



ADB

ASIAN DEVELOPMENT BANK

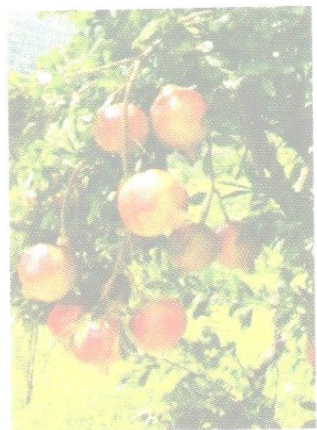


PACKAGE OF PRACTICES FOR SUBTROPICAL FRUIT CROPS OF HIMACHAL PRADESH

Developed by

**Dr. YSP University of Horticulture & Forestry
COHF- Neri, Hamirpur
(Under CS-04 Package of HPSHIVA PRF)**

**For ADB Funded
HPSHIVA Project
Department of Horticulture
Himachal Pradesh**





PACKAGE OF PRACTICES FOR SUBTROPICAL FRUIT CROPS OF HIMACHAL PRADESH

**Developed by
Dr. YSP University of Horticulture & Forestry
COHF- Neri, Hamirpur
(Under CS-04 Package of HPSHIVA PRF)**

**For ADB Funded
HPSHIVA Project
Department of Horticulture
Himachal Pradesh**

Expert Team of Package of Practices of Subtropical Fruit Crops of Himachal Pradesh CS04 under HPSHIVA

Prof. Som Dev Sharma	Team Leader	Head, Department of Fruit Science, COHF Neri- Hamirpur, H.P., Mob.: 94183-23345
Prof. Virender Rana	National Expert-Entomology	Head, Department of Entomology, COHF Neri- Hamirpur H.P., Mob.: 94186-02633
Dr. Rakesh K. Sharma	National Expert-Soil & Irrigation	Head, Department of Soil Science & Water Management, COHF Neri- Hamirpur H.P., Mob.: 94184-56352
Dr. Vikas K. Sharma	National Expert-Guava & Plum	Senior Scientist, Department of Fruit Science, COHF Neri- Hamirpur H.P., Mob.: 70186-01976
Dr. Sanjeev K. Banyal	National Expert-Litchi & Kiwifruit	Senior Scientist, Department of Fruit Science, COHF Neri- Hamirpur H.P., Mob.: 94180-59914
Dr. Ajay K. Banyal	National Expert-Pomegranate & Persimmon	Senior Scientist, Department of Fruit Science, COHF Neri- Hamirpur H.P., Mob.: 94180-01699
Dr. Kumud Jarial	National Expert-Plant Diseases	Head, Department of Plant Pathology, COHF Neri- Hamirpur H.P., Mob.: 94184-34769

Implementing Agency of HPSHIVA

Name and Designation	e-mail ID	Contact Number
Project Director	devinderthakur155@gmail.com	+917018615569
Deputy Project Director (DPD) Horticulture		
Deputy Project Director (DPD) JSV		
Procurement Manager		
Project Coordinator (F & A)		
Nodal Officer	nodalofficerhps viva@gmail.com	+917018134993
Finance Officer		
Assistant Procurement Manager	manojsharma3006@gmail.com	+9185809 58221
HDO's	sonalihorticulture17@gmail.com	+9197364 38376

Important Notice

The information on performance of recommendations given in this book holds good only when used under optimum conditions. Their performance may either change in due course of time due to several factors or can vary under different systems of management. Mishandling/negligence of the user can also result in damage/loss/non-reproducibility of results. In this regard, HP SHIVA team accepts no legal responsibilities.

PREFACE

Himachal Pradesh is a small state with more than 50% of its area in mountains and less than 10% in cultivation. The state's economic growth in the 1990s was driven by agriculture and its allied activities, but has gradually shifted to the industrial/manufacturing and services sectors. Himachal Pradesh is the only state in India where 90% of the state's population still lives in rural areas and nearly 62% of the state population relies on agriculture and its allied sectors for livelihood. Fruit growing is one of the important and age old practices, in India since ancient times. Cultivation of fruit crops plays an important role in nutritional and socio-economic upliftment of the nation and the mankind. Fruit growing offers a wide range of choices to the farmers for crop diversification and provide ample scope for sustaining various allied industries and generate employment opportunities. The hardworking farmers of horticultural based farming in temperate region are earning more than Rs. 1.07 lac/month per capita income contrary to the farmers of subtropics with an average earning of Rs. 8000 per month. As a consequence, farmers get discouraged to pursue farming/agriculture as a profession. The tales of youth suffering/being exploited in search of job are not unheard of. This is in stark contrast with farmers of temperate region, most of whom have managed to make effective use of each piece of land under horticulture-based farming by exemplary profitability in this very field. This has been achieved by the horticultural entrepreneurship coupled with use of latest production technologies. The state of Himachal, as a whole, has largely untapped potential to progressively move in this direction with high density planting of selected cultivars of chosen crops along with precise technologies under cluster farming and co-operative marketing to end user.

Himachal Pradesh is known as the horticulture state in the country, having diversified agro-climatic situation ranging from subtropical, warm temperate to wet and dry temperate climate. The major focus of research and institutional support in Himachal Pradesh has been on temperate fruits till date whereas, the subtropical region has remained largely unexplored. The subtropical fruit crops have huge potential for commercialization in Zone-I (low hill subtropical zone) of the state as the agro climatic situations in these areas differ from high and mid hill of Himachal Pradesh and from subtropical/tropical plains of India as well. The altitudinal variation within the subtropics of the state ranges from 390 to 1000 m above mean sea level and the region comprises about 60% area of this hilly state. The ensuing project, HPSHIVA aims to increase livelihood opportunities of rural households in Himachal Pradesh. Due to rise in temperature, as a result of global warming, there is extension in the subtropical area of the state which has moved upwards. This has, in turn, created an opportunity for

introduction and cultivation of a wide variety of subtropical fruit crops possessing seasonal advantage of produce which comes a little later in market than the plains.

The subtropical horticultural crop production has not gained sufficient momentum in the state due to various factors, which include small and marginal land holdings comprising about 80% of the total holdings, besides the adherence of the farmers to traditional maize-wheat and rice cropping pattern despite being uneconomic. This situation is further aggravated by lack of irrigation facilities, marketing opportunities and low level of awareness among farmers for horticultural entrepreneurship. In the last two decades, a large number of farmers have abandoned their farmland due to various problems including monkey and wild animals menace and migration of youth to big cities for better job prospects.

Readily available scientific information to the various stakeholders involved in production of fruit crops is an important pre-requisite for such a progression. New technologies in production of fruit crops are forthcoming gradually from the different research organizations that are required to be experienced, fine-tuned and adopted by the fruit growers. However, due to continuous demand for the information with updated research findings in the production technology of major fruit crops, an initiative was undertaken to revise the available information and bring out the compilation of the updated scientific knowledge of modern fruit production of mandated fruit crops of HPSHIVA project.

The 'Package of Practices' prepared as part of CS04 package contains the latest literature, consultation-experience based recommendations and readily-usable information available on high density plantation of mandated crops fruit of HPSHIVA project collated and compiled by the team of experts from national and international domains through the coordination of the Team Leader of HPSHIVA. It is purposely written in a simple and easy-to-understand language because these recommendations are intended for the use of field level extension workers and the fruit growers of sub-tropical region of Himachal Pradesh.



(Som Dev Sharma)

Team Leader

HPSHIVA CS04 Package

COHF (YSPUHF) Neri, Hamirpur

CONTENT

Sr. No.	Crop	Page No.
1.	Introduction	7-11
2.	Mango	12-39
3.	Citrus	40-61
4.	Litchi	62-76
5.	Guava	77-90
6.	Pomegranate	91-105
7.	Plum	106-116
8.	Kiwifruit	117-128
9.	Persimmon	129-139
10.	Pecan nut	140-144
11.	Nutrient and water management in nursery	145
12.	Literature Consulted	146-147

INTRODUCTION

Himachal Pradesh is agrarian mountainous state of India with more than 90 per cent of population living in rural areas. The economy of this hill state is, therefore, primarily dependent on agriculture and its allied activities. Increasing farm incomes for sustainable growth of the economy of the state is of prime importance. The cultivated area of the state is around 10 per cent of the total geographical area and distributed in the mountainous and hilly terrains. The average farm holding is less than 2 ha and accounts for about 80 per cent of land holdings in the state. The hill and mountain areas differ from the plains in topography, elevation, physiographic features, diversity of flora and fauna, ethnic diversity, land use pattern and socio-economic conditions. The sloppy terrains and mountains and its geographical location can be utilized as an advantage.

Himachal Pradesh has witnessed a phenomenal increase in area under horticultural crops specifically in fruit, vegetables and flower crops during the past 50-60 years. The state has become a model hill state largely due to development of temperate fruit industry thus known as apple state of India. The state is heading towards becoming horticultural state of India as farmers have started growing other fruits, vegetables and flower crops. To come forward as horticultural state of India, more emphasis has to be given on production of other nutritionally and commercially important horticultural crops in accordance to existing micro climatic situations throughout the state .

The agro-climatic conditions of the state are suitable for growing a variety of fruit, vegetable and flower crops ranging from temperate to sub-tropical. The sub-tropical area of state though accounts for 16.40 per cent of total geographical area of the state but, it is inhabited by more than 40 per cent of the population and accounts for about 52 per cent of the total cultivated area. Presently, the farmers of the area depend on rainfall and grow only cereals, pulses and occasionally fruits on marginal land. Because of rainfed farming, the productivity of cereals is 1.5 tonnes per ha which is quite low as compared to national and international level. Thus, farmers of the region are performing only sustenance farming. Therefore, in order to enhance the farm income as well as to improve the living conditions in the rural stakeholders, it is highly essential to increase the productivity of cultivated areas, by shifting from self-subsistence farming to low volume-high value crops i.e. horticulture based diversified agriculture. At present, about 40 fruit species are being cultivated in Himachal Pradesh. The area under subtropical fruit crops in 1960-61 was only 1848 ha which has progressed to 80,000 ha in 2019-20. The shift in land use pattern towards horticulture avocation has occurred fast despite of low productivity in Himachal as compared to adjoining areas of adjoining states like Uttarakhand and Punjab having similar climatic conditions. This situation has been primarily due to fruit growing on marginal wastelands, selection of inferior/and unsuitable cultivars, unavailability of elite planting material, scattered unsystematic and conventional planting, adherence to unscientific methods and scanty technological support in production under rainfed farming.

Agro-climatic Situation

The state is known as the horticulture state in the country having diversified agro-climatic situations ranging from subtropical, warm temperate to wet and dry temperate climate. The major focus has been on temperate fruits till date although other fruit crops also have huge potential. The agro-climatic situations in these areas differ from high and mid hills of the state as well as subtropical/tropical plains of India. The enthusiasm of the farmers of the area for shifting from the traditional agriculture to fruit cultivation is very high. In last three decades the plantations of sub-tropical fruits in low lying areas (300 to 1100 m amsl) referred as Zone-I (comprises about 60% area of this hilly state) accounted for 6 per cent growth rate as compared to 2.5 percent in the rest of the state. The climate of the region is of subtropical type with average annual rainfall of 1200 mm and there is a huge scope for water harvesting and its managements by using water use efficient technologies. The mean annual

temperature of the zone is 24°C with summer and winter temperature average of 32°C and 14°C, respectively. Further, cultivated land in this zone is not more than 33 per cent and as high as 90 percent of area is rainfed. The status of food-grain crops is thus that of only subsistence in nature thus farm economy needs right reinforcement. In the light of all the above facts, horticulture has an eminent place in terms of land use efficiency with better opportunities for higher returns, tech-friendly environment and employment generation in the state.

The cultivation of subtropical fruits have expanded from merely 3 districts in the 70's to 10 districts at present (up to the elevation of 900 m to 1100 m above sea level) due to changing climatic conditions. The major sub-tropical fruit producing districts are Bilaspur, Kangra, Una, Hamirpur and parts of Mandi, Chamba, Solan, Sirmaur and Shimla districts. Around 80,000 hectare area under subtropical fruit crops accounts for 36% of the total area under fruits whereas, total annual production of subtropical fruits is only 70,000MT.

This part of state lying in the foot hills of Shivalik ranges differs from the plains of India in topography, elevation, physiographic features, diversity of flora and fauna, ethnic diversity, land use pattern and socio-economic conditions which can be taken as an advantage. The micro agro-climatic situation varying after every 10-15 km and even from one hill slope to another, further provide varied micro-climatic situation suitable to particular crop/variety. So the selection of fruit crop/varieties should be done carefully keeping in consideration the market potential and qualitative attributes. Large area of the region is prone to frost during winters, hence frost resistant/tolerant varieties/crops as well as technologies for subtropical fruit crops need to be utilized. Further severity of frost is a deciding factor for selection of crop. Moreover, the micro level planning is also needed to utilize full potential of the niche areas and disseminating the developed technologies to the stakeholders. There is a tremendous scope for diversification in horticultural crops due to varying extent of agro climatic conditions. Diversification at crop and variety level will not only increase productivity but would be helpful in providing resilience to climate change in the region.

Diversification

Diversification has become a major component for stepping up growth in subtropics of the state. The picture of the last few decades points that the gain from diversification is contingent upon the technology development of high value crops. Diversification of agriculture towards selective horticultural crops is compatible with the comparative advantage of the region. Available evidence shows that the net returns from production of different fruits are about 8 to 10 times higher under conventional horticultural growing than returns from other cereal crops produced in the state. Cultivation of fruits can also generate employment to the tune of 860 men days per ha/year under conventional planting system against those of 150 mandays by cereals crops. This may further generate more than 2000 mandays under high density plantings. In addition, the state has seasonal employment of in harvest maturity, quality and cost of producing a variety of fruits. The adoption of horticulture crops is advantageous to Himachal Pradesh economy in several ways. First, it promotes the productive use of abundant marginal lands available in the region. Second, these crops help in maintaining and improving the ecology and environment by promoting soil conservation and improving soil fertility and in turn, the carbon sequestration. In economic terms, it can lead to significant improvement in the income, employment and quality of life of the people.

In order to improve the productivity and quality of fruits, there is an urgent need to transform wheat-maize/rice based cropping pattern and conventional fruit growing towards hi-tech farming. In the region, lot of scope is available for horizontal expansion through encouraging shift from cereal crops to highly remunerative horticulture. Some progressive farmers of the region have set glaring examples of high returns by performing hi-tech horticulture, however, they need to be provided with strong scientific back up to make hi-tech horticulture a profitable and lucrative venture on sustainable basis.

