CHAPTER 2

CLIMATE AND SOIL

Climate is very crucial for optimum vegetative and reproductive growth of litchi trees. It is the climate that largely determines whether this crop would be successful or would meet the failure in a particular locality. Climate, as the fundamental force in the environment, includes many factors whose actions and interactions must be considered in detail for successful production of litchi in an area. The principal climatic elements are temperature, moisture (humidity) and light. Microclimate refers to the climate of a "small area", may be of the area occupied by the orchard. Microclimatic variations are due to exposure, slope, surrounding vegetation, large water-body in the vicinity, and the thermal capacity and conductive characteristics of the soil.

Litchi is found in a narrow range of climates in comparison to many other sub-tropical fruit such as citrus and guava, etc. There are few critical studies on the response of the litchi to weather. These have indicated that under field conditions, sunshine, temperature and soil moisture content are often correlated with the plant performance. Temperature, soil moisture and atmospheric humidity for different stages of litchi have been described. The main commercial plantings of litchi are found at low elevation in the sub-tropics vis-a-vis higher elevation in tropics and mountainous region. These areas have cool winters and warm to hot summers.

Temperature

The litchi is one of the most environmentally sensitive fruit tree crops. It is adapted to the tropics and warm subtropics between 13° to 32°N and 6° to 29°S. It crops best in regions with winters that are short dry and cool (daily maximums below 20° to 22°C) but frost free, and summers that are long and hot (daily maximums above 25°C) with high rainfall (1200 mm) and high humidity. Good protection from wind is required for good cropping. Litchi flowers best with day temperature below 20°C. Temperature governs the flowering time, intensity and duration, sex ratio, fruit set, fruit growth and development and ripening time of litchi fruits. Total duration of relatively low temperatures has been considered more important than

frequency. Therefore, it is concluded that a cold, dry winter favours flowering. It has been demonstrated that winter and autumn temperature of between 0^0C and 13^0C coupled with a moisture deficit induce more profuse flowering in seasons where there have been below 13^0C temperature for about 200 hours.

High temperatures reduce both the duration of flushing and the interval between flushes. Low temperature also affects the rate of reproductive development with panicles emerging earlier but taking longer time to reach anthesis. Higher numbers of female flowers are associated with an average temperature of 18^0C during early flower development and the lower numbers of female flowers at the average temperature of 23^0C. In contrast, the rate of flower opening is related to the number of flowers per panicle. Therefore, it has been concluded that the areas with winter temperature maximum of above 25°C are not well suited for litchi cultivation.

Litchi can tolerate relatively high temperatures during growth and flowering. The normal day temperature limit during the most sensitive growing phase is 40°C whereas it grows satisfactory well under temperatures range from 20°C to 35°C; the optimum being 300C. Below 20°C, growth is slowed down significantly and below 15°C or 16°C, vegetative activity ceases. Finally, widely fluctuating day temperatures in sub-tropical climates seem to contribute towards vigorous vegetative growth.

Adult trees suffer serious damage and may be killed at -4°C or -5°C, even though they may have withstood temperatures of -6°C for a few hours in the resting state with only slight damage. Freezing temperatures below -1°C or -2°C can cause serious damage to tender shoot and young trees are usually died. It has also been found that layered plants are more susceptible to cold in their early years than plants grown from seed. It seems that the shallower root system of layered plants is more easily damaged than the deeper root system of those grown from seed. Below freezing temperatures and hot, dry winds kill inflorescences. When the terminal buds are frosted just prior to panicle emergence, a large number of axillary panicles develop. When the terminal panicle is destroyed by physical or chemical means, even after fruit set, a second axillary flowering occurs, provided that temperatures are low so as to stimulate floral initiation.

Temperature has been shown to have strong effects on pollination, but these responses do not necessarily translate into better fruit production. Maximum fertilization occurs when the number of pollen tubes per ovary does not increase with time after fertilization. Pollination is optimum at 19° to 22°C, with maximum fertilization obtained after seven days. At 15°C, pollen tube elongation is strongly inhibited. However, from 15° to 27°C, at least 10 per cent of ovules contain pollen tubes indicating that they are fertilized. Such a level of fertilization appears sufficient for most cultivars to produce a high yield, although at 33°C, all female flowers abscise, suggesting a limitation for good yields when days are above 30°C for long periods.

