CHAPTER

4

SUBTROPICAL FRUITS AND THEIR CULTIVATION

OBJECTIVES

After studying this chapter, you will be able to:

- Identify subtropical fruits, describe their importance and their main production sites
- Describe major cultural requirements of subtropical fruits
- Identify major problems of subtropical fruits and describe their management
- Enlist major insect-pests and diseases of subtropical fruits and their integrated management strategies
- Able to establish orchards of subtropical fruits
- Able to start a business of these fruits

INTRODUCTION

In the previous chapter, you have learnt about tropical fruits, their production problems and management. In this chapter, you will come to know about subtropical fruits i.e., the fruits, which are grown in areas, which experience both the extremes of temperature i.e., high temperature during summer and very low temperature in winter. This type of the climate prevails in most of the northern states of our country where there are extremely cool winters and very hot summers. The major subtropical fruits grown in India are citrus, grape, pomegranate, *aonla*, *ber* and litchi. Although, some subtropical fruits can grow in tropical climate and others in temperate climate. For instance, pomegranate grows well in warmer temperate climate. *Aonla* grows in tropical climate as well. Most of the subtropical fruits are rich source of carbohydrates, proteins, vitamins and minerals and thus protect our body from several ailments. For example, *aonla* is very rich source of Vitamin C. *Ber* grows well in arid climate and is commonly called as apple of tropics. In this chapter, we will learn the cultural requirements of these fruits, their major problems and solutions.

What are subtropical fruits?

The fruits, which are cultivated successfully in areas, which experience both the extremes of temperature i.e., very high temperature during summer and very low temperature in winter are called as subtropical fruits.

CITRUS

Citrus comprise a group of fruits belonging to family Rutaceae, with basic chromosome number, X = 8. The members of this group are well spread over the areas ranging from tropical and subtropical regions of the world lying within 40^0N and 40^0S latitude.

Citrus species are believed to be originated in South-Eastern Asia. Citron (*Citrus medica* L.) is believed to have originated in south China or northern eastern India. Lime (*C. aurantifolia* Swingle) originated in the east of Indian Archipelago. Lemon (*C. limon* Burmann) originated in north Africa or from Spain. Sweet orange (*C. sinensis* L.) Osbeck originated in southern China or Indonesia, *Citrus grandis* (Pummelo) originated in Malaysia, grapefruit (*C. paradisi* Macf.) in Barbados (West Indies), Mandarin (*C. reticulata* Blanco) probably in Indo-China and South China. The others related minor genera i.e. *Poncirus trifoliata* (L.) Raf. (trifoliate orange) and *Fortunella margarita* (Lowi) Swingle, are known to have originated from southern China and both are freeze hardy species.

Some principal countries growing citrus are the USA, Brazil, Mexico, Spain, Italy, Algeria, Morocco, Israel, Egypt, Pakistan, China, India, Australia and Japan. In India, Maharashtra, A.P., Punjab, NE states, Karnataka and Bihar are the major citrus producing states.

Juice present in the vesicles is the edible portion of the citrus fruit. The juice contains 12-14 per cent sugars, citric acid, and ascorbic acid (Vitamin C). The leaves, flowers and fruits contain essential oil, which has several flavanoids. 'Hesperidin' is the universal oil present in most of the citrus fruits. Other flavonoids identified are neohesperidin, naringin, aurantamarin, limonin, narirutin, mobiletin, tangeretin etc. The bitter principles present are 'naringin' of graperuit and 'limonin' of Navel orange.

Soil and climatic requirements

Commercial citrus cultivation in India is done on soils ranging from coarse sands to heavy clays. Although, citrus has been reported to be grown in soils with pH ranging from 4.0 to 8.5 but ideal pH ranges from 5.5 to 6.0.

The growth and development in citrus is optimum in temperature regimes ranging from 25 to 30^{0}C to minimum of l3^{0}C. High temperatures cause poor pigment development in fruits and also sunburn or sun-scalding is occasionally met. Low humidity favours proper fruit colour development, while high RH leads to development of juicy fruits with thin rind thickness. Annual rainfall of 800-900 mm, well distributed throughout the year, is optimum for citrus growth and production.

Commercial cultivars

Sweet oranges: Mosambi, Sathgudi, Valencia, Pineapple, Jaffa, Hamlin, Shamouti, Malta, Malta Blood Red, Ruby, Washington Navel, Frost, Washington, Navelina, Gillett, etc.

Mandarins: Major varieties are Owara, Mikado, Wase, Silver Hill, King, Willow Leaf, Nagpuri, Khasi, Coorg, Kinnow and Satsuma.

Lemon: Major acid lemon varieties are Eureka, Lisbon, Assam lemon, Elaichi nimbu, Pani Jamir, Meyer lemon, Karna Khatta, and *galgal* (hill lemon).

Lime: West Indian (Mexican, Key), Kagzi, Tahiti lime (Persian), Pond, etc.


Mandarin fruit

Grapefruit: Duncan, Foster, Marsh Seedless, Thompson Seedless and Red Blush are the major cultivars of grapefruit.

Pummelo: Nagpur (*chakotra*) and Common pummelo are usually grown in India.

1. **Inter-varietal crosss:** Kinnow (King x Willow Leaf mandarin), Kara (Satsuma x King mandarin) and Wilking (King x Willow Leaf mandarin).
2. **Interspecific:** Tangelo (*C. reticulata* x *C. paradisi*), Tangor (*C. reticulata* x *C. sinensis*), Lemonime (*C. limon* x *C. aurantifolia*), Lemonage (*C. limon* x *C. sinensis*), Lemondrin (*C. limon* x *C. reticulata*).
3. **Intergeneric :** Citrange *(Poncirus trifoliata* x *C. sinensis*), Citrumelo (*P. trifoliata* x *C. paradisi*), Limequat (*C. aurantifolia* x *Fortunella japonica*), Citrandarin (*P. trifoliata* x *C. reticulata*), Citrudias (*P. trifoliata* x *C. aurantium*), Citrumquat (*P. trifoliata* x *F. japonica*).


Kinnow mandarin

Besides, some bi-generic and tri-generic hybrids and complex hybrids with distinct rootstock

characteristics have also been developed viz., Citrangequat (Citrange x *Fortunella margarita*), Citrangedin (Citrange x *C. mitis*), Citrangor (Citrange x *C. sinensis*), Citrange (Citrange x *P. trifoliata*).

Plant propagation and rootstock

Citrus trees are propagated by both vegetative mean and sexually by seeds. Vegetative methods are preferred because they ensure uniformity in quality and bearing. Seeds of several citrus species are polyembryonic and produce nuclear seedlings, which produce true-to-type plants. Mandarins and acid limes are mostly propagated as seedlings. Lemons, citrons, sweet limes are easily propagated by stem cuttings. Air-layering is mostly practiced in pummelo, mandarin, acid lime and seedless lemons. Most of citrus cultivars are propagated by 'T' budding on a suitable rootstock.

Rootstock and polyembryony: An ideal rootstock should have high degree of polyembryony, graft compatibility, adaptability to wide range of soil conditions and tolerant to biotic and abiotic stresses. No single rootstock possess all the characters together, however, few rootstocks commonly employed for citrus propagation are rough lemon, sour orange (*C. aurantium* L.), Karna Khatta (*C. karna*), Rangpur lime (*C. limonia*), sweet orange (*C. sinensis L. Osbeck*), Citranges like Troyer, trifoliate orange (*Poncirus trifoliata* L. Raf.), and Cleopatra mandarin.

Planting, agro-techniques and orchard management

Cultivated citrus genotypes are commonly planted in a square or rectangular system. Planting density has tremendously increased with the use of dwarfing rootstocks (planting densities of more than 400 plants/ha). It is now possible to accommodate higher number plants. In square system, the planting density of 4 x 4 m, 5 x 5 m, 3 x 3 m can accommodate 625, 400, 1111 plants/ha. Similarly, in rectangular system, spacing of 3 x 5 m (667 plants/ha) and 4 x 6 m (417 plants/ha) are being adopted.

Pits of 50 x 50 x 50 cm size are dug in summer according to the layout plan. The exposed soil after 30-40 days is mixed with 15-20 kg well rotten FYM and 50 g chloropyrophos (to kill white ants) and filled tightly. The best planting time is beginning of rainy season. Care must be taken that bud or graft point should be at least 10 cm above the soil surface. The irrigation channels/sub-channels basins are also laid out at the planting stage.