Critical Gaps Identified:

The subtropical horticultural crop production has not gained sufficient momentum in the state due to various factors which include small and marginal land holdings, comprising about 80% of holdings as such this cannot support conventional fruit based farming under normal spacing; Besides this, adherence of the farmers to traditional uneconomic maize-wheat-rice cropping pattern which further aggravates due to lack of irrigation facilities, lack of marketing opportunities for small scale production and low level of awareness among farmers for horticultural entrepreneurship.

Furthermore, large number of farmers have abandoned their valuable farmland due to various problems including stray animal, monkey and wild animal menace, which resulted in poor farmers income in this subtropical zone of state. This forced the farmers/youth to migrate to cities/industrial area for the want of job to earn their bread and butter. Consequently, such fertile land has become marginal and turned into wasteland covered with Lantana, Parthenium, Ageratum, weeds and uneconomic bushes which provide shelter for wild animals adjoining to other farmer fields.

Therefore, the ecological settings of the area becomes fragile and are harnessed by the local inhabitants, through their generational experimentation with natural endowments and underlying socio-economic conditions. However, due to changing resource pressure and increased demand for cash flow vis-a-vis climate change, There is huge gap for developing location specific technological interventions in the form of cash generating farm activities for which fruits, hold good promise.

Opportunity of Sub-tropical Horticulture:

A wide variety of horticultural crops can be grown in different agro ecological situations of the zone. The farmers of the area are innovative and hard working. There are areas where productivity and profitability have increased and farmers feel proud to be attached with their fields and specific farming system. There are huge potentials of promotion of fruit crops in subtropical areas of Himachal Pradesh viz. i. Climatic advantage and favorable agro-climatic conditions prevailing in the state for producing little bit late/off-season horticultural crops. ii. Receptivity and high interest of farmers toward high value-low volume horticulture crops and adoption of new technologies. iii. Under changing climatic scenario, the snowline has gradually receded towards higher altitudes upto 250 m from its original position, which further resulted to enhance the jurisdiction of sub-tropical zone. This has in turn created an opportunity for introduction and cultivation of a wide variety of subtropical fruit crops. iv. Sufficient rainfall occurs during monsoon and winter season which can be used through water harvesting for crop production. Majority of subtropical area experiences 850-1500 mm rainfall and is suitable for most of the higher temperature requiring of subtropical/tropical fruit crops. This area has another advantage of diurnal temperature variation which leads to premium quality attributes from subtropical fruits.

On the basis of above major potentials, this state is quite different from most parts of the country. The fruit growers thus, can get remunerative prices for their produce in the domestic and international market. Fruit crops thus have great potential for export also. There is also great scope for expansion of area under fruit crops for intensification of subtropical horticulture in the state. Bringing vast untapped potential regions under fruit cultivation through area expansion, rising demands from domestic as well export market, capacity building of growers, hi-tech horticulture such as the high density planting, drip and fertigation scheduling, mulching, raised bed technology, on spot advisory, genuine planting material, by default organic fruit cultivation, high yielding and consumer oriented varieties having more shelf life, product branding etc. offer new opportunities. For differentiation, private sector is keen to join horticulture business value chain which are some of the opportunities which can be tapped as potentials of the area. The requirement of food grains, vegetables and fruits in 2020 and 2050 indicate a growth rate of 1.12% for food grains, 2.41% for vegetables and 3.71% for fruits to maintain requisite self-sufficiency.

The produce of this region is little bit late which has high potential to fetch premium prices besides it will regulating the market by expanding the availability of fresh fruit. It will reduce the burden of foreign exchanging through imports on state exchequer as well as avoid low fruit availability to the processing industry.

There is a need to adopt high density planting with higher water and nutrient use efficiency, precision farming instead of conventional planting, production and protection technologies suitable to specific micro-climate situations.

By realizing the importance of horticulture from adjoining areas propelled by experimentation of technology by institutions on sloppy wasteland, front line demonstration under high density planting on the farmers field of the area have created momentum for high density planting of fruit crops. However, site specific advisory and technologies need to be developed so as to sustain this vocation.

Suitability of crops for premium pricing on sustainable basis:

The diverse agroclimatic situations at micro-climate level is a common feature in the subtropics of the state. The selection of fruit crop/varieties in the location should be done carefully as the micro-climate varies with the location alongwith physiographic situations. The performance of selected crop/variety entirely depends on the micro agro-climate situation of the location. So, before selecting crop/cultivar for a particular location, department of horticulture/stakeholder must have an understanding on agroclimatic situations particularly frost occurrence alongwith its severity, aspect, sunlight, slope gradient, altitude, coordinate, topography, soil type, soil depth, soil pH, EC, salt concentration, organic carbon, dry zone with rain shadow zone, rainfall, distribution, humidity, abiotic stress, water logging situation, minimum and maximum temperature for successful fruit growing. Keeping all the points into consideration, the selection of fruit crop/cultivar should involve departmental official, experienced horticulturist having sound understanding of hill horticulture under prevailing agro-climatic situation or working official of the area. Exhaustive planning for selection of suitable variety of a suitable crop under suitable micro agro-climate is deciding factor to produce premium quality, highest yield potential, higher productivity and profitability by reducing the cost of production. This area has high potential for some fruit crops like citrus, mango, guava, litchi, pomegranate, pecan nut, plum, persimmon, kiwifruit, peaches in the subtropics and kiwifruit in mid-hill zone. All these crops are not new crops to this area as these crops have been grown since centuries on unsystematic, scattered, conventional system on small scale in orchards or in kitchen gardens. Under frost prone areas, pomegranate, pecan nut, persimmon, citrus, low chill plum and peaches should be grown for better harvest.

Well adapted and multi location tested varieties should be selected ranging from early, mid and late season based on climatic variability for market regulation, for fresh consumption of fruits and to provide raw material to processing industries for extended period. The next important factor is consumer's preference in domestic and international market i.e. fruit production is market driven. The selected variety must fulfill the market and processing attributes. Preferably indigenous, well adapted and performance proven varieties having insect-pest, diseases and abiotic stress tolerance should be selected. Such varieties should have high nutritional profile with low cost of production. After selection of suitable cultivars of suitable crop, the role of quality planting material and production technology alongwith, training-capacity building for management practices is to be addressed promptly which need guided protocol in the form of package of practices based on local agro-climatic situations.

Canopy density is determined by the number and size of leaves. Moreover, canopy architecture has significant impact on fruit production which is determined by the number, length and orientation of branches and shoots. In any fruit crops, for optimum fruiting and quality fruit production, the canopy management of the tree is prerequisite that deals with development and maintenance of their structure in relation to the size and shape. The basic idea of canopy management of the tree is to manipulate the tree vigour and use maximum available light and temperature to increase productivity, fruit quality and also to minimize the

adverse effects of the weather. Subtropical fruit crops particularly mango, guava, pomegranate, litchi, citrus, kiwifruits are light loving plant and enough light should be available in the tree canopy for quality fruit production. The green leaves trap the sunlight to produce carbohydrates which are then transported to the sites (buds, flowers, fruit etc.) Restricting the build up of micro-climate congenial for the development of diseases and insect pests and convenience in carrying out the cultural operations are also important considerations in canopy management. However, balance between vegetative and reproductive growth must be maintained by giving emphasis to have less wood and more quality fruits on plant canopy.

It is pertinent to mention here that the farmers as well as extension official are not skilled and also do not have practical understanding of high density planting of subtropical evergreen fruit plants, particularly canopy management which is required regularly to sustain desired growth, productivity, quality and cropping. So, skill of growers and field functionaries needs regular field based capacity building along with on spot advisory and monitoring under experts. This will help to achieve the aim and objective of high density planting of subtropical fruits growing under different micro-agro climatic situations prevalent in various clusters on farmer's fields.

Presently, the package of practices for high density planting of fruit crops under subtropics of state is not available. The progressive farmers who have adopted hi-tech horticulture feel strongly discouraged for want of solution to high density planting and the new emerging problems. Hence, there is urgent need to develop package of practices on high density planting alongwith matching technologies on the basis of existing micro agro-climatic situation to provide farmers friendly information.

MANGO

1. Climate

Mango grows well under up to an altitude of 1000 m amsl in both humid and dry conditions of Himachal Pradesh. However commercial cultivation of mango can be achieved in places from 350 m to 900 m of altitude receiving 100 to 110 cm rainfall. There is a direct effect of temperature on flowering time and period, fruit set and development. The optimum growth temperature for mango is 23.9 to 26.7°C. Temperatures below 20°C affect mango plants adversely. Heavy rainfall during pre-flowering period increases vegetative growth and flowering is reduced. Besides this, rains and high humidity during flowering and fruit set stage result in increased incidence of diseases and insect pests which hampers the process of pollination and fruit set. Therefore, areas with dry summers and well distributed rainfall are ideal for mango cultivation. Areas experiencing severe frost should be avoided for mango cultivation.

2. Topography and Soils

Mango grows on a wide range of soils, however, slightly acid to neutral, well drained and aerated, loamy or alluvial deep soils are best suited for mango cultivation. Heavy clay soils should be avoided for mango cultivation. Under rocky and compacted soil, pit size should not be less than 90x90x90 cm for mango orchards. Undulating topography is very common on hilly areas where planting should be done on 1m wide terraces/contours. Being a tropical plant mango should be grown on eastern, southern and western aspects.

3. Recommended Cultivars

In Himachal, more than 90% of the of these varieties area under mango is covered by early and mid-season varieties. The harvesting period of these varieties coincides that of the adjoining states. Farmers fetches poor prices in the market due to glut. Hence, the late, improved cultivars of mango which mature during August onwards to 1st fortnight of September have huge potential for improving the socio-economic status of the farmers due to non-availability of the mango in the market at this particular time. Hence, the new plantations should be done with late season improved cultivars like Mallika, Arunika, Arunima, Pusa Shrestha, Ambika, Chausa and Ramkela (pickle type).

Mallika: Strong regular bearing tendency. Average fruit weight 350-400g with deep yellow pulp, high TSS, good flavour, uniform fruits and moderate keeping quality.



Arunima: Medium sized fruit with attractive skin colour. Pulp deep yellow, TSS is around 20° Brix.



Pusa Shreshth : Semi vigorous, regular bearing with elongated and uniform sized fruits (228g). Peel attractive red; pulp orange, fibreless, firm at ripening, contains beta carotene and aerobic acid in good amounts with moderate blend of sugar: acid.



Ambika: Medium sized fruits, bright yellow with dark red blush, less fibrous in flesh but firm, late maturing cultivar with 21⁰B TSS.



Arunika : Regular bearer and dwarf variety. Attractive fruits having red blush, firm flesh, high TSS (24⁰B) and high carotenoids.



Chausa: Late maturing variety, which matures during end of July to mid of August. Fruits are large weighing about 350 to 400 g. Fruits are bright yellow in colour. Pulp soft and sweet. It is a biennial bearer.



Ramkela: Remains sour throughout, suitable for pickle making, harvested in July.



4. Propagation

Seedling rootstocks of mango are raised for grafting with the scions of desired commercial variety.

Raising of Rootstock

The current propagation practice by collecting pre-germinated mango stones (seeds) that fall under the tree, increase the risk of pests and diseases in the seedlings. Therefore the proposed improved practice for collecting mango stones and raising seedling rootstock should be followed.

Preparing the seed

Collect the best mango fruits from selected productive trees. It is essential to clean the mango pulp from the seed before sowing in the seed bed. Seed viability decreases with the delaying in sowing after extraction from the pulp.

- Wash the seed properly after extraction from the pulp.
- Seeds should be sterilized in plastic drum with 2.0 percent potassium nitrate solution for 24 hrs.
- The treated seeds should be sown in nursery beds and the layer of seeds should be covered with well rotten FYM for better germination.

Planting the seed

- Sown seed should be covered with grass mulch.
- Maintain optimum moisture in the medium.
- Seed germination begins 10-14 days after sowing. Inspect seed regularly after sowing.
- Seedling should be transplanted 1 month after sowing, when the leaves turns dark green, into the polybags and should be light root pruned (leaving 2 inch taproot)
- About 8 - 12 months after transplanting, the seedling attains 30 - 40 cm height and 0.8-1.0 cm diameter (graftable thickness), and becomes ready for grafting with desired commercial cultivars.
-

Grafting

The most common grafting techniques are:

- Veneer grafting
- Wedge grafting

Recently wedge grafting has been demonstrated successfully by different institutes including COHF Neri. The time for propagation by this method is July-August and February-March (under protected conditions). Both the methods can be used for commercial propagation.

Preparing the scion

- Scion wood should be taken from terminal portion of mature stocks (3-4 months old) with visible buds from non-flushing and non-flowering shoot.
- Semi hard scion wood which bends a little upon applying pressure should be taken.
- Scion taken from young and soft portion will dry quickly.
- Remove leaves from scion 7 to 10 days before detaching from the mother tree, but keep the petioles to promote buds to swell in order to enhance the success rate of graft.
- Cut about 10 cm long top portion of the shoot with a diameter similar to that of the rootstock diameter (it can be thinner than the rootstock, but not thicker).
- The scions can be stored up to 1 week by placing them in a bucket of water. For transportation from distant places, scion should be wrapped in moist paper and kept in sealed plastic bag and don't let the scion to dry out.

Wedge Graft

This technique is widely used and is easiest for mango propagation, if done well it produces a very strong joint and with stands in windy conditions.

- Two (2-3cm long) slanting cuts are given on each side of scion to prepare the wedge.
- Head back of rootstock about 30 cm above the surface of medium then cut a 2-3 cm long slit down the centre of stem.
- Wedge formed in scion should be slid into the slit cut of rootstock. Line up surface of scion and stock, or at least on one side so that the surface at the union of scion stock feels smooth.
- Wrap the graft with grafting/budding tape (12 mm wide), start from 1 cm below the bottom end of joint and move upward and be sure to completely cover upto 1 cm above the top of the joint. If necessary give a second wrap moving the tape downward along the joint.
- Place the newly grafted plants in a 50 percent shaded net.
- Wedge grafted plants of mango should be covered with polythene cap so as to improve graft success
- Remove the polycap immediately after bud sprouting.



