt. agencies are encouraging farmers with lucrative price incentive to adopt them for their fruit orchards. Optimal irrigation scheduling of litchi trees should meet plant's water needs and ensure maximum saving in water application and maximum yield.

In nutshell, young trees that are not bearing yet are irrigated throughout the year. Producers normally stop irrigating the trees during the coldest months of the year (November-March) so that they can have a proper dormancy period. In areas where it is never very cold, irrigation should be stopped to force the trees into dormancy. Bearing litchi trees need regular watering and therefore it is essential that enough water must be available from fruit set to harvest. Because the edible portion of the litchi fruit has a water content of 86%, the availability of water remains important during the development period.

Water shortage will delay development of the fruit and adversely affect the size, mass and quality of the litchis.Irrigation must continue after harvesting to ensure that a normal growth flush occurs during August-September just before the beginning of the dormant period. During dormancy (November-February) irrigation should be reduced, but the tree should not suffer severe drought.

Mulching

The process of covering plant root zone or entire basin with protective coverings is called mulching. Mulching is beneficial to all litchi orchards. It is very much useful in plants raised under rainfed conditions or in adverse soils. The covering materials may be organic or inorganic in nature. Using mulch can help a litchi orchard in many ways.

Mulches make unfavourable conditions for seed germination of weeds and provide a physical barrier for emerging weeds. A good mulch layer saves many hours of manual weeding. Thick layer of mulch material is very effective in preventing the number of annual weeds in the orchard, since they have difficulty to penetrate such a layer.

Mulches maintain uniform moisture conditions in the litchi orchard. Moisture loss through evaporation is reduced, and soil erosion is decreased in rainy season. Slow and steady water infiltration takes place in the soil and crusting is prevented. Mulches reduce the force of raindrops, thereby protecting the structure of the soil at the surface. Mulches may serve as vapour barriers, thus reducing evaporation of soil moisture.

Organic mulches add nutrients and humus to the soil as they decompose, improving its tilth and moisture-holding capacity. Some mulches are tilled into the soil before planting a new crop, and therefore may have an effect upon soil fertility and soil property. In the short term, mulches may decrease nitrogen available for a given crop. A material that has a high carbon content and is very low in nitrogen and other nutrients may actually "bind" or immobilize plant-available nitrogen temporarily. This occurs because soil microorganisms use available nitrogen to metabolize and decay the organic material. The immobilized organic nitrogen can be made available (mineralized) later as the organic matter continues to decompose.

The increased organic matter content due to mulches increases soil aggregation, infiltration, and water-holding capacity. In poor soils, addition of organic material improves water retention and reduces water losses through deep percolation.

Mulches shield the soil surface from solar radiation effects. Because of the increased moisture content and reduction of incoming solar radiation energy, a mulched litchi plant basin has lower difference between day and night temperatures. However inorganic mulches can act otherwise. For example, dark mulch can absorb more solar radiation and may actually increase soil surface temperature; transparent plastic mulches may increase temperature through "the greenhouse" effect; and can prevent water from entering soil, thereby decreasing soil moisture and increasing water runoff.

Organic Mulches

Saw wood dust: A layer of sawdust provides good weed control. Five cm thick mulch of saw dust adds nearly 450 g of nitrogen, if applied 10 cubic feet around the basin. Fresh sawdust contains high carbon and low nitrogen, and its breakdown requires that microorganisms take nitrogen from the soil. It is very good material for plants particularly to new plants. It is readily available from sawmills but it tends to be expensive.

Straw: A 15 cm thick layer of paddy/legume straw provides good annual weed control. These materials may decompose quickly and therefore should be replenished as per need. They stay in place and improve the soil as they decay. Avoid straw of weeds that is full of viable seed. Legume such as cowpea, supplies nitrogen as it quickly breaks down. Wheat and paddy straw are readily available in villages.

Field grasses and weeds: The layer of mulch is made gradually using dry grass. A 5 cm layer of local grass and weed cuttings provides good weed control and moisture conservation. Layer of green grass/weeds gives off excessive heat and foul smell and decompose slower than other organic material. In limited quantity, green grasses decompose rapidly and provide an extra dose of nitrogen to growing litchi plants, as well as making fine humus.

Dry plants leaves: After tree pruning, all the twigs should be collected at one place where dry leaves are collected and used as mulch material. A 5-7 cm thick and compact layer of dry litchi/other plant leaves provides good weed control and moisture conservation. Leaves decompose quickly and improve the soil once decomposed. To reduce blowing of dry leaves due to wind blow, the leaves should be surrounded by a basin bund or these may be used only after partial decomposition.

Crop residue and compost: Apart from above organic mulch materials, compost, crop residues, including twigs and branches etc. can be used as organic mulch material in the litchi orchard.

Inorganic Mulches

Black polythene: One layer of black polythene provides excellent weed control. It is relatively slow to decompose, but broken down by sunlight and should be replaced every two years. It increases the soil temperature which may cause soil temperatures to rise too much in mid-summer, damaging the roots of plants. A good foliage cover can prevent direct absorption of sunlight on mulch surface. It is easy to obtain, but is fairly expensive. A new type of black polythene has recently come into the market which has a white, reflective side to prevent the overheating problems. In all cases, polythene mulching insists litchi feeder roots to confine on upper surface which increases cracking under stress.

White polythene: White polyethylene can also be used as mulch material in litchi orchard but it is very expensive. It increases the soil temperature and is also not much effective in weed management, hence it is not used commercially.

Method of Mulch Application

Most of the organic mulches should be applied after plants are well established. In developing litchi plants also, organic mulch can be applied but problem of termite should be taken care of. Remove all weeds before spreading the mulch. Apply mulches when there is reasonably good soil moisture and before the weather turns hot. Infiltration of rain water will be slowed somewhat by mulch, so it is best not to place the mulch on soil which is dry. Water thoroughly or wait for a good soaking rainfall before applying any mulch. Application of organic mulch in plant basin can delay the termite infestation to tree trunk for some days as termite feed on mulch material and do not move to tree. However, it aggravates the infestation in subsequent days when mulch is digested and no additional mulch is replaced. To keep these termites in check, tree trunk should be pasted with chloropyriphos 0.02% + coal tar paste and mulch should be applied one foot apart form the tree trunk. This practice delays the termite infestation and restricts the soil mounding on tree trunk. Black polythene and similar materials should be spread on land that has been completely prepared for planting and has a high moisture level. Edge of the mulch should be buried with soil to prevent it from blowing away due to air.