Intercropping: This is not recommended in citrus unlike other fruit crops as intercropping is reported to cause harm to the main crop. However, in the initial years of establishment, i.e., up to 3-4 years, vegetable crops like onion, potato, chillies, pulses, gram, etc. can be grown.

Weed control: A broad range of weeds compete with citrus plants namely, *Cyperus rotundus*, *Cynodon dactylon*, *Sorghum helpense*, *Euphorbia khirta*, *E. microphylla*, *Convovulus arvensis*, *Amaranthus viridis*, *Paspalum spp*., *Imperata cylindrica, Ageratum* spp. etc. These weeds appear according to the season and occupy the open space and area underneath the plants. Weeds compete for water and nutrients and harbour pests and diseases. Light hoeing is essential to control the geminated weeds. Chemicals viz., atrazine, simazine (6 kg a.i./ha) are recommended right from germination to flowering stages. Glyphosate is also gaining popularity as a broad spectrum weedicide. However, care must be taken to check the problem of spray drift.

Integrated nutrient management

For sustainable production of fruits and for proper maintenance of plant and soil health, efficient nutrient management programme must be adopted. Citrus is a nutrient exhaustive crop as plants in the population density of 400 plants/ha can remove about 200 kg N, 50 kg P_2O_5 and 200 kg K_2O/ha. Citrus is grown on a wide range of soils and hence no generalized recommendations can be made for any type. Besides. the dose of nutrients increase with the increase in plant age. For 'Khasi mandarin' application 300 g N + 250 g P_2O_5 : 300 g K_2O has been found economical. Under Coorg conditions, 600 g N, 200 g P_2O_5, 450 g K_2O/plant has been recommended

Bearing tree of grapefruit

for mandarins. Similarly, for lemons, 500 g N, 250 g K_2O was found ideal.

Foliar spray of micronutrients has given beneficial effect on improving the yield and quality. One to 2% urea, alongwith $ZnSO_4$, $MnSO_4$, $MgSO_4$ (each 0.5%) and $CuSO_4$(0.25%) is beneficial for all citrus cultivars.

Physiological disorders

Granulation: This is the major disorder of sweet orange, mandarin wherein the juice sacs become tough, enlarged, colourless and tastelss. There is a marked increase in the pectic substances, gels etc. and marked decline in sugars, organic acids and carotenoids. These fruits are insipid and fetch poor price in the market. Some of the factors associated with it are: high soil humidity, high relative humidity and temperature during fruit growth. Hamlin and Mosambi orange are highly prone to granulation. This malady can be kept under control with the application of 16 ppm of 2,4-D on developing fruits. Similar, effect was also noted with the spray of $ZnSO_4$ + $CuSO_4$ + KCl each at 0.25% at monthly interval from August to October.

Fruit cracking/splitting is a serious problem in lemon. It can be reduced by regular irrigation and spraying borax and calcium chloride.

Fruit drop: High fruit drop in citrus is primarily due to auxin deficiency. Commonly, this drop is also referred to as 'May-June drop' in sub-tropical regions. The developing fruitlets compete for carbohydrate, water, hormones and other metabolites. Excessive high temperature (35-40^{0}C) during fruit development causes high fruit drop. Application of 2,4-D or 2,4,5-T (10-30 ppm) during fruit development check fruit drop.

Fruit cracking: This is common disorder of sweet orange, lemons and acid lime. The splitting starts at stylar end and progresses towards the pedicelar end. Splitting is basically caused due to factors like deficit soil moisture, atmospheric temperature and relative humidity. Borax (0.2%) spray can check splitting and timely application of irrigation water must be ensured.

Cracked lemons

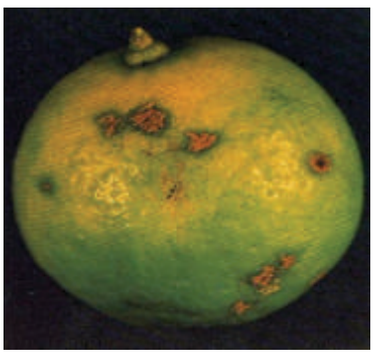
Plant protection

Maturity, harvesting and yield

Insect-pests	Damage	Control measures
Aphids (*Toxoptera citricidus, T. aurantii, Aphis pome, Myzus persicae)*	Suck sap from young leaves and twigs thereby causing severe curling of leaves, stunting of plant and facilitate sooty mould growth by excreting honey dew. These aphids act as vector for Tristeza virus.	Sprays of monocrotophos (0.025%), phosphomidon (0.03%) or parathion (0.03%) are useful for the control of aphids.
Citrus psylla (*Diaphorina citrii)*	Suck sap from young leaves and act as a vector for transmitting greening disease.	Spray systemic insecticides like phosphomidon (0.03%), monocrotophos (0.025%) or oxydemeton methyl (0.03%).
Leaf miner (*Phyllocnistis citrella*)	Yonug ones cause damage by mining the leaves.	Synthetic pyrethroids viz., fenvalerate (0.01%), permethrin (0.005%) or cypetnethrin (0.001%) are most effective. Oxydemeton methyl (0.03%) is also effective.
Lemon butterfly (*Papilio demoleus*)	Caterpillars may defoliate entire leaves.	Dusting and spraying with sevin (0.1%) has been found very effective.

Fruit sucking moth (*Ophideres* spp., *Achoea janata)*	Adult insects suck sap from mature fruits, thereby leading to fruit rot and drop.	Use light traps.
Nematodes like citrus nematode *(Tylenchulus semipenetrans)* and burrowing nematode (*Radopholus similis*)	Reduced plant growth and dysfunction of root system.	Soil application of aldicarb @ 6 kg a.i./ha is quite effective. Use oilcakes of *neem, karanj, mahua* or mustard.
Diseases	**Symptoms**	**Control measures**
Tristeza (Viral disease)	Symptoms like stem pitting, and yellowing of seedling yellows, etc. Infected plants show poor growth, die back, defoliations and ultimately death.	Use tolerant rootstock like Rangpur lime, Cleopatra mandarin, Trifoliate orange, use certified bud-wood, control aphids by insecticides.
Greening (Bacteria like organism)	The symptoms appear as chlorosis, resembling Zn deficiency, short twigs with upright yellow leaves, leaf drop, die back, formation of multiple buds and disfigured fruits.	Tree injection with tetracycline is found to be effective or employ cross protection technique. Control citrus psylla by suitable insecticides..
Phytophthora rot or gummosis *(P. citrophthora, P. parasitica* and *P. palmivora)*	Symptoms are noted as root rot, gummosis, blight of seedlings and fruit rot.	Use resistant rootstocks like *Poncirus trifoliata* or sour orange. Soil drenching with foltaf (0.2%) or avoiding water stagnation around tree trunk is widely adopted practices.
Bacterial canker (*Xanthomonas campestris* cv. *citri*)	Acid limes are most susceptible. Development of lesions with halo on leaves, twigs and fruits.	Spray 1% Bordeaux mixture or 500 ppm streptomycin sulphate and control of leaf miner (insect vector) by metasystox (0.1%). Prune infected portions.

Time of harvest in citrus varies with the region (tropical and subtropical) and the species. Marketable maturity is generally adjudged with the change in rind colour. Commercially, TSS: acid ratio is the most reliable method and it ranges from 10:1 to 16:1, depending upon citrus species and flush. 'Khasi mandarin in Northern-Eastern states is harvested during October-January, while 'Darjeeling' mandarin is harvested during November-December. 'Kinnow' in Punjab is harvested during January-February; 'Nagpur' mandarin is harvested during April-July, October-January in Coorg, January-February in Karnataka. Malta orange is harvested during January-February in Punjab. Mosambi is harvested in April-June (1st crop) in Maharashtra while pickings are also made during July and October-December. Sathgudi in Tamil Nadu is harvested during two seasons i.e. July (1st crop) and October-November (2nd crop). Hand picking is the most popular method to collect fruits while in some regions harvesting by shaking of main trunk is also done. Maximum productivity in citrus ranges from 700 to 1,000 fruits per tree, which depends on the age of plant, cultivar, rootstock and management practices. Kinnow plant can yield 300 to 800 fruits/plant, mandarin give 500 fruits, sweet orange 500-600 fruits/plant, Kagzi lime give 1,500 to 2,000 fruits/plant and



Citrus canker

lemon yields 600-800 fruits while rough lemon gives 1,000 to 1,500 fruits per plant.