Fruit Collection



Stone Extraction



Seed Bed Preparation



Seed Sowing



Germination



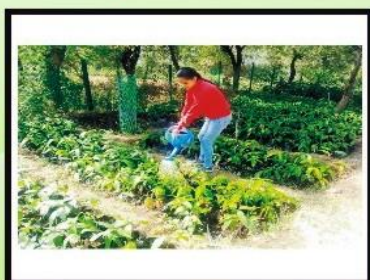
Filling of Polybags



Transplanting in Polybags



Fertigation with NPK



Graftable Rootstocks



Wedge Grafting



Commercial wedge grafting under protected cultivation

Nursery raising of Mango

Veneer Grafting

- This method is used when the rootstock is quite thicker than scion.
- Make an incision sloping cut (2.5-3.0 cm long) about 20cm above soil level on one side of the rootstock. Keep the portion above this cut for some time.
- Cut a wedge on one side of the scion matching the length of the incision given on rootstock (2.5-3.0cm).
- The scion is inserted into the incision given in root stock with some pressure so as to line up the cambium layers. Head back the rootstock slightly above the joint.
- Wrap the joint using grafting tape.

Grafted Seedling Management

- Freshly grafted seedlings need 50% shade. Apply water to keep the soil moist. The grafting tape can be removed when the graft union has healed after 8-10 weeks of grafting.
- The shoots arising below the graft union should be removed regularly.
- The grafted plants become ready for planting in the field 6 months after grafting, when the plants attain a 1 m length of about. If the plants are flushing, wait to transplant until the new leaves are greener.



Saleable plants

5. Layout and Planting

5.1 Spacing

High density orchards at 3 x 3m are suitable for regular bearing varieties. High density is successful only under proper canopy management practices. Mango needs regular pruning under high density plantation after harvesting otherwise it becomes overcrowded after 10-15 years.

Medium density mango orchards at 5 × 5m are suitable for vigorous cultivars with upright growth habit like Chausa in subtropical areas which accommodates 400 trees/ha. In hilly terrains spacing from line to line may be reduced in accordance with gradient of slope.

5.2 Land preparation and Plantation layout

5.2.1 Layout

The most widely suited mango planting system is square or rectangular. The orientation of planting should be North–South direction.

5.2.2 Preparation of field, bed, planting pit and filling

- Deep ploughing should be done and raised bed (2-meter-wide at bottom x 1.5-meter-wide at top x 45 cm height) should be prepared one month before planting.
- Where planting is done on steep sloppy sites, such soils are more prone to erosion and fast depletion of moisture, thus require frequent irrigation. On undulating, sloppy topography, contour and terrace orcharding having about 1 m wide terrace is recommended for commercial high density orcharding of mango.
- Planting should be done in pits of 60 x 60 x 60 cm size and pits are dug about a month prior to planting and disinfect by intense solar radiation. Each pit should be filled with

top soil mixed with farmyard manure (20kg), neem cake (1kg), and single super phosphate (500g). After filling the pit, watering is done to allow soil to settle down.

5.2.3 Planting season

6-18 months old grafted mango plant growing upright having 3-4 branches are generally good for planting. In Himachal Pradesh planting time is recommended in early spring after the risk of frost is over under assured irrigation. Otherwise rainy season is best for planting.

6. Canopy Management

Canopy management is very important to increase the productivity of mango tree productivity by developing an appropriate tree shape to balance the development of foliage while still producing quality fruits on economic level. It also helps the management of pests, diseases and carry out other cultural practices under high density planting. The orientation and crotch angle of branches is very important to develop proper canopy framework for production of high quality fruits.

6.1. Training

6.1.1 Development of New Mango Orchard:

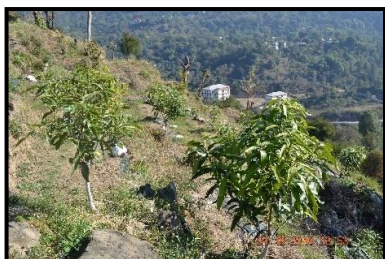
First order (1st Order): Head back plants at 45-50 cm when they attain the height of 80-90 cm, after planting.

Second order (2nd Order): As a result of head back new shoots emerge, 3-4 new shoots should be retained at least 30-45 cm above ground level.

- Ideal canopy can be developed by thinning out the shoots, so as to retain 3-4 shoots distributed evenly in all directions. These shoots develop as primary branches.
- As shoots become mature i.e., shoot colour changes from green to brown, second cutting should be performed. New shoots take about 4 months to mature.
- At this stage if new shoots are at smaller crotch angles, then increase the crotch angle by bending the shoot using rope/thread. Use a jute rope instead of nylon based/poly threads for bending.

Third order (3rd order): Heading back to 50 per cent should be performed on growing shoots when they attain 70-75 cm length. This will take 3-4 months to reach the stage for second cut to primary branches. This cutting also induces new growth.

- Crowding shoots should be removed so that 3-4 shoots are retained on each primary branch.
- New shoots emerge as a result of heading back and only 3-4 shoots are now retained in all directions.



Retaining of 4th Order branching

Fourth Order (4th order): Heading back of 50 per cent should be performed on growing shoots when they attain 70-75 cm length.

Fifth Order (5th order): Heading back to 50 per cent should be performed on



Heading back
at 45cm



Retaining of 3
shoots as 1st Order



Retaining of 2nd
Order branching



Retaining of 3rd
Order branching

growing shoots when they attain 70-75 cm length.

- Sharp secateur should be used to ensure smooth cut.
- This initial training creates open and spreading type canopy of trees.

6.1.2 Important points to consider:

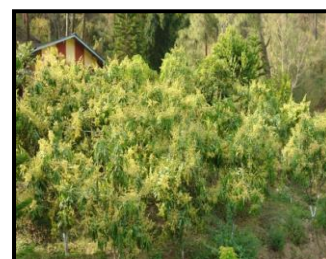
- In trees younger than 3 years, remove branches that compete with the axis (central leader), but leave the branches that open away from the axis.
- A very good way of recognizing the competing branches is by their angle of growth. Branches with less than 45 degrees opening from the axis should be cut out.
- Mango plant should develop 1st, 2nd, 3rd, 4th and 5th order of growth during two years.
- Mango tree start bearing under high density planting in 3rd year when plants attain 5th order of branching except Chausa which has vigorous upright growing habit and a shy bearing tendency.



Bearing in 5th order



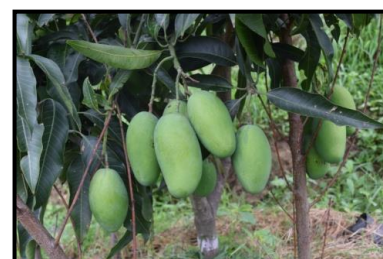
Pruning after harvesting



Flowering in High density planting

6.2 Pruning

- Pruning is required to regulate the growth and fruiting of mango tree under HDP. Pruning should be done immediately after fruit harvesting i.e., July-August by heading back 25-50%, branches particularly bearing twigs.
- The long-term sustainability of a mid-density orchard depends on an effective canopy management. In general, every pruned shoot produces three new shoot but occasionally more than three.
- Light or moderate pruning increases yields in mango orchards, while heavy pruning often inhibit fruit production for several seasons. However sometimes there is need to remove long branches affected by diseases or insect pests.



D-51 under ultra high density in 3rd year

Important points to keep in mind:

- Upright growing shoots should be removed. Lateral growing branches should be promoted.
- Remove about 20 cm of top branches around the tree every year. Severe pruning affects yields and should be avoided.
- Thinning out of upright branches should remain a continuous process every year.
- Avoid removal of branches with wide crotch angle during thinning out, as they are more productive.
- Most popular productive pruning shape is the “umbrella shape” (manual pruning).



Pusa Arunima under ultra high density in 3rd

- In bearing mango trees, upright shoots are thinned out in October for increasing productivity. The canopy development during initial phase is important for optimum fruiting.
- Significant reduction in tree height can be achieved by removal of one or two branches growing upright in the centre of tree which opens up the canopy to sunlight and ensures better photosynthetic activity.
- At any time, not more than 25% of plant biomass should be removed; otherwise it will lead to enhancement in vegetative growth.
- About 10-15% of plant biomass including criss-cross branches, dead/diseased wood has to be removed every year under HDP to allow better light penetration into the canopy.

7. Pollination

Under Himachal Pradesh subtropical climatic conditions, the flowering time is relatively precise (February- March), the period of full bloom is during March and the flowering remains for about 20- 25 days.

- For better fruit set, it is recommended that planting two or more varieties having synchronized flowering period instead of single cultivar should be done.
- The local pollinators, in decreasing order of efficiency are: domestic flies, syrphid flies, wasps, native bees and ants. Pollinators and pollinizers are important for pollination.
- During peak flowering time use of insecticides and fungicides should be restricted.

8. Orchard Management

8.1. Mulching

The bed should be covered with mulching (plastic or organic mulching) to check the weed population, conserve the soil moisture and regulate soil temperature. Preferably organic mulching having 15-20 cm thick layer of uprooted weeds from the field is considered economic and better for production and quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree.

8.2. Intercropping

During the initial two years, the intercropping of different annual crops should be undertaken as secondary crop as mentioned in the table to get additional income. Inter-cropping should be avoided during rainy season.

Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

Sr. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergourd, Parval, Colocasia, Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	—
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kidneybean (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak),	—

		Chino podium, Coriander, Fennel, Fenugreek	
5.	Fodder corps	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	—

9. Irrigation Management

- Adequate irrigation supply is critical at fruit development stage to get better yield and quality of fruits. In the reproductive phase water stress is beneficial at the time of flower bud differentiation but during the plant growth water stress should be avoided.
- Drip irrigation systems provide the most efficient and economic management to achieve high productive yields in mango orchards. This system is recommended for commercial mango orchards. Drip has very high water use efficiency and provides a good control of fertilizer application. For young trees use one drip line 40 cm away from trunk while for trees older than 3 years use one drip line on each side of the tree row 60 cm away from trunk.
- Adequate moisture is required during the vegetative growth for optimum flowering and fruit development. In high density planting, in-line drippers are well suited. The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers at 50 cm apart in each plant basin with 4.5 lph discharge. There should be a control unit/valve for each land holdings. The irrigation schedule below is recommended for mango orchards and it is applicable for drip irrigation.

9.1. Irrigation Scheduling

Year	Irrigation (litres per tree biweekly*)
1 st	4-6
2 nd	8-10
3 rd	16-18
4 th	20-25
5 th and above	28-35

* Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions. During Rainy season from July to September sufficient rainfall occurs in the subtropics of the state. Therefore, under such conditions there is no need of irrigating the crops except during failure of the monsoon. Irrigation Should not be given during November onwards till flowering.

10. Nutrition Management

10.1. Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months before mid-January.

Age of plant (year)	1 st	2 nd	3 rd	4 th	5 th year onwards
FYM (kg plant ⁻¹)	10	15	20	25	30

10.2 Nutrient recommendations: The amount of nutrients to be applied through fertilizers in high density orchard of mango depends on the age of tree, condition of plant and type of soil. The nutrient dose (g/ tree) should be divided equally among the number of splits and applied at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Age of the Tree (year)	Nutrient (g tree ⁻¹)*		
	N	P	K
1st year	50	25	50
2nd year	100	50	100
3rd year	150	75	150
4th year	200	100	200
5th year onwards	250	150	250

**Application of N, P and K should be based on soil/leaf test values.*

10.3. Stages of nutrient application:

Stage of application	N (%)	P (%)	K (%)
After fruit harvest	40	40	20
During fruit set	40	40	20
Fruit growth	20	20	60
Total	100	100	100

Cropping

- Soil application of chelated micronutrients 20g borax, 20g copper sulphate, 20g manganese sulphate, 20g iron sulphate, 20g zinc sulphate and 40g magnesium sulphate per tree per year in the month of January-February along with FYM application should be given.
- For better fruit set and cropping, micronutrients should be applied a foliar spray of 0.2% solution of the needed nutrient (fruit set and pea stage).
- Most known reason for flower and fruit drop is the inappropriate application of irrigation water. Two sprays of micronutrients (1st at pre flowering stage and 2nd at fruit set stage) particularly zinc sulphate (2.5g per litre), boric acid (1.0 g per litre) and calcium chloride (4.0 g per litre) should be done. Assessing and providing the water and nutrients required according to by the crop stage will address these issues.
- Regular visit and careful observation of the trees at least twice a week should be ensured to check and reduced the pressure of any disease, insect-pest such as mango hopper, mealy bug, powdery mildew, anthracnose etc.

11. Harvesting

Maturity Indices

- Slight colour development on the shoulder
- When one or two ripe fruits fall from the tree naturally (Tapka)
- Specific gravity of the fruit should be in the range between 1.01 and 1.02

Harvesting

- Harvesting should be preferably done by hand picking

- For export, the approximately 1.0 cm fruit stem/pedicle is cut along with fruit with the help of sharp scissors. Then fruits are kept upside down for two hours so that the latex flows out from the fruit completely.

Grading

The export quality mangoes are categorised into three grades according to the fruit weight viz., category-I: 200-250g, category-II: 251-300g, category-III: 301-350g.

Washing

Fruit should be washed and dipped in water containing fungicide for the control of post harvest disease.

Ripening

Mango does not normally need any post harvest ripening treatment for local marketing. It is a general practice to harvest fruits early in the season (premature stage) to capture early market. These fruits do not ripen uniformly without ripening aid. Such fruits could be ripened uniformly using Etherel in a ripening chamber.

Packing

CFB boxes of 5kg and 10kg capacity are used for packing and shipping of mango fruits for domestic markets as well as export purposes. Paper scraps, newspapers, are commonly used as cushioning material for packaging of fruits. Wrapping of fruits individually (Unipack) with newspaper or tissue paper and packing in honeycomb nets help in getting optimum ripening with reduced spoilage.

Storage

Storage is essential for extending the consumption period of fruits, regulating their supply to the market and also for transportation to long distances. The mature green fruits can be kept at room temperature for about 4-10 days depending upon the variety.

For exports, harvested fruits are pre-cooled at 10-12°C and then stored at an appropriate temperature. The fruits of Mallika at 12°C, Langra at 14°C and Chausa at 8°C with 85-90% relative humidity can be stored for 3-4 weeks.

12. Yield

Commercial crop in mango plants (planted on high density system) are borne 2-3 years after planting. The tree starts bearing fruits at 3rd year onwards with 5-6 kg yield per plant. The plants can bear 10-15 kg fruit in 5th year which will stabilize in 7th year onwards at 20-25 kg per plant under good management practices.