The relationship between fruit set and weather is not well understood. However, continuous hot, dry conditions may reduce yields. Bagging can improve fruit quality, possibly

due to cooler temperatures and higher humidity. Moderately high temperatures and humidity are important during the fruit development. Moisture stress causes cracking and reduces the final weight and quality of the fruit. In some cultivars, it prevents the seed from being totally covered by flesh. If moisture stress is accompanied by high temperatures, sun-burning results and the fruit is totally damaged. It is also worth mentioning that excess rainfall or humidity during the ripening phase can cause cracking and poor quality of aril, the main edible part.

Light

Litchi came out as one of the dominant species in sub-tropical rain forests of Asia. However, as with many crops, the original environment may not be ideal for its commercial production. Solar radiation is the source of photosynthesis and its intensity varies with the location of orchard and plant density. Both flowering and fruiting are reduced once adjacent trees start to touch each other and therefore at this stage, thinning/pruning becomes necessary to provide sufficient light inside the canopy. The decline of yield in crowded orchards begins when a portion of the canopy are shaded for most of the day. Light may limit flower development although high sunshine hours are expected to be correlated with higher temperatures and therefore early anthesis. The reduction in fruit set during low sunshine hours or cloudy weather could be due to lack of assimilates for flower development, but is more likely to be related to a direct effect of rain on the anthers or stigmas. Overcast weather may reduce bee activity. Early flowering fails because of cool, overcast weather during fruit set. It has been reported that more than 75 per cent of terminal branches flower, even if the plants are shaded several months before flowering. Average seasonal changes in light would not be expected to strongly influence flowering, unless overcast weather persists for several weeks. Heavy shade for one week increases fruit drop. Thus, it is inferred that, solar radiation is essential for litchi, hence, a duct between tree rows is helpful for sufficient light in the orchard.

The photoperiod also has influence on floral initiation. As it reduces from 16 to 8 hours, there is an increase in Type-II flower anthesis. Although it is generally thought that bright light is essential for commercial production but sometimes 9 to 15 hours of sunlight per day has no effect on production. Shady conditions for young plants nevertheless seems to favour initial growth and it has been common practice in Israel to grow litchi under banana plants at least for the first two years. It is quite obvious that in addition to shade, the banana plant also provide protection from wind which is harmful to litchi.

Rainfall

It is generally observed that abundant rainfall or irrigation and the resulting high soil moisture level encourages vegetative flushing. The optimum rainfall level, according to the places where litchi is grown in India, varies between 1250 and 1500 mm. Also, there are areas where annual rainfall is around 1100 mm but litchis are cultivated on a commercial basis. The adult plant

of litchi is drought-tolerant and can survive 4 to 12 weeks without water. Even though a high rate of relative humidity favours growth, it has been shown that except in extreme conditions, this is not always an important factor provided that there is an adequate supply of water for irrigation. Litchi appears to suffer moisture stress on hot, dry, windy days of low relative humidity in May and June. Traditionally, litchi is grown in areas where rainfall is adequate to maintain good plant and fruit growth.

Relative Humidity

High rainfall during rainy season from July to September is usually associated with high relative humidity. Water loss from evapo-transpiration is greater in dry air during hot summer months, and situations can arise where wilting of newly planted trees occurs when available soil moisture is inadequate. Humid conditions can increase disease pressure. High relative humidity at fruit maturity can increase chances of getting more fruit borer infestation. Low rainfall and humidity, together with adequate irrigation water, provide good growth of young trees with low disease pressure. While warm, humid conditions are conducive for rapid growth and early high yields. High humidity can add significantly to the cost of production but reduce fruit cracking.

Hailstorms and Frost

Hailstorms which often occur sporadically are main disasters during flowering and fruiting in litchi. The ice pallets destroy the panicle, developing flowers and small fruits. The damage caused to larger fruits is by physical hitting on the fruit surface which leads to cracks in skin, rupture of aril and rotting of pulp. Secondary infection by fungus starts some time after the physical damage. Affected fruits are unfit for consumption. Netting of individual plant is only method to protect from hailstorm damage. Where hail is a perennial problem, economic litchi production is very difficult and only possible with netting of individual trees or entire orchard.