GRAPE

Grape (*Vitis vinifera* L.) is one of the most delicious, refreshing and nourishing fruits. The fruit is utilized in many ways. About 80 per cent of the grapes are used for wine making and the remaining 20 per cent are used for raisin, juice and canning purpose. France, Italy and Spain are the leading producer of wine. In India, grapes are mainly consumed as fresh fruit.

The fruits are a rich source of sugars. The colour of grape berries is mainly due to four or five anthocyanins viz., cyanidin (red colour), delphinidin (blue colour), petunidin (purple colour) and malvidin (blue colour). Muscat Hamburg and Bhokri cultivars have Muscat flavour whereas Concord has foxy flavour. The foxy flavour and aroma in grape is due to the presence of methyl anthranilate.

The American grapes consisting of *Vitis labrusca* and other species of Euvitis and Muscadinia, are considered to have originated in the North American region. The original home of European grape (*Vitis vinifera* Linn.) is Caucasus region, which lies between black and Caspian sea.

Grape has been classified under the genus *Vitis* of the family Vitaceae. *Vitis* has two subgenera (i) Euvitis and (ii) Muscadinia. The distinguishing characters of the sub-genera are as follows:

Characteristics	Euvitis	Muscadinia
Somatic chromosome No. (2n)	38	40
Tendril	Forked	Unified
Bark	Loose	Tight
Lenticels	Absent	Present
Seed	Beaked and pyriform	Beak absent
Diaphragm at the node of shoot	Present	Absent

Soil and climatic requirements

The grape has a strong root system and can be grown on a wide range of soils but the best soil is sandy loam that is well-drained and fairly fertile having good amount of organic matter. Heavy clay, sand or slit are unsuitable for grape. Grape is relatively tolerant to soil salinity and alkalinity, and upper salt tolerance limit is 0.3 per cent.

Grape requires a long, dry and moderately hot season during cane maturity and ripening of berries followed by cool winter. Rains during growing season are useful, but continuous rains, make it difficult to control diseases. Rains at the time of berry ripening are harmful as even a single shower of rain during berry ripening can destroy the whole crop. Similarly, vines don't grow well in humid summer due to the attack of several diseases. Bright sunny days help in accumulation of sugars in berries.

Bearing plant of Pusa Urvashi

Commercial cultivars

Table grapes: Important table varieties of grapes are Thompson Seedless, Pusa Seedless, Perlette, Beauty Seedless,

Pusa Urvashi, Bhokri, Cardinal, Black Muskat, Tokay and Delaware.

Raisin grapes: Some notable examples are Black Corinth, Thompson Seedless, Muscat of Alexandria, Sundekhani, Pusa Seedless and Kismish Beli.

Juice grapes : Early Muscat, Black Champa, Concord, Bangalore Blue, White Riesling, Arka Hans, Arka Shyam and Pusa Navrang are suitable varieties for juice making.

Wine grapes : White Riesling, Pinot Noir, Cabemet Sauvignon, Black Cheaper, Rubired, Madeleine Angevine, Cheema Sahebi and Pusa Navrang produce wine of good quality.

Canning grapes: Thompson Seedless, Pusa Seedless and Perlette can be used for canning purpose.


A bunch of Perlette grape

Grape varieties can be seeded or seedless, as grouped hereunder:

(a) Seeded cultivars

Anab-e-Shahi, Bangalore Blue, Bhokri (Panchdraksha), Cardinal, Cheema Sahebi, Gold, Gulabi, Pearl of Casaba, Pinot Noir, Arka Kanchan, Arka Shyam, Arka Hans, Pusa Navrang are important seeded cultivars.

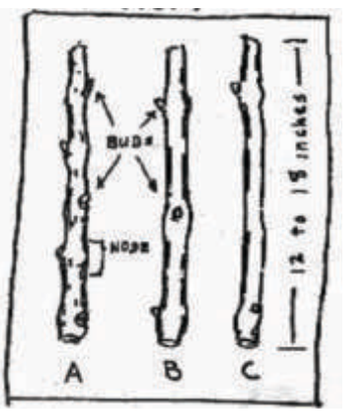
(b) Seedless cultivars

Beauty Seedless, Pusa Seedless, Perlette, Thompson Seedless, Delight, Himrod, Kishmish Charni, Arkavati, Pusa Urvashi are important seedless cultivars.

Some selections have been made by farmers. Tas-e-Ganesh, a selection from Thompson Seedless is popular in Maharashtra. It responds better than Thomson Seedless to gibberellic acid for berry elongation. Dilkush, Manik Chaman and Sonaka have been selected from Anab-e-Shahi in Hyderabad. In H.P., some local seedless types (Bargron, Shungron) having good berry quality are used for making a local wine called Angoori.

Plant propagation and rootstock

Grape is propagated by seeds for raising hybrid seedling or rootstocks whereas commercial varieties are propagated through hardwood cuttings. Cuttings are taken from mature canes of healthy, vigorous and disease-free vines. Depending on the length of internodes in a cultivar, the mature bud-wood from the annually pruned shoots should be cut into pieces (cuttings) of 25-30 cm so that each cutting has at least 4 buds. The cuttings should be of pencil thickness. The cut at the base of cutting should be perpendicular to the length of cutting, just below the bud, while the upper cut should be slanting and about 1.5 cm above the apical bud. These cuttings can either be planted in the field immediately after preparation or stored for sometime or buried in moist sand or saw dust in a cool place. The best time for preparation of cutting is north India is at the time of annual pruning in mid-January.



Hardwood cuttings of grape

Under certain specific conditions to impart protection from soil borne diseases and advance soil conditions (e.g, salinity), commercial varieties are budded or grafted on desired rootstocks (e.g., Dog Ridge, Salt Creek). 'T' and 'Chip' budding are successful methods for grape propagation.

Rootstock : For the control of Phylloxera in north American grapes, grafting on tolerant rootstocks like Riparia Gloire, St. George, 1202, or 99-R is done. Most of the *V. vinifera* cultivars are susceptible to nematodes. By grafting or budding the commercial varieties on Dogridge, Salt Creek, 1613, 1616 rootstocks, this problem can be avoided. Dog Ridge and Salt Creek rootstocks have also been found to be useful to impart resistance

against salinity in soil.

Cultivation

Layout and planting: Normally, a spacing of 2 m x 2 m is recommended for head system, 3 x 3 m for trellis and bower system, for low and medium varieties. Vigorous varieties are trained on bower system and hence a spacing of 3.6 x 3.6 m is usually followed. Square system is followed in most cases but under certain specific system of training, rectangular system of planting is followed. After deciding the spacing, planting spots should be marked, dug out to a dimension of 90 x 90 x 90 cm. The pits are allowed to remain open for 3 weeks. The pits should be re-filled with 1:1 mixture of top soil and FYM. One kg super phosphate, 500 g sulphate of potash and 30 g chloropyriphos may be mixed and added in each pit and irrigated immediately. The poles should be fixed at a specific distance, depending on the training system.

Planting : Usually, one-year-old rooted cuttings are planted. The planting is done during January-February in north India and during March-April and September-October in south India.

Training : Training is done to give proper shape and desired growth for good quantity and quality of fruiting. The different training systems are bower, head, kniffin, trellis, telephone, etc. The most commonly followed training system is bower system, which is also called as Arbour or Pergola system of training. It is best suited for vigorous cultivars like Thompson Seedless, Anab-e-Shahi, Cheema Sahebi and Bhokri. In this system, the vines are spread over a criss-cross network of wires, usually 2.1 to 2.4 m above ground, supported by pillars (concrete, stone or iron) and angle arms of iron. Vines are spaced 3 x 3 m or more and are allowed to grow straight, without any branch, upto the height of 2.4 m. When the wine reaches the wire, it is pinched off to induce initiation of side shoots. Two vigorous shoots, opposite in direction are selected as primary shoots. On each primary arm, 3 laterals are kept on each side as secondary arms. These arms are allowed to produce 8-10 tertiary branches, which act as fruiting canes. This system provides a very high cost benefit ratio (1:2.09) but cultural operations like spraying, pruning, etc. become difficult.