13. Diseases

There are many fungal and bacterial diseases infecting mango. Important diseases prevalent in sub tropical zone of Himachal Pradesh are listed below:

13.1 Anthracnose:

Causal organism: *Colletotrichum gloeosporoides*

Symptoms:

- Anthracnose symptoms are visible on young leaves, stem, inflorescence and fruits.
- Oval or irregular, greyish-brown spots are seen on leaves which may coalesce and cover the remaining area of the leaf later.
- The affected areas on leaves dry up and shred.

- Leaves borne on infected petioles also drop and fall.
- Grey- brown spots develop and enlarge which girdle and cause drying of the affected area on young stem.



Symptom on fruit

- On twigs, from tip to downwards, black necrotic areas develop and cause dieback.
- On floral organs, minute, black dots are found in humid weather which are basically acervuli of the fungus.
- Ultimately, partial or complete de-blossoming occurs.
- The infected fruits have pre-harvest latent infections.
- The ripened fruits show typical symptoms of anthracnose in the form of black spots on skin of the affected fruits gradually becoming sunken and coalesce.

Disease cycle and Epidemiology

- Infected leaves, dried twigs and fallen debris are the primary sources of inoculum. The pathogen can also survive saprophytically for a long time. Secondary source of inoculum are conidia which further spread the disease.
- Rainfall for a long time during flowering results in severe infection. 24-32°C temperature at shoot, flower and fruit development stage and relative humidity above 95% is most ideal for infection.
- If humidity is less than 62%, then conidia can survive for up to 2 weeks only.

Disease Management

Cultural method:

- Prune the affected branches of the tree and apply Bordeaux paste on cut ends.

Chemical method

- Spray with Bordeaux mixture (10g each of copper sulphate and lime / litre of water) or mancozeb (2.5 g / liter) twice at an interval of 15 days.
- Spray carbendazim (1ml / liter) at 15 days interval for four times before harvesting.

13.2 Powdery Mildew

Powdery mildew is one of the important diseases of mango which affects almost all varieties of mango. The disease is most prevalent during the dry periods of January to March. The disease causes severe yield losses.

Causal Organism: *Oidium mangiferae* .

Symptoms

- Symptoms of this disease appear as whitish or grayish powdery growth on inflorescence and tender leaves which is the most common stage of this disease.
- The infection starts from the tip of the inflorescence and spreads downwards.



Powdery mildew

- On leaves and shoots symptoms of the disease are quite common.
- Severely damaged infected floral parts drop off.
- Number and size of flowers is reduced leading to less yield.
- Fruits become malformed and off coloured and drop at premature stage.

Disease cycle and epidemiology:

- The pathogen perennates as dormant mycelium and conidia on host in resting stage. It also survives on annual or perennial hosts.
- Disease initiation, development and spread is favoured by dry weather.
- Disease development is more in cooler nights, light intermittent rain and cloudy humid weather at the time of flowering.
- Disease is favoured by temperature range of 15-17 °C and humidity of 65-85%, dispersal is favoured by warm moist weather and cooler nights.

Disease Management

Cultural Methods

- Remove weeds and alternate hosts of the pathogen.
- Removal and burning of infected parts of the plants to avoid further spread of the disease.

Chemical Methods

- Three sprays of Wettable sulphur (2g per litre of water) or carbendazim (1g/liter) or hexaconazole (0.5ml/liter) which include first spray as preventive spray is applied when the size of panicle is 8-10 cm, second spray is done after 10-15 days of first spray, third spray is need based which is done after 10-15 days of second spray, are also recommended.
- The fungicide spray should be avoided at the time of full bloom of flowers. Although three sprays schedule is recommended for the management of the disease, intelligent management with one or two sprays is possible with critical period identified for the spread of the disease.

13.3 Mango Malformation

Symptoms

Three types of symptoms appear:

- Bunchy top phase
- Floral malformation and
- Vegetative malformation.

Bunchy top phase

- Symptoms of Bunchy top phase appears on 4-5 months old young plants in the nursery beds.



Vegetative mango malformation

Floral malformation

- There is formation of thick small shootlets in a bunch which bear small rudimentary leaves or sometimes leaf axils give rise to many bunches from top or lower portion of the main shoot.
- Axis remains the same and shootlets are much thicker than them. Therefore, the shoot remains short and stunted.
- Growth of the plant stops giving rise to bunchy top appearance.

Vegetative malformation

- In vegetative malformation, excessive vegetative branches of limited growth appear in seedling and orchard plants.
- They become swollen with short internodes which forms bunches of different size and the top of the seedling and orchard plants show bunchy top appearance.

Floral malformation

- Symptoms are seen as the inflorescence shows variation in the panicle. Malformed head dries up in black mass and persists for long time. Secondary branches are transformed into number of small leaves giving witches broom appearance.

Pathogen: *Fusarium moliliforme* var. *subglutinans*

Disease Cycle and Epidemiology

- Dead necrotic malformed panicles serve as primary inoculum and site of multiplication of the fungus from where mites disseminate the conidia and mycelia to emerging buds
- Conidia show maximum viability in the morning hours and germinate within 5-6 h at 30°C.
- The intensity of vegetative malformation progresses steadily from mid-June to end of July (temp. 25-30°C, RH > 85%) while that of floral malformation in February-March (temp. 9.8-19°C, RH>87%).
- Temperature range of 8-19°C and high relative humidity (87%) are favourable for both invasion and symptom manifestation.
- Development of floral malformation compared with vegetative one is more sensitive to higher temperature.
- The maximum infected buds and malformed shoots are recorded during spring flush and minimum in summer.

Management

Cultural Methods

- Destroy the diseased plant parts.
- Disease free planting material should be used.

Chemical Methods

- Spray of 100-200ppm NAA during October is effective to reduce incidence of the disease.
- Spray the infected trees with potassium metabisulphite (KMS) @ 0.06 % (0.6 g/l) in October and repeat in the month of January.
- Prune diseased parts along the basal 15-20 cm apparently healthy portions followed by the spraying of Carbendazim @ 0.1% (1g/litre of water)

13.4 Die Back and Gummosis / Decline Complex

Die back is one of the serious diseases of mango. Disease symptoms are noticed at any time of the year but it is most conspicuous during October-November.

Pathogens associated: *Lasiodiplodia theobromae* (*Botryodiplodia theobromae*), *Pestalotia mangiferae*, *Colletotrichum gloeosporioides*

Symptoms

Four types of symptoms appear:

- Twig Blight
- Die Back
- Gummosis
- Bark Splitting.
- Symptoms appear as drying of the tip, discoloration and darkening of the bark at some distance from the tip becomes visible primarily.
- Main characteristic of the disease is dying back of twigs from top downwards mainly in older trees.
- The disease progresses downward involving bigger branches. Thus, leaves roll upwards and are shed. Twig drying and complete defoliation occurs which gives the scorched by fire appearance.
- Gum exudations are seen from the diseased portions. On young twigs, dark patches are seen. Cracking on branches is also seen from where gummosis occurs before its death.
- Graft union of nursery plants dies due to infection.
- Infection on nodes below growing point leads to death of growing twigs.
- During winter and rainy season, gummosis is found to be more prominent.
- In severe cases, bark splitting and cracking may also be seen.



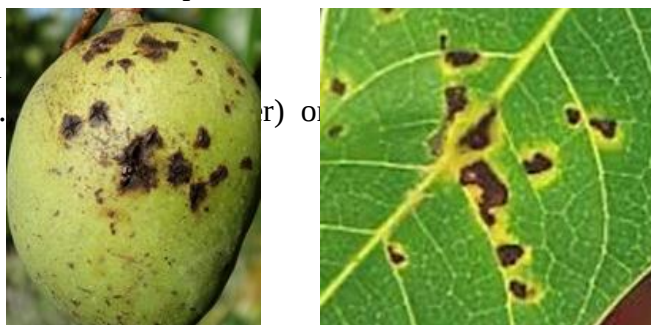
Management:

Cultural Methods

- Prune diseased twigs 2-3 inches below the affected portion.

Chemical Methods

- Spray Copper Oxychloride (0.3%) on
- Apply Copper Oxychloride paste @0. (r) on pruned twigs.



13.5 Stem end Rot

Pathogen : *Diplodia natalensis*

Symptoms

- After harvesting of the fruits, a dark rot develops from the stem end as fruit ripens.
- At the stem end, disease progresses as a dark brown to black rot as a dark brown ring and then infection proceeds towards the other end.
- The difference between anthracnose and stem end rot is that the latter produces dark streaking of the water-conducting tissues.

Management

Cultural Method

- Pruning and destruction of infected twigs.

Chemical Method

- Spraying of Carbendazim (1 g/ litre of water) at fortnightly interval during rainy season.

13.6 Grey Blight

Pathogen : *Pestalotia mangiferae*

Symptoms

On the margin and at the tip of the leaf lamina, brown spots develop. Size of the spots increases and become dark brown. On the spots, acervuli of the fungus appear as black dots.

Disease cycle and epidemiology

On mango leaves, fungus survives for over a year. Disease dispersal is through conidia which are wind borne. During monsoon, heavy infection is noticed at temperature 20-25°C and high humidity.

Management

Cultural Methods

- Infected plant parts should be removed and destroyed.

Chemical Methods

- Copper oxychloride @ 0.3% (3g/litre of water), Mancozeb@ 0.25% (2.5g/litre of water) or Bordeaux mixture @ 1.0% (10g copper sulphate + 10 g lime in 1litre of water) should be sprayed.

13.7 Red Rust

Pathogen: *Cephaleuros virescens*

Symptoms

- Foliage and young twigs are infected.
- On leaves, initially circular, slightly elevated rusty spots appear which coalesce to form irregular spots.
- The spores after maturing fall off and show cream to white velvet texture on the leaves surface.

Disease cycle and Epidemiology:

- Reproductive structures develop after reproductive phase.
- On thallus which is sessile and thick walled with orange pigments., sporangia are formed directly.

- On the vegetative filaments, sporangia are formed singly. The contents are converted into zoospores, when the sporangia are ripened and liberated through an opening in the wall.
- The zoospores are orange coloured, ovoid and swim by means of cilia.

Management

Chemical Methods

- Spray the crop with Bordeaux mixture @ 0.6% (6 g copper sulphate + 6 g lime in 1litre of water) or Copper oxychloride @ 0.3% (3g/litre of water).

13.8 Bacterial Canker and Black Spot:

Pathogen: *Xanthomonas campestris* pv. *mangiferaeindicae*

Symptoms:

- Black angular spots are raised and appear on leaf lesion, which develop greasy margins and leaf venation. These are surrounded by a chlorotic (yellow) halo.
- These lesions coalesce and turn in to large necrotic patches. During high humidity, bacterial ooze is seen on lesions.
- Leaf lesions dry and become light brown to ash-gray in color after several months of infection.
- In severe case of infection, defoliation occurs.



Mango bacterial blight fruit



Mango bacterial blight leaves



Bacterial Canker on leaves

- With fruit maturity, fruit susceptibility increases which is correlated with the weakening of the lenticels
- Symptoms on fruits begin around lenticels as small irregular water-soaked specks or as small star-shaped lesions.
- With the progress of the disease, lesions blacken, develop greasy raised which later develop cracks.

Disease cycle and Epidemiology:

- Relative humidity of more than 80 %, temperature range of 24–30°C and rainfall favour disease development.
- Infection occurs through the openings like stomata of old leaves, fruit and stem lenticels and wounds present on leaves, stems, and fruit.
- The pathogen does not survive on the ground in soil or in dead leaves

Management:

Cultural Methods

- Disease free nursery plant material is important for disease management.
- Good nursery practices should be followed such as disinfection of budwood which can be done by using bactericides, protection of plants from wind-driven rain by using windbreaks, destruction of source of inoculum, and reduction of epiphytic bacterial populations by using copper sprays.

Chemical Methods

- Chemical control of the disease is generally not so effective.
- Cupric compounds help to reduce epiphytic inoculum when lesions are absent but have no curative action.

14. Insect Pest Management

There are number of insect-pests infesting mango crop in the low and mid hills of Himachal Pradesh. Among these important insect-pests prevalent in subtropical zone of Himachal Pradesh are listed below:

14.1 Mango Hopper *Amritodus atkinsoni* (largest), *Idioscopus clypealis* (smallest), *I. niveosparsus*(medium) (Cicadellidae: Hemiptera)

Host: Mango

Symptoms and nature of damage:

- During flowering, the hoppers develop enormously in number, suck juice from the inflorescence and other tender plant parts reducing the vigour of the plant leading to reduction in fruit set and even premature fruit fall.
- The infestation also leads to development of sooty mould on the honeydew excreted by the insects.
- Egg laying also inflicts injury to the inflorescence. The infestation ranges from 25 to 50 per cent and in severe case it may lead to total loss of crop.
- During the remaining part of the year (off season), these hoppers occur in small numbers inside barks or on leaves of mango. High humidity in the air during flowering time encourages insect multiplication.
- The damage results in the following
- Affected flowers wither and drop down.
- Presence of black sooty mould on floral and other tender plant parts.

Life Cycle:



Hopper infestation in Mango



Adult Mango Hopper and its infestation in mango plant

- These insects are monophagous on mango and occur as regular pests.
- They are wedge shaped measuring 3 to 7 mm in length and move diagonally.

- *A. atkinsoni* is the largest and light brown having two black spots on scutellum, the anterior margin of pronotum and vertex.
- *I. clypealis* is the smallest and lighter in colour with two spots on the scutellum, dark spots on the vertex. Clypeus is entirely black.
- *I. niveosparsus* is slightly smaller with three spots on the scutellum and prominent white bar crossing its dusky wings. It is the most injurious species in South India.
- High humidity in orchards due to water logging, shading and overcrowding of trees favour the build up of the pest.
- The June-August generation hoppers are seen on mango tree trunks, while February-April generation is confined to the foliage and causes severe loss.
- Adult hoppers spend winter in the cracks in the barks of the tree. Hoppers prefer shady and damp places.
- After spending winter in the adult stage, the female lays eggs about 100-200, singly within the tissues of flower buds, tender leaves, during February – March.
- The eggs hatch in 7-10 days.
- The nymphs soon after hatching begin to suck the plant sap.
- Nymphs are smaller than the adults.
- The nymph period lasts for 2-4 weeks.
- There are two peak generations of this insect during a year i.e. during February – April and June-August periods.