Frost is common feature in northern and hilly areas of India. The temperature below 1.1^0C in the night, bright sunshine during day and sharp drop in evening temperature with no wind are the pre-condition of frost. The frost affects litchi plants adversely. The extent of damage by frost depends upon age of the tree, moisture content of the soil, condition of growth, actual timing of frost occurrence, severity and duration of the frost. Well grown up trees with mature wood are less affected than young trees which are immature and in active growth phase. Level of soil moisture affects the extent of frost injury. Moist soil or irrigated soil raises the soil temperature and provides protection against mild frosts therefore; trees of such growth and age growing under dry soils conditions are severely damaged by frost than to those growing in wet land.

High Velocity Wind/Hurricane

High velocity of wind can affect litchi trees in many ways. Younger plants during initial years of establishment have drooping, brittle branches that can be severely damaged by storm even if they are properly staked. High wind velocity leads to quick evaporation of water from the soil and thus, reduces moisture availability which is very much necessary for ideal growth and development of the plant. Litchi trees normally assume a dome shaped canopy and are comparatively less prone to damage of limbs and branches due to wind however, owing to week attachment of peduncle, a large amount of fruit drop takes place due to high velocity dry wind. Strong winds (more than 120 km/hour), gales or storms blow away the branches, leaves or panicles and sometimes fully grown trees also get toppled. It is more so in the areas adjacent to a vast open land mass not fully protected with windbreaks. It prevents flowering on branches which are exposed to constant buffeting, burns inflorescences, causes flower and fruit shed and its drying effect leads to skin-cracking.

Wind damages young shoots by way of burning especially when it is accompanied by high temperatures and breaks branches. A violent hurricane uproots trees. Fruit drop at initial stages of growth is a common problem of high velocity wind. Various measures are recommended to limit the damage but the most recommendable is perhaps to tie the main branches with thick, rubber insulated wire and the raising of thick and strong wind breaks around the litchi orchard. Planting tall trees like Shisoo on the boarder of the orchard can minimise the impact of wind to litchi trees up to an inward distance measuring 3-4 times of its (windbreak) height.

The Ideal Climatic Conditions

The key factors to consider when assessing the potential of different areas for litchi are temperatures in winter that affect flower initiation, temperatures and light levels in spring which affect fruit set and reliability of rainfall which affects fruit development. Normally, temperatures below 20°C induce flowers, while flowering is irregular at higher temperatures. A short drought period in winter assist flowering, especially in the more tropical cultivars, but is not essential. Annual rainfall of 1,200 to 1,500 mm is probably required in the absence of irrigation. The other critical part of the crop cycle is fruit set that is reduced when temperatures fall below 20°C for extended periods during flowering. Persistent cloud cover at flowering time can also pose a problem. The ideal condition for litchi cultivation is:

- A frost-free climate
- Absence of strong wind
- A cold (minimum temperatures between 8^0C and 14^0C), dry period prior to flowering (autumn and early winter)
- Moderate rainfall (1200 mm) and temperatures during flowering
- Moderate temperatures and humidity during fruit setting and maturation

- Deep, well-drained, non-saline calcareous soils with proper texture, good soil fertility with high organic matter content

Soil

Soil is the source of essential plant nutrients and thus, its chemical and physical properties are fundamental importance. The ability of the soil to support plant growth is often its fertility and the growth and fruiting of litchi trees are thus, directly related to the soil fertility status. The most important factor in soil fertility is the amount and availability of the forms of the nutrients available to the plant. Such levels are related to many factors, among which are the solubility of the nutrients, the soil pH, the cataion-exchange capacity of the soil, the soil texture, and the quantity of organic matter present. The nutrient status (or the fertility status) of the soil is the net effect of many interacting factors that include the status of soil-nutrient, micro-organism activity, organic matter and pH. The mineral interactions in soil can be very complicated and supply of one nutrient can affect uptake or utilization of another. One element may counter or depress the effect of another (antagonism) or increase the impact of another (synergism). For example, raising levels of phosphorus may depress nitrogen uptake, increasing nitrogen can depress boron uptake.