Pruning : Judicious removal of any plant part for increased productivity, facilitation of various cultural operation, regulation of crop and maintenance of vitality of vine is referred to as pruning. It is the most important and crucial operation in grape and should be done with great care keeping in view the growth pattern of the varieties under different climatic conditions. In north India, it is done during dormant season, from late-December to end- January, and in south, pruning for fruiting cycle is done during October-November and the foundation pruning for vegetative growth is done in April. After pruning, a single spray of blitox (0.2 per cent) should be done to avoid fungal attack on the cut portion of the vines. By staggered pruning, Bangalore Blue, Panch Drakshi and Anab-e-Shahi cultivars give two crops in a year.

Irrigation : In north India, the grape is irrigated at 7-10 days interval during growing season until beginning of sugar formation in berries and thereafter irrigation frequency is curtailed to allow proper ripening of grapes. Generally, 12-15 irrigations are given to grape in south India.

Manuring and fertilization

(a) Vines under the age of 3-5 years, should be given 40-50 kg well rotten FYM, and fertilizer combination of 500 g N + 300 g P_2O_5 + 700 g K_2O.

(b) Vines above 5 years of age, should be given 50-70 kg well rotten FYM and fertilizer combination of 500 g N + 700 g P_2O_5 + 1000 g K_2O per year.

The N and K fertilizers should be applied in two split doses. The first dose of 60 per cent N, full P and 50 per cent K and full FYM should be applied soon after pruning. The rest of N and K should be applied at fruit set during the first year, the fertilizers should be applied 30 cm away from the trunk in a circular ring. In the subsequent years, these should be applied in 15 cm deep furrows. The fertilizers should be mixed well in soil and the field should be irrigated immediately.

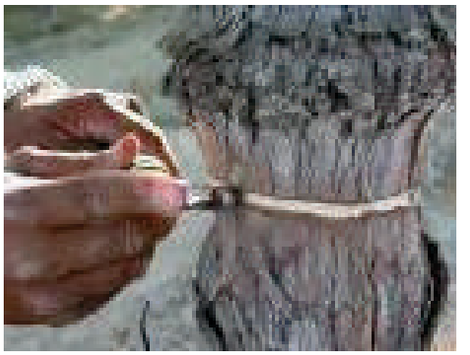
Weed control

In India, weeding in the vineyards is generally done manually. However, diuron @ 3 kg/ha and simazine @ 2 kg a.i./ha can control all weeds except *Cyprus rotundus*. Atrazine @ 2-3 kg/ha is another effective herbicide in the vineyard. Mulching also controls weed population and conserves moisture in a vineyard. Mulching with sarkanda (*Saccharum munja*) and black polyethylene has been found to be good mulch materials for vineyards.

Crop regulation and quality improvement

Some techniques can be used to regulate grape crop to obtain good yield and quality of grapes. These are described below:

(a) **Pruning and thinning:** A sizeable number of canes should be retained during pruning. In general, 60-70 clusters are considered optimum in Bower system at 3 x 3 m spacing. Similarly, 40-50 clusters in Telephone and Kniffin and 20-30 clusters on head system is optimum load. Berry thinning helps in proper development of berries, colour, ripening and quality.


Girdling in grapevine

(b) **Girdling:** It consists of removal of a complete ring (0.5 cm) of bark from the shoot, trunk or cane of a plant. The stage of girdling depends upon the cultivar and the grower's interest. For example, to improve berry set and yield, girdling is done one week before flowering, for increasing berry size, it is done at berry set or just after set and for advancing ripening, uniform colour and quality development, it is done at veraison (colour change) stage. Girdling wounds heal within a month. This technique is very effective if integrated with pruning, thinning or growth regulators sprays.

(c) **Growth regulators:** GA_3 has been found to be highly beneficial in loosening the bunches, increasing berry size and yield and in improving fruit quality in seedless varieties like Thompson Seedless, Beauty Seedless, Pusa Seedless, Perlette, Delight and Kishmish Charni. Sprays of 45 ppm GA_3 at full bloom in Pusa Seedless, 45 ppm at half bloom in Beauty Seedless, 30 ppm at half bloom in Perlette and 40 ppm in Thompson Seedless at full bloom stage have been recommended.

Plant protection

Insect-pests	Damage	Control measures
Chafer beetle (*Macrodactylus uniformis*)	It feeds on buds, young and old leaves, eating away whole lamina, leaving only the skeleton of veins.	Dust chloropyriphos on plants.
Thrips (*Phiphiphorothrips cruentalis*)	Thrips suck sap from the lower leaf surface, producing silvery blotches, affected parts turn brown, dry and brittle, which later drop off.	Spray malathion (0.5%) during March.
Nematodes *(Meloidegyne incognita* and *Rotylenchulus reniformis*)	Distortion of roots, stunted growth of plants	Aldicarb and carbofuran (6 kg a.i./ha) control the nematodes. Use nematode resistant rootstocks like Dog Ridge, Salt Creek and 1613.

Diseases	Symptoms	Control measures
Powdery mildew (*Uncinula necator*)	Virulent in south India. Powdery growth of fungus develops on the leaves and berries, which may drop. Berries do not ripen properly, become hard and crack.	Sulphur dusting or spraying wettable sulphur (0.2%) or karathane (0.1%) protect the vine from powdery mildew.
Downy mildew (*Plasmopara viticola*)	Initially, light-yellow translucent spots appear on the upper surface of leaf. Afterwards, white mould patches develop on the lower surface of the leaf. Severely affected leaves, flowers and young berries may dry and drop off.	Spraying Bordeaux mixture (1%) at a weekly interval or fytolan (0.25%) holds good for control of downy mildew.
Anthracnose (*Gloeosporium ampelophagum*)	Development of erupted brown to black spots on all green parts of the vine. The growth is completely checked, resulting in death of affected parts and splitting of bark.	Destroy affected plant parts. Spray 0.2 per cent copper oxychloride or blitox (0.3%) or fytolan (0.3%) or bavistin (0.2%) at fortnightly interval during rainy season.

Pink berry formation is a serious disorder in Thompson Seedless grapes. Its causes are unknown, yet high temperature and excessive use of ethrel enhances it.

Maturity, harvesting and yield

Grape is a non-climacteric fruit and does not ripen after harvest. Therefore, fully ripe fruits are harvested. Most commonly used maturity index is colour change, depending upon the cultivar. Harvesting of bunches is done by detaching them from the vine along with canes. Preferably, grapes should be harvested either in the morning or evening hours. The bunches after harvesting should be kept in shade. Immature, rotten, cracked, diseased or deformed berries are gently removed. Grading is done considering size, colour and variety. Packing is done in hard cardboard boxes with appropriate cushioning or packing material. Well-maintained vineyard of Perlette, Thompson Seedless may yield about 25-30 and 15-20 t/ha, respectively.

LITCHI

The litchi (*Litchi chinensis* Sonn.) is one of the most important sub-tropical evergreen fruit crops. Litchi fruit is famous for its excellent quality, pleasant flavour and attractive red colour. In India, litchi is mainly liked as a table fruit. In China, however, canned or dried litchi is preferred. Dried litchi is known as 'litchi nut'. In USA, frozen litchi is preferred. Litchi is mainly a source of sugar and acids.

Litchi is native to south China and China, Japan, Australia, South Africa, Thailand, Burma, USA, West Indies and New Zealand are major litchi producing countries. In India, it is cultivated in Muzaffarnagar, Saharanpur and Dehradun (UP), Darbhanga and Muzaffarpur (Bihar), Gurdaspur and Hoshiarpur (Punjab), Hoogly (West Bengal), Kangra valley and Sundarnagar (Himachal Pradesh), and Nilgiri hills of south India.

Litchi belongs to family Sapindaceae and genus *Litchi* with basic chromosome number, X= 7 and somatic

number, 2n= 28. Botanically, mature litchi fruit is called as 'one seeded nut' and its edible portion is 'aril'.