Management

- Keep orchard clean
- Avoid overcrowding and water logging
- Proper pruning of the tree after harvesting to facilitate proper sunlight and air, that minimises hopper population
- Spray schedule is recommended as follows
- At flower bud initiation, imidacloprid 0.5 ml/l or Cyantraniliprole 10.26OD @ 0.3 ml/l or methyl demeton 25EC @ 1ml/l at emergence of inflorescence stalks and before flower opening (anthesis).
- In severe cases apply the above mentioned pesticides at petal fall stage.
- During anthesis and pollination, insecticides should not be sprayed.
- When fruits are of pea size, imidacloprid 0.5 ml/l or dimethoate (0.03%) (1ml/l). Adding sulphur 3.5g/l to the insecticide based on need to check mites and sooty mould (*Capnodium mangiferum*).
- Directing the spray first to stem/ trunk, then branches, twigs, leaves and finally inflorescence is a recommended method.

14.2 Mango fruit fly *Bactrocera dorsalis* Tephritidae : Diptera

Host

- It is one of the major pests of mango in India. It also infests guava, peach, citrus, ber, banana, papaya and so on.

Symptoms & Damage

- Semi-ripe fruits with decayed spots.
- Dropping of fruits. Damage to semi-ripe fruits is caused by both maggot and the adult.
- The oviposition punctures made by the female serve as entry for fermenting organisms.

- Maggots feed on the pulp and convert the pulp into bad smelling discoloured semi liquid mass, unfit for use.
- The fruits develop brown rotten patches on them and fall to the ground eventually.

Life Cycle

- Adult fly is a brown or dark brown with hyaline wings and yellow legs.
- Eggs are laid in small clusters of 2-15 just beneath the skin of the fruit. About 200 eggs are laid by a single female during a period of 1 month.
- Egg period is 2-3 days in March and April and prolonged up to 10 days in winter.
- Maggots become full grown in 6-29 days depending on the season.
- Maggots come out of the fruits and pupate in the soil. Entire life cycle takes about 25 days in the tropics.



Hopper infestation in



Adult fruit fly



Maggot infestation

Management

- Collection and destruction of fallen, rotten fruits.
- Raking under the trees to expose the pupae.
- Mixing of carbaryl 10D in soils @ 50-100 g/tree.
- Install pheromone traps.
- Foliar spray with malathion 2 ml/l + gur 20 g a month before harvesting the fruit crop, repeated after 15 days.

Post-Harvest Control (Heat treatment techniques):

- Hot water treatment: Submerging fruits in hot water at 43 to 46.7°C for 35- 90 min.
- Double dip method: Immersion of mango fruits in water at 40°C for 20 minutes, followed by 10 minutes at 46°C to get 100 per cent mortality of *Bactrocera dorsalis* eggs.
- Spray Spinosad @ 0.2 ml/l or Chlorantraniliprole (0.25ml/l) before ripening and 15 days after first spray.

14.3 Mango Mealybug *Drosicha mangiferae* Pseudococcidae: Hemiptera

Host

- It is one of the major pests of mango in India. It also infests guava, banana, papaya and so forth.

Symptoms & Damage

- Both nymph and adults suck sap from other tender plant parts thus reducing the plant vigour.

Life Cycle

- Female lays eggs in clusters within ovisacs in soil under the trees 5-15 cm deep during April and May.



Severe infestation of mealy bug in mango plant

- The adult female crawls down the tree in April-May and enters the soil for laying eggs, which hibernates till November. The eggs hatch during November- December.
- The nymphs ascend the trees and settle on inflorescence. Nymphs and adults suck sap from inflorescence, fruit stalks, fruits *etc.* leading to flower drop, premature fruit drop *etc.*
- They also excrete honey dew on which sooty mould develops and the fruit development is hampered.

Management

- Deep summer ploughing up to base of the tree trunks, after harvesting to expose eggs of mealy bugs.
- Dusting chlorpyrifos 5D or Malathion 5D around tree and incorporating in to the soil.
- Spraying with acetamiprid 0.5 ml/l or imidachloprid 0.5 ml/l or chlorantraniliprole 0.3 ml/l, when severe mealybug infestation noticed on the twigs.
- Wrapping 25 cm wide, 400 gauge polythene sheets on the tree trunk 30 cm above ground level and pasting grease over it to prevent migration of freshly hatched first instar nymphs during winter (Nov-Dec) from soil to trees, one week before their emergence.
- Crawlers collecting beneath the polythene sheet may be scraped with a knife.

14.4 Mango Shoot Borer *Chlumetia transversa* Noctuidae: Lepidoptera

Host: Mango

Symptoms & Damage

- Damage results in withering and drying of new terminal shoots

Life Cycle

- This pest is active from August to October. Eggs are laid on tender leaves.
- Freshly hatched caterpillars bore into midribs of tender leaves and come out after a couple of days to bore into tender shoots near the growing point tunnelling downwards, throwing out the excreta out of the entry hole..
- When the caterpillar is full grown, it comes out of the shoot and pupates on dried leaves, bark, soil *etc.*



Shoot borer infestation



Larvae of shoot borer

Management

- Clipping off and destruction of affected shoots.
- Foliar spray with cypermethrion (1ml/l) or spinosad (0.2ml/l) or Chlorantraniliprole (0.3ml/l) or flubendiamide (0.25ml/l) or imidachloprid (0.5ml/l) or at the time of new flush.

14.5 Mango Shoot Gall Psylla, *Apsylla cistellata* Buckton Hemiptera : Psyllidae

Host: Mango

Symptoms & Damage

- Feeding of nymphs and subsequently secretion of certain chemicals through the saliva results in the formation of conical galls in place of apical and axillary buds.
- The gall formation is caused by this pest only after tree start flowering and fruiting.
- Absence of gall formation of twigs with no eggs.

Life Cycle

- Adult females of the pest lay eggs at the sides of midrib during first week to end of March.
- Incubation period lasts from first week of March to middle of august.
- Eggs hatch in the middle of August and gall formation start from first week of September.



Mango shoot gall psylla infestation

- Nymphal period lasts from mid of August to end of February.
- Adult emergence starts from fourth week of February and continued up to third week of March.

Management

- **Cultural control:** Practice of removal of eggs bearing leaves from a shoot during March last week which decreases number of shoot gall formation.
- **Mechanical control:** Pruning of shoots upto 30 cm which bear galls during September to check further spread of incidence.
- **Chemical control:** Spray imidacloprid @ 0.5ml /lt which is having ovicidal action during second week of March.
- Spray with acetamiprid (0.2ml/l) or Chlorantraniliprole (0.2ml/l) during middle of August. If needed repeat the spray with same chemical.

14.6 Mango Stem Borer *Batocera rufomaculata* Cerambycidae: Coleoptera

Host: It is a polyphagous pest, infesting mango, apple, fig, mulberry, Eucalyptus, jack fruit, papaya and so on.

Symptoms of Damage

- Masses of frass and sap exuding from the bore holes.
- Leaves of damaged branches dry and fall.
- Branches collapse, tree succumbs in severe cases.

Life Cycle

- Adult is a well built, conspicuously long, brownish grey beetle measures ring about 4.5 to 5.5 cm.
- It has two pink dots and lateral spines on thorax and has hard elytra and is long horned.
- Female deposits eggs singly under the loose bark or in wounds of the mango tree trunk.
- Egg hatches in 1-2 weeks.
- The grub bores and tunnels through the bark of branches and stem feeding on the inner contents. As a result of feeding, the affected branches start drying up. In severe cases of attack the whole tree dies.
- The Full grown grub is yellowish white, fleshy and about 10 cm long with dark brown head having strong jaws. It pupates inside the larval tunnel in the stem itself.
- Pupal period lasts for 4 -6 months. Adult emerges out during May-June.



Damage caused by stem borer



Larvae of stem borer

Management

- The affected portions with grubs and pupae should be removed and destroyed, if branches are affected
- The bore holes are traced and opened. A swab of cotton wool soaked in chloroform or petrol 5ml or carbon disulphide or kerosene oil or Lambda cyhalothrin (1ml/l) inserted in to the hole and sealed with mud.

- Methyl parathion 4ml/l poured in to the hole or tablet of aluminium phosphide inserted into the hole to kill the grub or dichlorvos 4ml/l poured into the hole.
- When burrows are superficial, extract the grubs with stiff hooked wire and paint bordeaux paste.
- Spray spinosad (0.2ml/l) or lambda cyhalothrin (0.25ml/l) or imidachloprid (0.5ml/l) or cyantraniliprole (0.2ml/l) or chlorantraniliprole (0.3ml/l)

14.7 Mango Leaf Webber *Orthaga exvinacea* Noctuidae : Lepidoptera

Host: Mango

Symptoms of Damage

- Larvae web up leaves into clusters and feed within. Leaves surface are scraped and they wither and dry up.

Life Cycle

- Moth is grayish with brownish wings and has wavy lines on fore wings.
- Adults lay upto 30-50 yellowish green eggs singly near the leaf veins.
- Egg period is 4 days.



Leaf webber infestation in Mango plant



Damage done by larvae



Caterpillar of mango leaf webber

- Caterpillars are pale greenish with brown head and prothoracic shield.
- Pupation occurs in leaf web.
- Adult emerges in 11-14 days.

Management

- Remove and destroy the webbed leaves along with larvae and pupae.
- Spray carbaryl @ 2ml/litre or dichlorvos (1ml/l) or cypermethrin (1ml/l).

- Conserve predators like carabid beetle *Parena laticincta*, reduvid *Oecama sp*, parasitoid *Hormiusa* and fungus *Paecilomyces farinosus*.

14.8 Mango Bark Eating Caterpillar *Indarbela tetraonis*, *Indarbela quadrionotata*

Metabelidae : Lepidoptera

Host: Mango, Guava, Litchi, Orange, Pomegranate, Loquat, Mulberry, Moringa, Rose and Eugenia.

Symptoms of Damage

- Young trees succumb to the attack. Caterpillars bore into the trunk or junction of branches make zig zag galleries.
- Presence of gallery made out of silk and frass is the key symptom.
- They remain hidden in the tunnel during day time, come out at night and feed on the bark.
- Under severe infestation, flow of sap is hindered, plant growth arrested and fruit formation is drastically reduced.

Life Cycle

- Adult emerge in summer and lays 15-25 eggs in clusters under loose bark of the trees.
- Eggs hatch in 8-10 days.
- Larvae make webs and feed by making zig zag galleries on the wood filled with frass and excreta and later bore inside the wood.



Larvae



Adult



Larval infestation on bark

- Larval period is 9-11 months and pupates inside the stem.
- Pupal stage is 3-4 months.

Management

- Kill the caterpillars by inserting an iron spike into the tunnels.
- Injecting Spinosad 1.6 ml or kerosene oil in the ratio of 1:3 into the tunnel by means of a syringe and then the opening of the tunnel is plastered with mud.
- Dip a small piece of cotton in any of the fumigants, like chloroform or petrol or kerosene. Introduce into the tunnel and seal the opening with clay or mud.
- Spray spinosad 0.2ml/l or cypermethrin (1ml/l) or cyantraniliprole (0.3ml/l) or chlorantraniliprole (0.3ml/l).

14.9 Mango gall midge

Host: Mango

Symptoms of Damage

- The midge infests and damages the crop at different growth stages.
- The larvae (maggots) bore inside leaf tissue and feed within and results in formation of small raised wart-like galls on the leaves. Galls formation begins within 7 days and attains a maximum diameter of about 3-4mm.

- Heavily galled leaves curl up and drop off prematurely, causing dieback of whole branches in susceptible cultivars.
- Small emergence holes may be detected where larvae leave the galls as they go to the soil for pupation.

Life Cycle

- The female lays eggs singly into the tissue of young leaves, on the under surface, leaving a small reddish spot.
- The eggs hatch within 2-3 days.



Mango gall midge infestation

Adult Female

- Upon hatching, the minute larvae/maggots penetrate the tender parts where the eggs have laid and start feeding on them.
- The mature larvae drop down into the soil for pupation, leaving small holes on the leaves.
- Larval period varies from 7-10 days while pupal period varies from 5-7 days.
- Adults usually emerge from the underside of the leaf leaving the pupal skin protruding from the emergence hole.
- There are 3-4 overlapping generation of the pest.

Management:

- The following insecticide are recommended against mango gall midge;
- Imidacloprid (0.5ml/l) or chlorantraniliprole (0.3ml/l) or dichlorvos (1ml/l) or cyantraniliprole (0.3ml/l) or spinosad (0.2ml/l)
- Planting resistant varieties of mango.
- Maintenance of field hygiene/sanitation.
- Proper weed control.
- Mixed and intercropping farming reduces the pest population.
- Hand picking the midges, especially if the population is not dense.
- Use of sticky traps to catch the flies.

14.10 Mango Stone Weevil *Sternochaetus mangiferae* Curculionidae: Coleoptera

Host: Mango

Symptoms of Damage

- The mango stone weevil is considered as a minor pest as it causes no significant economic damages to fruit.
- The minute egg-laying scars are barely discernable at harvest and the weevil is present only within the seed.
- The fine tunnel in the flesh, the young larva causes as it burrows towards the seed heals, leaving no sign of its earlier presence in the flesh.

Life Cycle

- Eggs are first laid on small young fruit about 30 mm in size.

- Female weevils lay eggs over a number of weeks and egg-laying can continue in the orchard until a month before harvest.



Damage caused by stone



Larvae, Pupa and Adult

- Each egg produces a white, legless and elongated slender grub which appears a typical of weevil larvae.
- Adult weevils are dark brown to black with grey markings and a tough exoskeleton.
- The time from egg to adult takes 5-8 weeks and only one generation is produced each year.

Management:

- Monitoring for egg-laying on young fruit is the best way to detect adult during fruit growth.
- A weevil control program should use three strategies to control weevil infestation, quarantine, hygiene and chemical control.
- Removal of all fruit and seed material from the orchard will aid in minimizing the infestation in following seasons.
- Spray Acephate 75 SP @ 1.5G/L when the fruits are of lime size (2.5-4 cm diameter). This spray should be followed by spinosad (0.4ml/l) after 2-3 weeks.

15. Physiological Disorder

15.1 Black tip of mango

- Black tip is a serious disorder of mango.

Symptoms

- The distal end of the affected fruit exhibit etiolation patches of mesocarp which turn black and becomes hard.
- The affected fruits drop pre maturely.