Litchi is very much particular to soil type and good drainage. It can be grown on a range of soils, including alluvial sands, loams and soils with a high content of organic matter and pH. From the physical viewpoint, litchi does not require as deep soils as do mangoes. It can be adequately grown in soils with 40 cm depth, and even in rocky and calcareous soils. There can also be problems on very sandy soils that dry out during hot weather and on calcareous soils with potential iron, zinc or manganese deficiencies. These soils need to be carefully managed. Trees perform best on well drained clay loams of medium to high fertility with a minimum one meter of well drained topsoil. In general, litchi prefers deep alluvial soils, containing sufficient amount of organic matter. Litchi nevertheless adapts to soils of different textures like sandy, loamy, clayey-sand, clayey-loam and even soils with 40 per cent clay content, but the heavier soils requires better drainage.

Slopes more than 15 per cent are avoided as they do not allow the safe use of machinery and prone to erosion. When trees are grown on terraces, the planting site is generally filled with quality loam and organic matter to improve soil structure and fertility. Soil type influences total root density and feeder root distribution (depth of the soil where 80 per cent of roots are located). Though some roots are found below 300 cm in a deep calcareous sandy loam, most roots are located in the top 45 cm. A tremendous network of roots up to one meter has been observed in sandy soils while trees growing in clay soils have a shallow root system. The deep roots are, however, capable of absorbing enough water during the dry season to support the crop. Soils with a low water retention capacity and a low fertility level are important where commercial production is concerned since, in such soils, vegetative growth is easily checked which has a favourable effect on flowering and fruit production. This is why light soils are

preferred for very vigorous varieties but are not so essential for other less vigorous varieties which can produce adequately under a wide range of soil conditions. From the chemical viewpoint, litchi does not require very fertile soil. For commercial production, it requires a high nitrogen level and a moderate level of phosphorous, potassium and calcium. Many poor soils contain adequate quantities of magnesium and micro-elements which are suitable for litchi.

Soil should be examined for suitability in respect of depth, drainage and compacted layers. It should preferably be 1 to 2 m deep. Once it has been determined that the soil is suitable from this point of view, a soil analysis should be done six months prior to planting to determine the quantities of fertilizer which will have to be applied sufficiently in advance. Preparation of the soil according to the results of the soil analysis is needed, especially when large quantities of lime are required. For successful litchi production, some soil related issues such as soil organic matter, soil pH, wetting and water table are important.

Soil Organic Matter

Soil organic matter consists of decomposing plant and animal residues. The freshly fallen leaves, and drying roots begin rapid decomposition, and the residues become a part of soil humus. Crop residues (e.g. weeds, grasses, fallen tree leaves), worms, bacteria, fungi, and actinomycetes are part of this mixture. Although most cultivated soils contain only 1-5 per cent organic matter, which is mostly in the top 25-30 cm of soil, that small amount can modify strongly affect its chemical and biological properties. Organic matter is constantly undergoing change and must be replenished continuously to maintain orchards' soil productivity.

Water Table

A constant water table is ideal for good growth and development of litchi crop. Litchi can withstand up to 14 days of immersion, provided the water does not become stagnant. It may die on heavy clay soils if water becomes logged. Trees subjected to continue flooding found to be dwarfer than those on better drained soils. Poor drainage in heavy clays can increase the incidence of collar rots and root diseases. Hilling of the soil along the rows to give ridges of 0.5 m high is recommended in wet sites. The addition of drainage can also assist growth in wet soils.

Soil pH

There is little information on the response of litchi to excess salts as data on salt tolerances are scarce and contradictory. Some reports indicate that litchi tolerates the presence of salts in its root area well, even better than mango whereas, others state that salt tolerance is practically nil. However, litchi appears to be less sensitive than other fruit crops, still it is in the low tolerance class of plants. It is recommended that trees should not be irrigated with water having an electrical conductivity greater than 0.5 dsm^{-1} m or about 500 mg soluble salts

per litre. Sometimes, plant may get damaged during dry weather under high salt condition especially when young trees are over-fertilized. The tips and margins of the old leaves may burn due to toxicity.