Soil and climatic requirements

The litchi can grow on a variety of soils but fairly deep, friable, welldrained soil with high organic matter and pH range between 5.5 and 7.5, are preferred. The water table should not be less than 1.5 to 2 m. Litchi requires mycorrhizal association for successful growth. Hence, it is suggested that new plants should be grown in soil taken from the vicinity of old trees for the introduction of mycorrhiza in the new site. The litchi is exacting in its climatic requirements. In general, litchi flourishes best in areas experiencing moist atmosphere, abundant of rainfall (125 cm or above) with freedom from frost. For proper vegetative growth, a temperature of 28-30^{0}C is best. However, for profuse flowering, a temperature below 7.2^{0}C (200 hrs) in autumn and winter is considered ideal. The dry hot winds in summer during fruit development are harmful and cause fruit cracking and subsequent damage to the fruit pulp.


A bunch of litchi fruits

Commercial cultivars

Shahi, Rose Scented, Purbi, Late Bedana, Rose Scented, Muzaffarpur, Calcuttia, Seedless Late, Dehradun, Desi, Bombai, Elaichi Late and China are popular varieties of litchi in India. Other cultivars like Early Bedana, Maclean, Longiya Kaisailiya are grown on a small scale.

Plant propagation

Litchi can be propagated by seed and several vegetative means. Propagation of litchi by seed is not common, as the plants raised through seeds take 8-10 years to come into bearing. Thus, the most common and easiest method adopted all over the world is 'air layering' or goottee. In this method, one to 1½ years old healthy and vigorous branches are selected. A ring of about 2-2½ cm wide bark is removed below the bud. This cut is covered with a mixture of mud or sphagnum moss and wrapped with polyethylene sheet. The roots start emerging from upper end of the cut within a month's time. However, the layers should be removed after two months when sufficient numbers of roots develop in them. The best time for layering in India is July-August when plants are in their active growth phase and there is high humidity in the environment. Use of IBA (2,000-5,000 ppm) to induce rooting in litchi layers has been suggested.

Agro-techniques

Planting: The pits of 1 x 1 x 1 m size, in a square or hexagonal system, at 8-10 m spacing should be dug about a month before planting time. These pits should be refilled with a mixture of farm yard manure, top soil and manures and fertilizers and then irrigated. Adding a basket of soil per pit from a litchi orchard containing mycorrhizal fungi helps in better establishment and growth of newly planted trees. The best time for litchi plantation is beginning of monsoon season. Immediately after planting, a light irrigation should be given. Litchi orchard needs to be protected from strong winds which cause complete flower or fruit drop. During summer, the hot winds ('loo') cause cracking and sunburn of fruits. Therefore, a suitable windbreak (e.g., seedling mango, *jamun*, or eucalyptus) should be raised around the orchard at a right angle to the direction of wind. A row of tall growing trees may be raised at least one year before the establishment of the orchard.

Irrigation: The critical period for irrigation is from end of January until the onset of monsoon as this is the time when vegetative growth and fruit development occur. The plants should not be irrigated during December-January as the floral initiation takes place during this time. During fruit development (March-May), irrigation is necessary at regular intervals to avoid severe fruit drop and cracking. Irrigation of young plants should be done by basin system and the fully grown plants can be irrigated by furrow or basin system, depending on the availability and source of water.

Inter-cropping: The litchi is slow growing plant and it takes about 5-6 years to come into bearing. Therefore, inter-cropping of young orchards will not only add to the income of farmer in the pre-bearing period

but will also protect the young litchi plants, enrich soil, improve physical conditions of the soil and keep the weeds under control. For intercropping, leguminous crops are usually preferred. Near big towns/cities, vegetable crops, pulses, quick growing fruits like papaya and banana can also be grown.

Weed control: Usual practice of weeding or hoeing is laborious and expensive. So, application of herbicides is recommended for controlling weeds. Diuron and atrazine both @ 2 kg/acre are quite effective for controlling weeds both in young and bearing litchi orchards. The systemic herbicides like glyphosate, is highly effective for controlling persistent weeds and paraquat for *Cyprus rotundus* and *Oxalis corniculata*. Mulching also controls weed population to a greater extent. Among various mulch materials, black polyethylene is most effective.

Manuring and fertilization

It advisable to get the nutrient status in soil and leaf tested to decide fertilizer doses. On the basis of foliar nutrient status, the following fertilizer schedule is recommended for litchi:

Fertilizer schedule for litchi based on leaf nutrient content

Age of plant (years)	Nutrients per plant per year (kg)			
	FYM	CAN	SSP	Muriate of potash
1-3	10-20	0.30-1.00	0.20-0.60	0.05-0.15
4-6	25-40	1.00-2.00	0.75-1.25	0.20-0.30
7-10	40-50	2.00-3.00	1.50-2.00	0.30-0.50
Above 10 years	60	3.50	2.25	0.60

The fertilizers should be applied in 2-3 split doses i.e. during flowering, fruit growth and vegetative flush emergence. However, the fertilizer application should be withheld during the period of vegetative dormancy i.e. during autumn to winter. The fertilizers should be applied 30 cm away from the tree trunk, as litchi is sensitive to fertilizer burn. After mixing the fertilizers with soil, light irrigation should be given.

Flowering, and pollination

In India, the floral bud differentiation in litchi starts in December and ends by January. Subsequently, the flower emergence takes place in January and continues up to the end of February and fruiting takes place in April-May. The flowering duration ranges from 20-45 days, depending upon seasonal conditions. The flowers are self-sterile and insect pollinated. The chief pollinators are syrphid flies.

Fruit cracking and its control

Fruit cracking is a serious problem in litchi. Cracked fruits fetch very poor price in the market. High temperature, low humidity and low moisture conditions during fruit development, promote this disorder. A temperature higher than 38 ^{0}C and relative humidity below 60 per cent, are responsible for fruit cracking. Due to moisture stress during early period of fruit growth, the fruit skin becomes inelastic and cracks when internal pressure is increased due to rapid aril growth following irrigation or rain. Different cultivars have different intensity of fruit cracking, In general, varieties with relatively thin skin, few tubercles/unit area and round to flat in shape are less prone to cracking. Similarly, early cultivars are more susceptible than the late cultivars. Following remedial measures are suggested for checking fruit cracking:

Severely cracked litchi fruits

(i) Grow cultivars like China, Shahi and Calcuttia, which are comparatively less affected by sun burning and cracking.

(ii) Maintain optimum moisture level in soil by frequent irrigation during the critical period of fruit growth.

Fruit cracking is a serious problem in litchi. Sometimes 30-40% of crop is cracked. Its incidence can be reduced by growing resistant varieties (China, Shahi), maintaining optimum level of moisture during summer and spraying NAA (20 ppm) or GA_3 (40 ppm or borax (0.4%).

(iii) Growth regulators spray of NAA (20 ppm), 2,4-D (10ppm), 2,4,5-T (10 ppm) and GA_3 (40 ppm) also reduce the incidence of fruit cracking to a great extent.

(iv) Application of borax (0.4%) is effective in checking fruit cracking.

(v) Spraying zinc sulphate (1.5%) at weekly intervals, starting from pea stage to harvest is useful.

Plant protection

Insect-pests	Damage	Control measures
Eriophyid mite (*Aceria litchi*)	Both nymphs and adults cause damage by sucking sap from young leaves, buds, inflorescence and developing fruits. After laceration, there is development of velvety growth, gall formation, thickening and pitting of the affected leaves.	Both nymphs and adults cause damage by sucking sap from young leaves, buds, inflorescence and developing fruits. After laceration, there is development of velvety growth, gall formation, thickening and pitting of the affected leaves.
Bark eating caterpillar (*Indarbela quadrinotata*)	Caterpillars eat the bark and make holes in the trunk or main stem, resulting in complete girdling of plant.	Plug the holes either with mud or cotton, soaked in chloroform, formalin or petrol. Spray dichlorvos (0.03%) or endosulfan (0.05%).
Disease	**Symptoms**	**Control measures**
Red rust (caused by an algal parasite, *Cephaleuros mycoides)*	Initially, small lesions of velvety white growth on the lower surface of leaves occur, which later turn into velvety growth. Leaves show velvety growth and affected plants show decline in vigour and yield.	Six spray of lime sulphur (3 in spring and 3 in autumn) control red rust satisfactorily.