Causes

- This disorder has mainly been detected in orchards located in the vicinity of brick kilns.
- Gases like carbon dioxide, sulphur dioxide and ethylene constituting the fumes of brick kiln, damage growing tip of fruits and give rise to the symptoms of black tip.

Management

- Establishment of the orchards away from brick kilns by at least 1.6 km in east to west and 0.8 km in North to South direction and increasing the chimney height to at least 15-18 meters can be preventive measures for this disorder.
- Spray of 1 per cent borax (10g/lit) thrice; first before flowering, second during flowering and third at fruit set stage is very effective.

16. Post-Harvest management

Fruit should be harvested during morning hours. The optimum storage temperature for cold storage of mango is 13-14⁰C at 85-90% relative humidity for 3-4 weeks. Below this temperature the fruits suffer cold injury.

CITRUS

1. Climate

Citrus fruits in subtropical area of state are cultivated under varied agro-climatic situations right from Kangra to Paunta valley of Sirmaur district. The optimum temperature range for growth and production of citrus is 13⁰ C to 37⁰ C. Soil temperature around 25⁰C seems to be optimum for root growth. The sub-tropical climate of state is best suited for growth and fruit production of citrus.

2. Topography and soil

The ideal soil for citrus cultivation is deep, sandy loam or alluvial soils rich in organic matter, although, it can be grown on wide range of soils. Citrus orchards flourish well in light soils with good drainage properties. Deep soils with pH range of 5.5 to 7.5 are considered ideal.

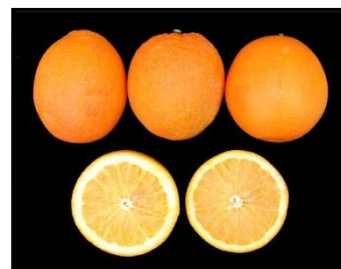
3. Recommended cultivars

Velencia Late, Mosambi, Jaffa and Malta Blood Red. Westin, Pera, Hamlin and Natal varieties are also recommended for commercial cultivation

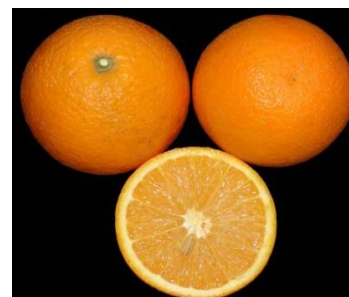
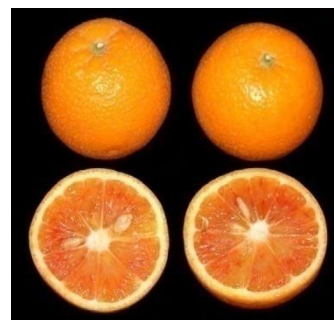
1. **Mosambi:** This is a very distinctive variety with its fruits being small to medium in size and broadly sub-globose. Its colour varies from light yellow to pale orange at maturity, surface is moderately to roughly pebbled with faint strips, narrow longitudinal grooves and ridges. The variety is marked by the presence of shallow areolar ring at the apex. The juice has low acidity and no marked flavour. The flesh is pale yellow or whitish with 20-25 seeds. It is early in maturity and ripens in November.



2. **Valencia Late:** Its fruits are slightly oval, medium in size and deep golden orange coloured at maturity. Fruits have abundant juice and the flavour is good but somewhat sub-acid in taste. The rind is medium thick and leathery with a smooth to faintly pebbled surface. Fruit holds exceptionally well on tree with little deterioration in quality. The fruits contain few seeds, usually 5 to 6. This is a late maturing variety and matures in mid-February. Trees of this variety are vigorous, somewhat upright, large and prolific.



3. **Blood Red:** It is distinguished by the development of red pigmentation in the pulp with deeply coloured cadmium-yellow glossy rind. The flesh is streaked red early in the season, but develops full red colour when ripe. Fruits develop excellent flavour and a pleasing blend of sweetness and acidity. Eight to ten seeded fruits ripen in December-January. The development of blood colouration is variable and is best in the sub-montane districts. This is a shy bearing variety.
4. **Jaffa:** The colour of this fruit is orange red under favourable conditions. It's rind is medium-thick, finely pitted and moderately pebbled. Fruit medium to large sized, globose to slightly ellipsoid or obovate and seeds are comparatively few, around 8-10. Flesh colour is light orange, tender, juicy with a good flavour. It stores poorly on tree, but ships rather well. It is a mid-season variety with maturity in December. Trees of this variety are vigorous, upright with dense foliage and have alternate bearing tendency.



4. Propagation

Virus free planting material is of prime importance for successful citrus cultivation since it is susceptible to a number of viral infections. The quality of nursery plants has a major contribution in the productivity of citrus orchards.

4.1 Recommended Rootstocks

Citrus plants are very sensitive to various biotic and abiotic stresses, therefore, selection of an ideal rootstock is a continuing challenge for the citrus cultivation. For budwood, disease free mother plants developed from the elite progeny of known pedigree should be selected. Rough lemon is most suitable rootstocks for sweet orange varieties.

4.2 Rootstock Raising

Seed for raising rootstocks should be obtained from healthy fruits of rough lemon harvested from vigorous trees. The seeds of rough lemon are extracted in September and immersed in hot water at 52⁰ C for about 10 minutes to check Phytophthora infection. The seeds should be sown immediately after seed treatment with captan @ 1g per kilogram of seed. The seeds are sown in nursery beds of 2 m×1 m size and in rows 15 cm apart. The seed should be sown at a depth of 2.5 cm 10-12 cm tall, uniform seedling are transplanted to polybags. Spray of 19:19:19 15 g/litre of water solution on Jatti Khatti seedlings at monthly interval (March to December) increases the proportion of graftable plants.

4.3 Maintenance of Mother Trees

For the induction of more bud wood required for the nursery production, the mother trees of sweet orange should be planted at 2×2m spacing and pruned at 6 feet height from ground level along



**Mother plant of citrus
under net house**

with topping of side branches during last week of January to first week of February. Bordeaux paste should be applied on cuts after pruning. The fruits should also be removed from the mother trees after fruit set in the month of April.

4.4 Budding

Primary nursery beds are prepared on light fertile soils or in the HDPE trays under shade net structures. The most commonly used method for propagation of citrus is T-budding. Budding should be done in month of July-August.

Pencil thickness seedlings are budded by inserting shield shaped bud into the slot cut in the bark of the seedling at 15-20 cm from the ground level. It can be made by first making a horizontal cut about 1.5-2.0 cm long according to the thickness of the stock. Another vertical cut, about 2.5 cm long, is made downwards from the middle of the horizontal cut to receive the bud shield. After the 'T'-cut has been made in the stocks, the bud is removed from the budstick and inserted into the slot and wrapped up with the plastic tape keeping the bud eye uncovered. The wrapping should be fairly tight, but not so tight as to girdle the stock. The sprouts of the stock seedlings below and above the bud union should be removed regularly.

T-budding in Citrus



Extraction of Seeds from fruits for raising of rootstock treated with captan @1g per kg of seed



Treated dried seeds should be sown within a week of extraction



Germination of citrus seeds



4-6 leaf stage seedling should be transplanted



Polybags filled with media ready for transplants



Seedling ready for budding/grafting



Collection of Scion wood



Extraction of budwood



Preparation of scion wood



Insertion of budwood on rootstock



Successful plants ready for transplanting to the farmer's field

Important Points to keep in mind:

- Always take bud wood from true to type and diseases free mother plant for nursery production.
- Use soil, FYM and cocopeat potting mixture (2:1:1) in polybags for containerized nursery production.
- Budding should be performed at 15-20cm above the ground level.
- Containerized nursery production helps in propagating plants in shorter time and reduces the incidence of insect-pest and diseases.

5. Layout and Planting

5.1 Spacing

Citrus should be planted at 3.0 m x 3.0 m accommodating 1111 plants/ha.

5.2 Layout

Square or rectangular planting systems should be adopted in citrus planting. The orientation of planting should be North–South direction. However under the condition with undulating topography, planting should be done by mulching contour terraces.

5.3 Preparation of field, bed, planting pit and filling

- Deep ploughing should be done and raised bed (2 meter wide at bottom x 1.5 meter wide at top x 45 cm height) should be prepared one month before planting.
- Planting should be done in pits of 60 x 60 x 60 cm size and pits are dug about a month prior to planting and disinfect by intense solar radiation. Each pit should be filled with top soil mixed with farmyard manure (20kg), neem cake (1kg), and single super phosphate (500g). After filling the pit, watering is done to allow soil to settle down.

5.4 Planting

- Place the tree in the hole so that the potting mix mark is slightly higher than ground level to allow for some sink. Fill the hole up to half level with soil and press it gently towards the root.



High density plantation

- Fill the hole with water and allow it to drain before completely filling the hole with soil. Do not place fertilizer in the planting hole as this can burn sensitive roots.
- Apply a layer of organic mulch in 1 m diameter around the trees.
- Planting should be done during early spring or rainy season depending on availability of irrigation water.
- Polybag raised plants can be planted without disturbing their roots.



High density planting in 4th year

- Staking should be provided to young plants to keep the plant straight and avoiding breakage of shoots by winds. Use 50-80 cm long wooden sticks and tie the main branches with strings. Wooden sticks should be treated with chloropyrifos 2 ml/litre for termite protection.

6. Canopy Management

- Citrus produces 3-5 growth flushes each year according to the growing environment. Each new growth flush is added onto the previous flush, resulting in a drift of young bearing wood to outside of tree canopy. Over the time, this produces larger trees with increased shading inside the canopy, restricting the fruit development to top and side of the trees.
- Growth rates are highly variable depending on climate, cultural practices, tree spacing, scion and rootstock. Younger trees have higher growth rate in relation to tree size. Once the tree reaches desired height, annual pruning may be required to maintain the height, thin the growth, and promote prolific fruiting.
- Maximum fruits are set on wood that is less than 2 years old. Pruning should be least damaging to tree yields when done on a regular basis to wood on the outside of the canopy.

6.1 Training

- To develop structural framework training operation should start after 6 months of planting when the plants have attained a height of 45-60 cm.
- All branches up to 30 cm height should be removed and first ring of branches should start 30 cm above the ground.
- During the second phase, select 3-5 primary branches above 30 cm height in all directions. The selection of primary, secondary and tertiary branches should remain continuous during next year.
- The orientation of primary branches should be toward peripheral canopy at about 60° angle with stem and upright growing branches should be thinned out.
- During development of framework structure, training should be done continuously for first two years.
- The maximum height of grown tree should not exceed 2.5 m and canopy should be developed in round dome shape.

6.2 Pruning :

The best time for pruning the bearing trees is immediately after the harvest of the fruits. For getting better yield of high quality fruit, pruning of such branches is necessary to open up the tree for proper ventilation and provide more chances for inner wood to bear fruit. Removal of dead and dried wood is necessary to check the further spread of diseases.

- Hard pruning of thick shoots should be discouraged.
- Removal of water sprouts and water shoots should be continuous except in May-July.
- Pruning of dried, intermingled and diseased branches should be done during winter months.
- Apply Bordeaux Past to the cut ends having diameter more than 10 mm or spray.
- Copper oxychloride 3g/L. to the plants after pruning.

6.3 Operations to be done during pre-pruning & pruning

- Sterilize the secateurs or pruning tool with sodium hypochlorite (2 to 3 ml/l) while pruning.
- Remove weeds and suckers.
- Collect and burn fallen leaves/debris from the orchard.

7. Pollination

Under subtropical conditions of Himachal Pradesh, the flowering time in sweet oranges is early spring *i.e.* February-March as the temperature rise after winter. Most of the citrus cultivars are self-fruitful. However, in mixed planting cross pollination can also occur which boosts the yield of plants.

8. Orchard Management

8.1 Mulching

The bed should be covered with mulching (plastic or organic mulching) to check the weed population, conserve the soil moisture and regulate soil temperature. Preferably organic mulching having 15-20 cm thick layer of uprooted weeds and dry grass from the field is considered economic and better for production and quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree; Keep mulch 30 cm away from the trunk. Mulching should be done in the month of February, which helps in conserving moisture and reducing weed growth. In case of plastic mulch bed should be covered from one corner to another corner completely.

8.2 Intercropping

During the initial two years, the intercropping of different annual crops can be undertaken as secondary crop as mentioned in the table below to get additional income. Intercropping should be avoided during rainy season

Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

Sr. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergourd, Parval, Colocasia, Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soybean, Blackgram (Urd), Greengram (Moong), Kideybeen (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chinopodium, Coriander, Fennel, Fenugreek	
5.	Fodder crops	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed, Mustard	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	
8.	Fruit Crops	Strawberry,	

8.3 Integrated management of fruit drop in Orange

- Prune citrus trees to remove diseased and dead twigs during January to February after the fruit harvest and spray Bordeaux Mixture or Copper oxychloride (3g/litre of water).
- Repeat spray in March, July and September to reduce die-back of twigs.
- Collect and burn all the pruned wood.
- Spray GA₃ (10 mg/litre of water) in mid April, August and September.
- Collect and destroy the mummified fruits on the trees as well as the fallen fruits by deep burying.
- Avoid flood irrigation in orchards, as it increases the attack and spread of Phytophthora disease.

8.4 Quality Improvement

To improve fruit size and increase yield in orange, three foliar sprays of 1.0% potassium nitrate (13:0:45) 10g/litre at the end of June, July and August should be done.

9. Irrigation Management

Irrigation is one of the most important factors in producing a good quality yield of citrus. Citrus requires uniform and optimum moisture regime in rhizosphere. The annual water requirement varies from 900 to 1100 mm per year depending upon the location.

9.1. Irrigation Scheduling

Quantity of water and frequency of irrigation depends on the soil texture and growth stage.

Micro irrigation systems ensure good retention of fruits during crucial stages of crop growth and cropping. The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers at 50 cm apart in plant basin with 4.5 lph discharge. There should be a control unit/valve for each land holdings.

Amount of water to be applied to sweet orange through drip irrigation

Months	Irrigation (litres per tree biweekly*)				
	1st year	2nd year	3rd year	4th year	5th year onwards
Jan.	0.75	2.0	4.0	7.0	9.0
Feb.	1.0	4.0	6.0	15.0	16.5
Mar.	1.3	5.0	12.0	15.0	16.5
Apr .	1.5	6.5	14.0	25.0	28.0
May	2.0	7.0	16.0	28.0	30.0
June	3.5	8.0	18.0	30.0	34.0
July **	1.2	4.5	10.0	19.0	22.0
Aug. **	1.2	4.5	10.0	19.0	22.0
Sept.**	0.75	2.5	5.0	8.0	12.0
Oct.	0.75	2.5	5.0	6.0	8.0
Nov.	0.75	2.5	5.0	6.0	8.0
Dec.	0.75	2.5	5.0	6.0	8.0

* Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions.