Acid soils with pH between 5.5 and 6.5 are generally considered as ideal but litchi tolerates soils with a pH of less than 5.5 easily. They may also be planted in alkaline soils with a pH of up to 8.5 subject to the adequate supply of micronutrients externally. Nutrition has to be carefully managed on these soils to avoid deficiencies of micronutrients such as iron.

Most growers aim at a pH between 5.5 and 6.0, although lower pH is probably acceptable with slight pit management. Nutrition management, especially the application of micronutrients needs to be modified at extremes of soil pH. No more than 5 tons of lime per ha should be applied in a single application on sandy soils. Where more lime is required, a second amount should be applied three months later. Dolomite can be used instead of the lime, if soil magnesium concentrations are low.

Moisture

Drought during fruit development generally reduces production but it induces flowering. Shoot growth is very sensitive to changes in tree water status as its growth decreases as the level and duration of drought increases. A period of drought before flower induction may assist flowering by delaying early shoot growth until winter. Once flower panicles are initiated, best fruit set is achieved when plants are well watered. Most of the flowers abscise prematurely in drought hit plants and the few flowers that reach anthesis become male. It indicates that trees should be irrigated from panicle emergence to prevent water deficits reducing fruit set, although threshold level of moisture below which production is affected has not been worked out precisely.

There is very little information on the response to irrigation during fruiting. The results indicate that there may be different effects on fruit production depending on the level and timing of the water shortage. Drought reduces the number of fruits per tree, average fruit weight, aril recovery and yield. Fruit splitting or skin cracking led by drought or temperature fluctuation at fruit development stage is a serious problem where some times 50 per cent or more of the crop may be lost.

Selecting Site for New Plantations

Litchi is a subtropical fruit and needs specific climate, hence, the selection of appropriate location for a litchi orchard is very important. While selecting the site, care should be taken to ensure that environmental factors and soil are supporting the litchi crop as any mistake at initial stage is likely to put the growers to heavy losses throughout the life span of the orchard. While selecting the site factors like soil type, soil depth, soil fertility, drainage, water table, etc. must be examined carefully. Among the factors determining the desirability of a piece of land for litchi growing is the land value as the cost of land contributes towards cost of production.

A cheap land may prove expensive in the end, if the probable expenses in making the land suitable for planting are not considered.

Successful orcharding consist not only of production, but efficient disposal of the produce as well. Location viz. proximity to road, market, transport, storage facilities, cheap source of electricity, water supply, availability of processing plant, etc. are also important. Almost 25 to 35 per cent of the total cost of the fruit growing is incurred on packing, transportation and other handling processes. The margins of profit can be increased if costs on these items are reduced. The site has direct impact on the growth, bearing and health of trees and location mainly concerns the economic disposal of the produce. Locations away from forest are preferred to avoid menace of wild animals.

The contour of the land affects the system of planting of orchard. It is especially important from the view point of erosion, frost, freezing and desiccation. There should be easy access to tree canopy from all directions to facilitate sprays and harvesting operations. For the same economic reasons, flat or slightly sloping land is preferred. A slope more than 15 per cent makes the land uncultivable whereas, 1-4 per cent slope may be kept clean without soil loss. Uneven land involves heavy expenditure in levelling, introduces other unfavourable situations and cultural difficulties. It is a strong belief that land slopes are chief cause of success or failure of the orchards. Southern slopes are generally warmer and affect the plants in a manner different from northern slops because of the difference in the quantum of sunshine that the plants receive.

While selecting the site, well recognised litchi growing areas or a site in the traditional litchi belt should be of first choice. However, new potential areas having suitable climate and soil, and good market demand can also be considered. In selecting the location, it is advantageous to have a place where fruit growing is not new since the experience of others, the knowledge of the cultivation practices and availability of skilled labour are really useful. Location with a heavy output attracts large buyers and the transport problem disappears and thus, the profit is greatly increased. Some of the states are well equipped with adequate infrastructure of meteorological data enabling farmers to study climatic conditions in each and every zone. In any case, it is necessary to choose areas that meet best of the conditions for litchi cultivation.