Maturity, harvesting and yield

Litchi is a non-climacteric fruits. Therefore, the fruits should be harvested at correct stage of maturity when these have typical taste and flavour of the variety. The various criteria recommended for judging fruit maturity are : (i) days after fruit set, (ii) development of colour on fruit, (iii) firmness of tubercles and smoothness of epicarp, and (iv) chemical changes in fruit. However, the development of colour on fruit is more dependable maturity index, though it varies from variety-to-variety. Shape of tubercles also indicates maturity of fruits, and when tubercles become somewhat flattened, fruits are ready for harvesting. TSS, acidity and specific gravity of fruit are also taken as maturity indices for proper harvesting of fruits. Litchi fruits are harvested in bunches along with a portion of a branch and a few leaves. Harvesting should be done on a bright sunny day in the morning and evening hours.

Litchi plants start bearing after 5-6 years of age. Commercial bearing, however, starts from 15th year. Yield depends on variety, age of plant, environmental conditions and management practices. At the initial stage, 100-150 fruits/plant are obtained. On an average, a full bearing plant bears about 80-150 kg fruit.

Development of velvety growth due to mite damage

BER

Ber (*Ziziphus mauritiana* Larnk.) belongs to family Rhamnaceae and genus *Ziziphus*. *Ziziphus jujuba* Mill. (Chinese jujube) produces large fruits but is not common in India. In India, *Ziziphus mauritiana* (Indian jujube) is grown commercially. Its fruits are rich in sugars, vitamin C, A and B complex. *Ber* is also cultivated in Africa and Australia. Chinese jujube is cultivated in China, Korea, Russia and in some south European countries. In India, the major *ber* growing states are Haryana, Punjab, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu.

Soil and climatic requirements

Ber is not particular in its soil requirement and can grow on a wide variety of soils, including saline and alkali patches. Once established, *ber* can withstand even high salinity in soil. It grows in a variety of climates up to 1,000 m above mean sea level. It can withstand extremely hot conditions but young plants are susceptible to frost. The trees shed leaves and enter into dormancy during summer. Under moderate climate of south India, however, the trees continue to grow throughout the year.

Commercial cultivars

The commercially varieties of *ber* are Umran, Banarasi Kadaka, Mundia, Gola, Seb and Kaithali. Cultivars like Gola, Seb and Mundia are suitable for extremely dry areas, Banarasi Kadaka, Kaithali and Meharun for the dry regions and Sanaur 2, Meharun and Umran for comparatively humid regions. In northern India, Gola is earliest to ripen, Kaithali and Mundia are mid season and Umran and Seb are late cultivars.

Fruits of Umran ber

Plant propagation

The *ber* is usually propagated by budding. The most common methods are modified ring, patch and 'I' or 'T' (shield) budding. Rootstock seedlings are raised by sowing seed kernels extracted by breaking the stones which germinate in about one week. If the seed stones are sown as such, germination takes in nearly one month. Germination of seed stones can be improved by soaking them for 48 hours in water or by treatment with sulphuric acid. Seedlings raised by sowing seeds of *boradi* (*Z. mauritiana* var. *rotundifolia*) or Z. *nummularia* are good rootstocks for *ber*. The best time for budding is June-July.

Planting

Transplanting of budlings or rootstock seedlings is best done with the onset of monsoon. For this, pits of 60 x 60 x 60 cm are dug during summer at a spacing of 6 x 6 m in low rainfall areas and at 8 x 8 m in irrigated and higher rainfall regions. While filling the pits in sandy areas, a layer of bentonite clay can be placed at the bottom and sides of the pit to reduce moisture losses by infiltration. Each pit is refilled with top soil, mixed with 15-20 kg FYM along with 50 g of chloropyrophos dust to protect damage by termite. In rainfed areas, the inter-spaces between the tree rows can be shaped to provide 5 per cent slope towards the plant. This would help to accumulate runoff water during monsoon near the tree roots thereby resulting in higher establishment success. In irrigated areas, *ber* plants can be transplanted during January-March also.

Training and pruning

During the first 2-3 years after planting, *ber* trees are trained to develop a strong frame. After planting during July, the main shoot is headed back during March keeping 1-2 nodes above the bud union to induce vigorous new growth from which one upright vigorous shoot is retained to develop into the main trunk. This is kept clean of side shoots up to 30 cm height from ground level and thereafter 3-4 well spaced shoots are allowed to grow. The main trunk is then headed back. During the second year, the side shoots are cut back retaining the basal 1-2 nodes from which vigorous new shoots emerge and form the main branches. On these main branches also, 3-4 upward growing well spaced shoots are allowed to grow.

Fruit bearing in *ber* takes place on current season's growth and the fruit quality depends on the vigour of shoots. Therefore, annual pruning is done to induce maximum number of healthy new shoots. It is also essential to remove the undesirable, weak, intercrossing, diseased and broken branches. The best time for pruning is during the hot and dry season when the tree sheds leaves and enters into dormancy. The time of pruning differs in different parts of the country. In Tamil Nadu, pruning is done during January to April, in Maharashtra by the end of April and in north India, it is done during the last week of May. In general, light pruning, i.e. pruning of the past season's main shoot at 25 buds has been found to be the best.

Nutrient management

250 g N and 250 g P_2O_5 increased fruit yield besides, an yearly dose of 40-50 kg well rotten FYM per tree is also applied. Total quantity of FYM and phosphatic fertilizer and half the dose of nitrogen are applied immediately after pruning and the remaining dose of nitrogen is applied during October when fruit development is in progress. In sodic soils, gypsum and pond soil should be added.

Water management

For establishment of young plants, 10 irrigations are considered essential during the first year. Irrigations during the period from November to February at 3-4 weeks interval should be given to get higher fruit production from *ber* orchards. Irrigation during October has been found to induce flower shedding and that during March-April, to cause fruit spoilage and delay in the ripening process in Punjab.

Plant protection

Insect-pests	Damage	Control measures
Fruitfly (*Carpomyia vesuviana*)	Maggots bore into fruits and feed on internal contents.	Collect and destroy the fallen fruits. Dig the soil under the tree and destroy the pupae. Schedule consisting of first spray at pea stage with 0.03 per cent monocrotophos, followed by second and third sprays with 0.05 per cent fenthion and third with 0.1 per cent carbaryl at 15 days interval should be followed.
Chafer beetle *(Adoretus* sp.),	Cause extensive damage to leaves by eating and biting holes.	Spray 0.02 per cent carbaryl 50 WP and 0.05 per cent monocrotophos.

Diseases	Symptoms	Control measures
Powdery mildew (*Oidium erysiphoides*)	White powdery mass appears on the leaves, tender branches and young fruits causing fruit drop. The fruits become unattractive in appearance and size.	The disease can be controlled by application of 2-4 foliar sprays of dinocap (0.1%), carbendazim (0.1%) and sulphur dust (250 g/tree) at 15-20 days interval after the initiation of the disease symptoms. One prophylactic spray of karathana (0.02%) must be done when new growth emerges after annual pruning.
Black leaf spot (*Isariopsis indica*)	Development of black spots on the lower surface of leaves causing leaf fall.	2-3 sprays of captafol (0.2%), carbendazim (0.1%), mancozeb (0.2%) and copper oxychloride (0.2%) at 15 days interval starting from the initiation of the disease symptoms.

Maturity, harvesting and yield

In north India, flowering in *ber* takes place during August-September. Fruits take 150-175 days to mature after fruit set. *Ber* is a non-climacteric fruit and all the fruits on the tree do not ripen at one time. Therefore, these have to be individually picked by hand or by mild shaking of branches several times during the ripening season. Fruits do not ripen after picking and over-ripe fruits lose their eating quality and storage life. Therefore, fruits which are just mature (having the desired sugar/acid ratio and ascorbic acid content) and have shining yellow colour should be harvested. Picking should be done in the forenoon. Pre-harvest spray of 750 ppm 2-chloroethyl phosphonic acid (ethephon) at colour turning stage induces early and uniform ripening and reduces number of pickings. Time of harvesting depends on cultivar and agro-climatic conditions. In south India, the fruits are harvested during October-November, in Gujarat during December-March, in Rajasthan during January-March and in Haryana, Punjab and Uttar Pradesh during February-April. Early maturing cultivars ripen during middle of February, mid-season cultivars during March and the late cultivars ripen by the end of March to mid of April. The average yield in different varieties during the prime bearing period (10-20 years) ranges between 80-200 kg per tree. Under rainfed conditions, 50-80 kg fruit per tree can be obtained.