****During Rainy season from July to Sept sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops except during failure of the monsoon. Irrigation should be stopped/restricted one month before harvesting.**

10. Nutrition Management

10.1. Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months during January- mid February.

Age of plant (year)	1 st	2 nd	3 rd	4 th	5 th year onwards
FYM (kg plant ⁻¹)	10	15	20	25	30

10.2 Nutrient recommendation:

The amount of nutrients to be applied through fertilizers in high density orchard of citrus depends on the age of tree, condition of plant and type of soil. The nutrient dose (g/ tree) should be divided equally among the number of splits and applied at weekly intervals.

For proper growth and higher yield, following nutrient doses should be applied:

Age of the Tree (year)	Nutrient (g tree ⁻¹)		
	N	P	K
1	80	40	80
2	160	80	160
3	240	120	240
4 year onwards	320	160	320

***Application of N,P and K should be applied on soil/leaf test values.**

10.3. Percent nutrient supplied through fertigation (minimum number of fertigation dose for all stages are four)

Stage - I (Jan –Feb.)			Stage - II (Mar-April)			Stage - III (May- June)			Stage – IV (July – Aug.)			Stage V (Sept – Oct.)			Stage VI (Nov - Dec)		
N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
0	0	0	30	40	10	30	35	10	20	25	30	10	0	25	10	0	25

Cropping

The inadequate fertilization is one of the reasons of citrus decline. Nutrition has become very costly input for fruit crops. Judicious use of manures and fertilizers helps to maintain productivity of citrus orchards. Right choice of fertilizers in an appropriate doses in split applications at critical growth stages of the crop results into maximum advantage.

- Soil application of chelated micronutrients 20g borax, 20g copper sulphate, 20g manganese sulphate, 20g iron sulphate, 20g zinc sulphate and 40g magnesium sulphate per tree per year in the month of January-February along with FYM application should be given.
- For better fruit set and cropping, micronutrients should be applied as foliar spray of 0.2% solution of the needed nutrient (fruit set and pea stage).

11. Harvesting

Maturity indices

Sweet orange fruits should be harvested when they have attained adequate size and 12:1 (TSS : Acid ratio) in juice. The best time for picking different cultivars varies from end of October to 1st week of February.

Harvesting

Harvesting season within the state also varies with locality and the cultivars. Harvesting is done with a clipper retaining a non-protruding short fruit stalk on the branch. Harvesting during early hours of the day when there is dew on fruits and harvesting immediately after rains should be avoided.

The harvesting should be done at a stage considering the growing area and the duration of transport, so that light green colour should not exceed one fifth of the total surface area of the fruit.

Grading

For local markets, the citrus fruits are graded as per the size into small, medium and large grades. The difference between categories will depend on the size of fruit.

Packaging

Citrus fruits are packed in stacks, bags, bamboo baskets and wooden boxes for sending to local markets. Corrugated trays are equally effective as packaging material while transporting the fruits.

Storage

After the fruits are harvested treatment of fruits with Bavistin 100 ppm reduces post harvest losses and extends the shelf life to 25-30 days even at room temperature.

The ideal storage temperature for sweet orange is 6-8⁰ C at 85-90% relative humidity.

12. Yield

The sweet orange tree starts bearing fruits at 3rd year onwards after planting with 8-10 kg yield per plant. The plants can bear 20-25 kg fruit in 4th year which will stabilize in 5-6th year onwards at 50-55 kg per plant yield under good management practices.

13. Diseases

Important diseases prevalent in sub tropical zone of Himachal Pradesh affecting citrus are listed below:

13.1 Anthracnose:

Causal organism: *Colletotrichum gloeosporoides*

Symptoms:

- The disease leads to defoliation and tip drying of twigs, it is called whither tip.
- Symptoms appear on leaves as black sunken spots which causes shedding of leaves and dieback of twigs leading to defoliation which ultimately leads to drying of tips.
- On the dead twigs acervuli appear as black dots.
- On fruits, light green spots appear which turn brown after some time.
- Pathogen also infects, stem-end of immature fruits which leads to fruit drop.
- Die back type symptom is observed in severe cases.
- Black spots appearing on skin of the affected fruits gradually become sunken and coalesce showing typical anthracnose symptoms on the ripening fruits.



Dieback/Citrus Anthracnose

Disease cycle and Epidemiology

- Primary source of inoculum in the spread of the diseases is in the form of mycelia in infected leaves, dried twigs and fallen debris. The pathogen can survive saprophytically for a long duration in dead tree parts. Conidia produced in acervulus serve as secondary source in the spread of the disease.
- Prolonged period of rainfall during flowering helps in severe outbreak of the disease.
- The temperature range of 30-32 °C, free water or relative humidity 80-95% is conducive for infection.

Disease Management

Cultural Methods

- Affected leaves should be collected and burnt.
- Infected branches should be pruned and Bordeaux paste applied on cut ends.
- Avoid N application in excess.
- Summer irrigation is effective.

Chemical Methods

- Spray 1% Bordeaux mixture (10g each of copper sulphate and lime / litre of water) or mancozeb (2.5 g/liter) twice at the interval of 15 days on leaves.
- Spraying of carbendazim (1ml/liter) at 15 days interval four times before harvest.

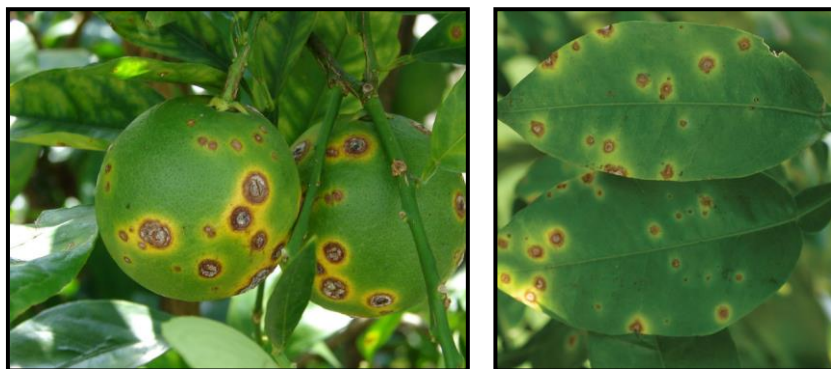
13.2 Citrus Canker

Causal organism: *Xanthomonas campestris* pv. *citri*

Symptoms:

- Initially small, round, watery translucent raised spots appear on leaves which later become yellowish brown.
- Symptoms appear on the lower leaf surface first and then on both the surfaces.
- With the disease progress, the surface of the spot becomes white or greyish and finally ruptures in the centre giving a rough, corky or crater like appearance.
- Yellowish brown to green raised margin and watery yellow halo surround the rough lesions.
- On petiole and midrib, spots cause premature defoliation.





Citrus Canker

- On fruits, symptoms same as that of leaves occur but yellow halo is not visible and the crater like depression in the centre is more prominent.
- There is only skin-deep injury and no effect on juice or pulp is noticed.
- Symptoms are same as leaves on stem, except that no yellow halo, bark eruption takes place, from cracks bacterial ooze is seen during warm rainy season.

Disease cycle and Epidemiology

- Temperature range of 20-35°C, high relative humidity and moisture on the host surface favour the disease development.
- Twigs bearing old lesions on the standing trees are the main source of perennation of the pathogen.
- Bacterial cells spread through irrigation water, agricultural operations, pruning shears etc.
- The bacterium enters the host by means of stomata or wounds. Canker pustules harbour and exude bacteria in the form of gummy substance. Dispersal is through wind and by rains. Citrus leaf-miner has a role in dissemination and infection of the disease.

Management:

Quarantine:

- If area is disease free, restrict the entry of planting material from infected to healthy area.

Cultural Methods

- Destroy the affected leaves, stem and fruits by burning
- Pruned portion of stem should be pasted with Bordeaux mixture

Chemical Methods

- Alternate spray of COC (3g/litre) + streptocyclin (1g/10litre) and neem seed kernel extract (50g/litre) starting from second fortnight of June up to second fortnight of October at 30 days' interval.

13.3 Citrus Gummosis / Root and Collar Rot

Causal organism : *Phytophthora citrophthora*, *P. parasitica*, *P. palmivora*

Symptoms:

- Yellowing of leaves, followed by cracking of bark and profuse gumming occur on the surface.
- Rotting of the bark and drying of tree leads to girdling effect.
- There is heavy blossom prior to death, but fruits die prematurely.
- Foot rot or collar-rot occurs.

Disease Cycle and Epidemiology

- Temperature range of 18-22°C and relative humidity of 90-95%, high soil moisture and pH 6-7 are conducive for development of the disease.
- Primary source of inoculum is in the form of dormant mycelia and oospore present in infected debris and infested soil.



Citrus Gummosis

- Disease is further spread by zoospore produced in sporangia borne on sporangiophores asexually and spread through soil, irrigation water.
- Sexual reproduction takes place by gametangial contact as antheridia and oogonia are formed in the mycelium and results in the production of oospores to continue the disease cycle in the next season.

Management:

Cultural Methods

- Provide good drainage, as it creates adverse conditions for the pathogen thus reducing the asexual reproduction and secondary inoculum
- Uproot severely infected plants and replant with tolerant varieties.
- Avoid low lying areas for citrus.
- Avoid excess N application, apply recommended K Application

Biological Methods

- Application of *Trichoderma* (100 g per plant) or *Trichoderma harzianum* + *Trichoderma viride* + *Pseudomonas fluorescens* (100 g tree⁻¹) is effective

Chemical Methods

- Chemical soil drenching and foliar spray of Bordeaux mixture (10g copper sulphate + 10 g lime per litre of water) or Copper oxychloride (3g/litre), Ridomil MZ 72 @ 0.25 % (2.5g/ litre of water) is effective in controlling the disease.
- Applying Bordeaux paste on trunk pre-and post monsoon

13.4 Sooty Mould

Pathogen: *Capnodium citris*

Symptoms:

- The pathogen produces superficial and dark mycelium. They grow on sugary substances i.e.



Citrus sooty mould

honeydew secreted by plant hoppers. Black encrustation covers the leaves which affect the photosynthetic activity.

- On the leaf surface, disease appears as black velvety growth.
- The leaf surface or portion of the leaf may be covered with fungal growth and in severe cases the whole plants are affected.
- The thin layer formed on the leaf surface can be rubbed off easily.
- Under the dry conditions this may be blown off as small fragments by the wind.
- The disease causing fungi in true sense are non-pathogenic, however, photosynthetic activity of the plant is impaired due to covering of the leaves.

Epidemiology and disease cycle:

- The disease causing fungi are non pathogenic. Insects secreting honeydew favour development of fungus.

Management

- Management should be done for both insects and sooty moulds simultaneously. Controlling of insect by spraying systemic insecticides
- Spraying starch solution (1kg Starch or Maida in 5 litres of water, boil and dilute to 20 litres) is effective. Starch dries and forms flake which are removed along with the fungus.

13.6 Citrus Tristeza

Causal organism: *Citrus tristeza Virus*

Symptoms

Citrus tristeza virus (CTV) causes different symptoms on citrus plants depending on the virus strain, the variety of citrus, and the scion-rootstock combination.

- Quick Decline (QD) or Tristeza is the most notorious symptom and is associated with the name Tristeza. When a sweet orange variety used as a scion grafted onto sour orange rootstock and infected with a quick decline strain of CTV, infection occurs.
- Virus affects the cambium layer right below the bud union and prevents the normal development of cambium.
- Severe strains of CTV cause symptoms such as stem pitting (SP) and seedling yellows (SY).
- Pits in the wood can be observed ranging from short and narrow to elongated and deep when the bark is peeled away; sometimes gum is associated with the pits.
- Trunks may be so severely impacted that they have a ropey appearance.
- Severely affected trees are chlorotic, stunted, and generally have a low yield of poor quality fruit.



Citrus tristeza

- Seedling yellows (SY) is typically not seen in field situations with the exception of top working of SY-infected trees with grapefruit or lemon budwood.
- It affects primarily young seedlings.

Epidemiology and Disease cycle

- 20°C - 25°C is the optimum temperatures for virus infection and multiplication.
- The infected plants and cuscute vines are primary source of infection and from where the virus gets transmitted through aphid vectors
- CTV is transmitted by aphid species, out of which citrus brown aphid, *Toxoptera citricida* is the most effective vector.

Management

- Use the seedlings obtained from seeds.
- Use a rough lemon root stock and other scion, protecting plants from phloem necrosis.
- As the disease severity increases cut and burn the affected parts.
- Phased manner replanting with resistant plants.
- Hot water treatment of rootstocks at 45°C for 10-25 min is effective.
- Removal of *Cuscuta* and spraying of systemic insecticide controls the aphid vector population.
- Apply recommended dose of N P K and FYM.

Greening in Sweet Orange:



Greening in diseases in sweet orange

Casual organism : *Candidatus liberobacter* spp. (*L.asiaticus*, *L.africanus*, *L.americanus*)

Symptoms

- Citrus greening is characterized by yellows type of symptoms which are highly variable.
- Leaf chlorosis is the main symptom which resembles the zinc deficiency.
- In the yellow tissues of the leaf lamina, scattered green islands are seen.
- Leaf veins are also yellow.
- A characteristic feature of greening is that the yellow areas are surrounded on one side by the mid rib and on the other side by lateral veins. The yellow expands towards the margins.
- The size of leaves is also reduced.
- The leaves are thicker than normal and usually remain erect.
- Internodes of the branches are shortened giving a bushy appearance to the branch (Witches broom).
- Such branches produce excess of buds and later show die back.
- Poor crop of predominantly green and worthless fruits is seen and only a portion of tree is affected.

- The affected trees produce small, irregularly shaped fruit with a thick, pale peel that remains green at the bottom. Such fruits taste bitter.

Epidemiology and disease cycle

- The Asian form (*L. asiaticus*) is heat tolerant and thus can produce greening symptoms even upto a temperature of 35°C.
- The African forms (*L. africanus*) are heat sensitive and in this case the symptoms can develop only upto a temperature of 20-25°C.
- The bacteria are transmitted by psyllid vectors and also by graft transmission.
- *Trioza erytreae* (African) and *Diaphorina citri* (Asian) are the two psyllids responsible for bacterial transmission.