Ber leaf damaged by chafer beetle

Powdery mildew affected ber twigr

POMEGRANATE

Pomegranate (*Punica granatum* L.) belongs to the family *Punicaceae* and genus *Punica* with basic chromosome number, x = 12. Pomegranate is a juicy fruit which can be processed into different beverages with the addition of sugar and preservatives. Sundried grains from cultivars having high acidity, known as *'anardana'* are used for garnishing curries and for culinary purpose. It is a delicious table fruit, rich in B complex vitamins and minerals like calcium, phosphorus and iron. Botanically, pomegranate is a '*Blausta*' in which arils around the seeds (grains) constitute edible portion.

Pomegranate is a native to Mediteranean region. It is commercially cultivated in Iran, Afghanistan, Russia,

Israel, North and Latin American countries, Africa and India. In India, it is cultivated in Maharashtra, Karnataka, Gujarat, Rajasthan, Andhra Pradesh and Himachal Pradesh.


Mridula pomegrante

Soil and climatic requirements

Although, pomegranate is not specific to soil requirement but it is sensitive to fluctuations in soil moisture particularly during the fruit bearing stage. Loam soils with medium texture having good moisture holding capacity is preferred. It thrives well in semi-arid and arid regions having marginal agro-climate. Warm and cool nights help in the development of good colour and sweetness in the aril. High humidity coupled with high temperature makes it susceptible to diseases. Fluctuations in atmospheric humidity cause fruit cracking.

Commercial cultivars

The popular cultivars of pomegranate are Ganesh and Muskat in Maharashtra, Bassein Seedless in Karnataka, Dholka in Gujarat, Kabul Red and Vellodu in Tamil Nadu and Kandhari, Jalore Seedless and Jodhpur Red in Rajasthan. Some promising clonal selections like Arkata, Bhagwa, Sindhuri, or hybrids like Mridula, and Ruby are also becoming popular. For *anardana*, seedling selections having high acidity have been made.

Plant propagation

Pomegranate is commercially propagated through semi-hard and hardwood cuttings treated with 1,000 ppm IBA as basal dip. The cuttings are planted in polythene tubes filled with a mixture of soil, FYM and sand in equal proportion. Cuttings taken from the mature, 6-12 mm thick branches emerging from the base of main stem, give better rooting. February-March is the most suitable season for planting of cuttings in nursery. However, planting can also be done during rainy season.

Planting

Pomegranate is planted at 5 x 5 m spacing. Pits of 60 x 60 x 60 cm size are dug about one month before planting and filled with top soil, pond silt and FYM mixture in 1:1:1 proportion adding 50 g methyl parathion to protect them from termite. Rainy season is the best time of planting. In north India, planting can also be done towards the end of winter when the plants are in dormant condition. In south India, where plants remain evergreen, onset of monsoon is the best time for planting. Under arid and semi-arid regions of Rajasthan, planting is done during rainy season.

Water management

Although pomegranate is a drought hardy fruit plant but to obtain good yield and fruit quality, assured irrigation is essential. To achieve better survival of plants, light irrigation is necessary just after planting of new orchard. Water requirement of pomegranate largely depends upon the desired *bahar*. For *ambe bahar*, 13 irrigations are considered enough for good growth and yield. For *mrig bahar*, 9 irrigations are found to be sufficient. In *ambe bahar* crop of Ganesh, regular irrigations from March to July at 7-10 days interval increased the fruit yield. In arid region, due to scarce irrigation resources, *mrig bahar* crop is preferred to take advantage of the moisture available during monsoon. If long dry spell occurs, irrigations may be required even for *mrig bahar* crop.

Nutrient management

Doses of manures and fertilizers for application in pomegranate orchard depend on the fertility status of soil. In normal soils, yearly dose of 10 kg FYM alongwith 125 g nitrogen, 50 g phosphorus and 50 g potash should be applied per plant up to five years of age. In sandy loam soils of Maharashtra, yearly dose of 625 g nitrogen, 250 g phosphorus and 250 g potash should be applied to a 5-6 years old pomegranate plant besides the basal dose of 40-50 kg FYM. Upto non-bearing stage, fertilizers are applied in three split doses during January, June and September. After fruit bearing starts, time of fertilizer application should suit the *bahar* to be taken. Generally, nitrogenous fertilizers are applied in two split doses, one at the time of first irrigation after *bahar* treatment and

the second after three weeks of the first application. Full doses of phosphorus, potassic fertilizers and FYM are applied at one time after *bahar* treatment.

Training and pruning

Pomegranate is bushy in growth habit and thus produces considerable number of shoots from the base. Retaining all these would create crowding leading to infestation by shoot borers. Since single stem training of trees takes the fruiting area too high, of 3 to 4 well spaced stems are kept at the ground level. Pomegranate bears fruits on terminal and maxillary short spurs arising from the mature shoots and thus does not require regular annual pruning. However, water sprouts, diseased and pest affected or dried branches should be removed.

Crop regulation

Pomegranate has three main flowering and fruiting seasons or *bahars* such as *ambe bahar* (spring season flowering), *mrig bahar* (June-July flowering) and *hasth bahar* (September-October flowering). For commercial production, only one crop in a year is desirable. Therefore, by crop regulation, the tree is forced to rest by different ways and then it produces profuse blossoms and fruits during the required *bahar*. Selection of the *bahar* depends mainly on the availability of irrigation water, risk of damage by diseases and pests and market factors. In dry areas of north-western India, with limited irrigation resources, *mrig bahar* is preferred to utilize the water available during the monsoon period. In irrigated parts of Maharashtra and Gujarat, respectively *ambe bahar* and *hasth bahar* are preferred since the fruit yield, quality and profitability from other *bahars* are impaired by the incidence of insect -pests and diseases and market factors. The operation, thus, maximizes production from the available inputs and also avoids fruiting during the period when insect-pests and disease infestation are common. For this, operations like withholding irrigations, root exposure, root pruning and spray of chemicals (thiourea, NAA or potassium iodide) are practiced to induce leaf drop and cessation of growth during the period of the unwanted *bahar*. This is followed by application of normal irrigation, fertilizer and tillage operations one month prior to the desired *bahar* to induce new growth, flowering and fruiting. In order to increase proportion of good size grade fruits, number of fruits on a tree is regulated to retain 50-60 fruits on one bush by hand removal or by chemical floral thinning by spray of 2,000 ppm ethephon or 500-3000 ppm Alar.

In India, pomegranate flowers thrice a year in certain localities, called *bahars*. Fruits of all the bahars may not be commercially desirable. Hence, regulation of flowering is desirable to produce fruits in desirable bahar. It can be done by forcing the plants to rest by different ways in unwanted bahar. After rest, plants produce profuse flowers during the required bahar.

Plant protection

Insect-pests	Damage	Control measures
Pomegranate butterfly (*Virachola isocrates*.)	Caterpillars enter the developing fruits during July and feed on the seeds resulting in rotting and premature drop of fruits. The holes made by caterpillars can be seen on the fruit.	Bagging of fruits with butter paper. Two sprays, one each with 0.002% deltamethrin and 0.2% carbaryl at 21 days interval in rotation after fruit set.
Bark eating caterpillar	Eats bark and enters the stem by making holes.	Training of bushes and keep only 3 to 4 stems. Spray dichlorvos (0.08%), or fenvalerate (0.04%), or carbaryl (1 %) or quinalphos (0.08%).

Diseases	Symptoms	Control measures
Fungal leaf and fruit spot	Development of brown spots on leaves, which not only affects leaf vitality and number but also affects fruit growth and spoils their appearance and market value.	Four sprays of copper oxichloride (0.4%) or thiophenate methyl (0.1%) or mancozeb (0.2%) or zineb (0.2%) at an interval of 15-20 days starting from the initiation of disease have been highly effective.
Bacterial leaf and fruit spot *(Xanthomonas compestris* var. *punicae)*	Occurs in more humid areas. Affected fruits become unmarketable.	Three sprays with 500 ppm pausamycin + 0.2% copper oxychloride at 15 days interval starting from the initiation of the disease significantly reduce the incidence.

Fruit cracking and its control: Fruit cracking is a major problem in pomegranate, which can be reduced to some extent by maintaining optimum moisture level in soil by frequent irrigation, spraying PGRs like NAA (20 ppm), or 2,4-D (10 ppm) or GA_3 (40 ppm) or by the application of borax (0.4%).

Cracked pomegranates

Maturity, harvesting and yield

Pomegranate bears male, female and hermaphrodite flowers on spurs and intermediate shoots. Only the bisexual flowers produce fruit. Fruits generally ripen 6-8 months after fruit set. Being non-climacteric, tree ripen fruits are harvested. Change in rind colour from light-green to yellowish-pink or red with waxy shining surface and a cracking sound of grains on pressing the fruit indicate fruit maturity. Ripe fruits are individually picked. A full grown pomegranate bush normally produces 40-50 fruits. However, as high as 100 fruits per bush can be obtained under good management.

AONLA

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn.) is an ancient, indigenous fruit of India. It belongs to the family *Euphorbiaceae*. All parts of the plant including the fruits of *aonla* are medicinally rich and are used in the preparation of various *Ayurvedic* medicines. Fruits are commercially used for preparation of *chayanprash and triphala*. Being a rich source of vitamin C, *aonla* is helpful in curing scurvy, problems of teeth, gums, eye and stomach. Fresh fruits are also used for the preparation of products such as preserve (*murabba*), pickle, *chutney*, shreds, etc. *Aonla* is cultivated in arid and semi-arid parts of India in the States of Rajasthan, UP, Haryana, Maharashtra, Gujarat and Tamil Nadu.

Aonla fruits

Soil and climatic requirements

Aonla can be grown on a wide range of soils but well-drained deep sandy loam soil having good water holding capacity is considered the best. In sandy soils, *aonla* plants can be successfully grown if irrigation facility is available. Calcareous soils are usually not suitable for its growth. However, if some amendments are used, *aonla* plantation can be raised on saline and sodic wastelands.

It can be successfully grown in hot arid climate. The trees shed their leaves and become dormant during winters. In young plantations, frost causes severe damage. The plants have to be protected by thatching and light irrigations in frost susceptible areas.

Commercial cultivars

Cultivars like Chakaiya, Banarasi and Francis have been grown in India. Shy bearing in Banarasi and predominance of internal necrosis in Francis are, however, serious demerits of these two cultivars. However, several other varieties have been developed. These are Krishna, Kanchan, NA-6, NA-7, Balwant, and Laxmi-52.

Fruits of Krishna variety

Plant propagation

Patch and modified ring budding on rootstocks of pencil thickness are the most successful methods for *aonla* propagation. July-August is the best time for budding in *aonla*. Budding period can be extended up to September-October in north India but in that case, bud union occurs but sprouting commences during February-March. *In situ* budding can also be done on the rootstocks raised in the field. Plants can also be propagated by softwood grafting and inarching. Old seedling trees can also be converted into improved cultivars by top-working.

Planting

Aonla is planted at 8 x 8 m spacing. Pits of 1 x 1 x 1 m size are dug during May-June and are filled after 15 days with FYM and top soil mixture in 1:1 ratio. To protect the plants from termites, 50 g methyl parathion dust (5%) is mixed in each pit. Plantation of *aonla* saplings is done during July-August. If assured irrigation and protection facilities are available, planting can be done during February and October. Since *aonla* has self-incompatibility, ten per cent population (15 plants/ha) should consist of pollinizer trees to ensure good fruiting. NA-7 is a good pollinizer for NA-6. In any case, planting of more than two cultivars in a block would take care of the pollinizer requirement. Plantation of seedling trees on the borders to serve as windbreak also provides seeds for raising rootstock plants.

Water management

Frequent irrigations at short intervals of 3-4 days are done for about one month after planting to ensure essential establishment of *aonla* plants in light soils of arid region. Afterwards, irrigation interval can be increased to 25-30 days. Flowering, fertilization and development of embryo in *aonla* takes place during the spring (March-April) and, therefore, light irrigations during March-July at 10-15 days interval are most beneficial. Drip irrigation on 20 per cent wetted area basis on alternate days has been found to improve growth and yield of *aonla*. In a normal monsoon year, irrigation during rainy season may not be required but in late maturing cultivars, irrigation is essential during September-October to avoid moisture stress. During winter, light irrigations are done particularly before the suspected time of frost occurrence to save the young plants from damage.

Nutrient management

Application of 10 kg FYM, 100 g N, 50 g P_2O_5 and 50 g K_2O per plant per year has been considered sufficient in arid region soils. The doses should be increased every year by the same quantity up to 10 years and then stabilized. The best time for manure and fertilizer application is January-February and June-July when the plants are in floriferous and fruit development stages, respectively. Full dose of FYM and phosphorus and half dose of nitrogen and potash are applied during spring season and the remaining half dose is applied during the rainy season. Deficiencies of micronutrients cause poor growth in *aonla*. Application of 250-500 g zinc sulphate/plant is found to be beneficial in sandy soils of arid region. Three foliar sprays with 0.06 per cent borax at 10-15 days interval have been found to reduce the malady of necrosis.

Plant protection

Insect-pests	Damage	Control measures
Bark eating caterpillar	Feeds on the stem and branches and makes holes in them causing girdling.	For its control, holes are cleaned, cotton swab soaked in kerosene / petrol / endosulphan (0.4%) is inserted and then these are plugged with moist clay.
Shoot capsule borer	Caterpillars make capsules on growing tips, which check growth of the shoots.	Removal and destruction of the affected portions followed by 2-3 sprays of 0.01% monocrotophos at 15 days interval provide effective control.
Disease	**Symptoms**	**Control measures**
Rust	Development of brown pustules on fruits	3-4 sprays of 0.2% chlorothalonil or blitox-50 or diathane M-45 at 15 days interval provide effective control.

Maturity, harvesting and yield

Vegetatively propagated trees start bearing 3-4 years after planting while the seedling trees take more than 8 years to start flowering and fruiting. In vegetatively propagated trees, commercial yield of 150-200 kg starts after 8-10 years. The fruits mature by November-December in different cultivars. In south India, however, flowering takes place during June-July. Maturity of fruit is indicated by the presence of shining green colour and reduction in acridity and increase in vitamin C content. Fruits are harvested by manual picking or by beating the branches with bamboo sticks. The fruits are collected and packed in gunny bags.

ACTIVITIES/EXERCISES

- Visit some *ber* orchard during summer, and observe how pruning is done in the orchard.
- Collect samples of insect damaged fruits from orchards of different fruits. Indentify the pest after looking its damage pattern and suggest measures for the control.

CHECK YOUR PROGRESS

1) Suggest measures to control fruit cracking in litchi
2) How can you regulate flowering in pomegranate?.
3) Enlist major production problems in litchi, *ber*, pomegranate, and *aonla*.
4) Enlist major varieties of sweet oranges and mandarins grown in India.
5) Enlist major insect-pests of citrus, which are found in India and suggest their control measures.
6) Enlist commercial seedless cultivars of grapes.
7) Enlist training systems of grape followed in India. Which systems gives best benefit cost ratio?

8) Describe briefly about citrus decline and granulation. Suggest measures to control these problems.

9) Describe one major disease of citrus, pomegranate, litchi, and *ber*. Write briefly about their management.

10) Describe briefly the damage caused by *anar* butter fly, fruit sucking moth, fruitfly and eriophite mite and write their management measures.

FILL IN THE BLANKS

1. Greening is a serious disease of ……
2. Leaf miner causes heavy losses to the nursery plants of …….
3. Red rust is a serious disease of ……..
4. Ber is commercially propagated by…….
5. Lemon plants can be commercially propagated by ……..
6. Fruit sucking moth causes damage to…… during night.
7. Krishna and Kanchan are varieties of …….
8. Kinnow is a ……. (mandarin, sweet orange)
9. Head system of training is commonly used in …….
10. The length of grape hardwood cutting should be …….
11. Best time for planting citrus plants is ……
12. Ber plants are pruned during…….
13. Budding in ber should be done during ……
14. ……..is used to control red rust of litchi.
15. Nagpuri is a variety of …….

SUGGESTED FURTHER READINGS

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