Management

- Chlorosis can be caused by nutritional disorders, many workers have claimed the control of greening with micronutrient spray which only temporarily masks the symptoms of greening.
- Use disease free planting materials.
- Destroy the infected plantations.
- Spray the crops with insecticides regularly to reduce the vector population.

14. Insect Pest Management

There are number of insect-pests infesting citrus. Important insect-pests prevalent in sub tropical zone of Himachal Pradesh are listed below:

14.1 Citrus Butterfly *Papilio demoleus*, *Papilio polytes*, *Papilio helenus* Papilionidae: Lepidoptera

Host:

It infests almost all citrus varieties though Malta (*Citrus sinensis*) is its preferred host. It can feed and breed on all varieties of cultivated or wild citrus and various other species of family Rutaceae. Besides citrus, it also attacks ber, wood apple, curry leaf.

- ***P. demoleus*** is a big beautiful butterfly with yellow and black markings on all the four wings, having wing expanse of about 50-60 mm. Its hind wings have a brick red oval patch near the anal margin and there is no tail like extension behind though common in Papilionidae.
- ***P. polytes*** males are black and females vary in form.
- ***P. helenus*** has black wings with three white distal spots.

Symptoms and Damage

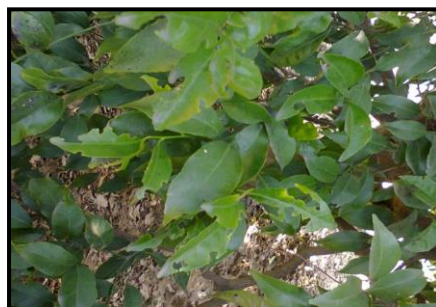
Leaves fed up to midribs.

Life Cycle

- Yellowish white, round, smooth eggs are laid singly on tender leaves and shoots by *P. demoleus*.



Citrus butterfly



Citrus butterfly infestation



Leaves fed up to midribs



Pupa

Larvae

Adult

- Egg hatches in about 3 – 8 days.
- Freshly hatched caterpillars are dark brown and soon develop irregular white markings on their body resembling bird's drop.
- The caterpillars feed voraciously on tender leaves right up to the mid ribs and defoliate the entire seedlings or the tree leaving behind only the midribs.
- The full grown caterpillar is deep green and cylindrical in form and measures about 40-50 mm in length with a hump in front and has a horn like structure on the dorsal side of the last body segment. When the caterpillar is disturbed, it pushes out from the top of its prothorax a bifid, purple structure called osmeterium which emits a distinct smell.
- Larval duration varies between 11 – 40 days.
- Pupation takes place on plant parts. Pupa which is a chrysalis is seen girdled by a fine silken thread on a twig of the plant. Adult emerges in a week in summer and in 12 – 20 weeks in winter.
- Hibernation is in pupal stage and there are 2-4 overlapping generations per year.

Management

- In small orchards and nurseries with mild infestation, hand picking and destruction of various stages of the pest.
- Natural enemies enumerated below suppress the pest population
Egg parasitoids: *Trichogramma evanescens*; *Telenomus* sp.
Larval parasitoid: *Distatrix papilionis*; *Brachymeria* sp.
Pupal parasitoid: *Pterolus* sp.
- Spraying of chlorantraniliprole (0.3ml/l) or cypermethrin (1ml/l) or flubendiamide (0.5ml/l) Spinosad (0.2ml/l)
- When the caterpillars are small. *B. t.* formulation HALT (9 g/l) is also recommended.

14.2 Citrus leaf miner *Phyllocnistis citrella* Gracillariidae: Lepidoptera

Host

It attacks all species of citrus but prefers sweet oranges. It also infests Ponagamia, jasmine etc.

Symptoms & Damage

- Characteristic silvery white zigzag galleries below the epidermis of tender leaves.
- Serious infestation causes retardation in growth. The infestation predisposes leaves to canker growth.

Life Cycle

- The pest is active all-round the year, except during severe winter (December – February). Maximum damage is caused during May-June and also during August-October, if the temperature is high enough.
- Adult is a silvery white small moth with brown striped forewings having a prominent black spot near the tip and white hindwings.
- Both pairs of wings are fringed with hairs.
- The adult moth measures 6 mm in wing span.
- Minute, flat and greenish yellow eggs are laid singly on tender leaves and young shoots. Egg period is 2-10 days.
- The tiny red, apodous larva mines in between the epidermal layers of the leaf in a zigzag manner and feeds on chlorophyll which results in distortion of the leaf lamina.
- The tunnel appears silvery white. New and tender leaves are preferred.
- Sometimes, the larva mines the outer layer of young green twigs.
- The full grown caterpillar is slender, yellowish green with brownish mandibles.
- It is found inside the gallery formed in leaf tissue. Larval period is 15-30 days.
- Pupation takes place inside the leaf mine. Pupal period is 5-25 days.
- Total life cycle takes on an average 20-60 days depending on the climate.
- There are 9-13 overlapping generations in a year.



Infestation predisposes the leaves to canker growth



Adult Moth



Zigzag galleries below the epidermis of tender leaves



Management

- Pruning of affected parts during winter and burning.
- Spraying of Neem cake solution 3ml/l or neem oil 2ml/l or imidacloprid (0.5ml/l) or cyantraniliprole (0.3ml/l) or chlorantraniliprole (0.25ml/l) twice at 10 days interval at every new flush time i.e. during June – July, Sep – Oct, Dec – Jan.

14.3 Citrus psylla *Diaphorina citri* Psyllidae: Hemiptera

Host: Citrus

Symptoms & Damage

- The damage is caused by the nymphs who crowd on the terminal shoots and buds and suck up the juice which results in Curling and cupping of leaves.
- Defoliation and death of young shoot in severe infestation and
- Fruits turning undersized and juice content reduced.

Life Cycle

- The pest is active from February to November and has 16 generations per year.
- Adults are reddish with jumping legs. Eggs are laid in tender shoots and anchored in the tissues by means of short stalks and the egg period is 8-35 days depending on the season.
- A single female lays 180 to 860 eggs.
- There are five nymphal instars and the nymphal period is 9-38 days.
- Adult life span is 135 days for males and 145 days for females.



Discoloration in leaves



Adult



Citrus Psylla



Management

- Spraying of methyl demeton (1ml/l) or imidacloprid (0.25ml/l) at seedling stage on fresh foliage twice at 10 days interval.
- Spraying of Neem cake solution (3ml/l) or neem oil (2ml/l) or imidacloprid (0.25ml/l) or cyantraniliprole (0.3ml/l) or chlorantraniliprole (0.25ml/l)

14.4 Citrus whitefly *Dialeurodes citri* Aleyrodidae : Hemiptera

Host : Persimmon and Darek

Symptoms & Damage

- Damage is caused by both the nymphs and adults.
- It sucks the sap from leaves, which curl and fall off.
- Nymphs excrete honeydew, which promotes the growth of sooty mould.

Life Cycle

- Adults lay eggs singly on the underside of soft young leaves during February.
- The eggs are stalked, oval and yellow.
- A single female during its life span of 7 to 10 days lay more than 200 eggs.
- The young larvae on emergence, crawls about for a few hours and then inserts its proboscis into the succulent portion of a twig.



Sooty mould



Adult causing damage



Eggs



Nymph



Leaf Infestation



Pseudo Pupae



Aleurotolius Marlatti
(Quaintance)



Dialeurodus Sp.

Citrus Whitefly

Management

- Removal and destruction of affected shoots.
- Spray imidacloprid (0.5ml/l) or acetamiprit (0.5ml/l) or cyantraniliprole (0.3ml/l) or chlorantraniliprole (0.3ml/l) during February, March, May-June and July-August.

14.5 Citrus bark eating caterpillar *Indarbela tetraonis*, *Indarbela quadrionotata*

Metabelidae: Lepidoptera

Host : Mango, Guava, Litchi, Orange, Pomegranate, Loquat, Mulberry, Moringa, Rose and Eugenia.

Symptoms of Damage

- Young trees succumb to the attack. Caterpillars bore into the trunk or junction of branches make zig zag galleries.
- Presence of gallery made out of silk and frass is the key symptom.
- They remain hidden in the tunnel during day time, come out at night and feed on the bark.
- Under severe infestation, flow of sap is hindered, plant growth arrested and fruit formation is drastically reduced.

Life Cycle

- Adult emerge in summer and lays 15-25 eggs in clusters under loose bark of the trees.
- Eggs hatch in 8-10 days.



Larvae



Caterpillars bore into the trunk or junction of branches make zig-zag galleries



Adult Moth

- Larvae make webs and feed making zig-zag galleries on the wood filled with frass and excreta and later bores inside the wood.
- Larval period is 9-11 months and then pupates inside the stem.
- Pupal stage is 3-4 months.

Management

- Kill the caterpillars by inserting an iron spike into the tunnels.
- Injecting ethylene glycol and kerosene oil in the ratio of 1:3 into the tunnel by means of a syringe and then the opening of the tunnel with mud.
- Dip a small piece of cotton in any of the fumigants, like chloroform or petrol or kerosene. Introduce into the tunnel and seal the opening with clay or mud.
- Spray cypermethrin (4ml/l) or imidacloprid (0.2ml/l) or cyantraniliprole (0.4ml/l) or chlorantraniliprole (0.4 ml/l) or spinosad (0.8ml/l)

14.6 Citrus fruit fly *Bactrocera dorsalis* Tephritidae : Diptera



Infestation on fruit fly maggots on ripe fruits



Brectocera Zonata



Brectocera Dorsalis



Brectocera Correcta



Fruit Infestation

Life Cycle

- Adult punctures the ripening fruits

- Infested fruits get rotten due to bacterial/fungal attack

Management

- Collection and destruction of infested fruits
- Light ploughing during winter/summer
- Use of traps (methyleugenol) @10/acre
- Spray spinosad (0.25ml/l+200 g gur/l) or indoxacarb (0.25ml/l) at 15 days interval

15. Physiological Disorder

15.1 Granulation

Sometimes, the juice sac of citrus fruit becomes harder with greyish colour and some enlargement. This causes decrease in juice content, TSS and acidity of fruit. Factors responsible for granulation include high relative humidity, high temperature during spring and delay in time of picking.

Management

- Harvest fruit at proper maturity.
- Continuous moisture regime and suggested nutrient scheduling should be followed.
- The application of fertilizer should be done according to the fertilizer schedule as the high concentration of calcium, manganese and low concentration of phosphorus and boron in plant tissues is responsible for granulation disorder.
- Granulation could be reduced to 50% by applying 2-3 sprays of NAA (300 ppm – 3.0 g in 10 liter of water) in month of August-September and October.

16. Post-Harvest Management

Citrus fruit can be stored for up to 6-8 weeks under optimum storage (0-8⁰ C temperature and 85-95% RH) which depends upon cultivar, pre-harvest conditions and post-harvest handling. Regular inspection of fruit for checking any type of decay/disorder should be ensured.

LITCHI

1. Climate

Litchi prefers moist subtropical climate for successful growth and quality fruit production. Such Condition are available at altitudes from 300-900mamsl in Himachal Pradesh. Availability of moisture in the root zone during critical developmental stages is essential for litchi cultivation. Dry weather without rains before flowering induces flower bud differentiation, blossom and consequently give high production. Rainfall during flowering time interferes with pollination and fruit setting. Seasonal variation in temperature is necessary for proper fruiting, but temperatures beyond 40⁰ C will affect strongly the productivity and quality of fruits. Litchi is affected by frost, high temperature accompanied by low humidity and hailstorm causing direct damage to fruit bud and development of fruits. Further, cloudy weather and rain during blossoming period reduce flower development and pollination because of diseases and low activity of pollinators.

Temperatures below 0⁰ C can kill young trees, though mature orchards and trees in dormant condition can tolerate light frost but severe frost incidence hinders fruit setting.

2. Topography and Soil

Litchi can grow on a wide range of soils, however, its growth and yield is optimum in well drained, deep, fertile and loamy soils rich in organic matter with pH 5.0-7.0. Avoid heavy clay soils and water-logging but rocky and compacted soils with impervious layer should not be considered at all. Litchi plants need a continuous optimum moisture regime in the rhizosphere and good aeration in soils. Litchi fruit quality and productions have been associated with good level of zinc and boron in the soil. Under undulated topography planting should be done on tracing and contouring of at least one meter width.

3. Recommended Cultivar

3.1 Dehradun

Dehradun is the most suitable litchi cultivar for production of high quality fruits. This variety is mainly grown for table purpose. It is a mid-season variety and fruits start ripening in third week of June in areas adjoining Punjab and Haryana whereas, it ripens in the first week of July in the inner parts of Shivaliks. Fruits are medium in size, obliquely heart-shaped to conical, colour at maturity bright rose pink. Pulp is greyish-white, soft, moderately juicy with TSS 17%.



Dehradun

4. Propagation

The most widely used and commercial method of propagation in litchi is air layering.

4.1 Air layering

The best time of the year to propagate litchi by air layering in Himachal Pradesh is July-August.

- Select a healthy terminal branch with a thickness of 1.2-1.5cm on a well developed tree.
- Remove the bark to make a ring of 2.5 cm width on the branch about 40-50 cm below the apical growth.

Layering in litchi



Removing of bark and cambium should be kept intact



Media preparation for layering



Air layering



Ditching air layer from mother plant



Removing of wrapping material of air layer



Drenching of air layered ball before shifting to polybags



Shifting air layer



Growing nursery



Saleable plants

- Rub off the cambium layer to expose the woody portion of the stem. Apply a paste of 2400 ppm (2.4 g/l) IBA to the exposed area and cover it with a layer of moist moss alongwith well rotten leaf compost and litchi orchard soil.
- Wrap the treated area with a piece of polythene sheet (20×25cm) and tie it well at both ends.
- The roots develop from the upper end of the ring after 45-60 days.
- Remove the layer by making a sharp cut about 5 cm below the lower end of the wrapped area.
- Before planting them in polybags, remove 50% of leaves, place the layers under shade for hardening and irrigate frequently.

5. Layout and planting

5.1 Spacing

Litchi should be planted at 4.0 m x 4.0 m accommodating 625 plants/ha.

5.2 Layout

Square or rectangular planting systems should be adopted in litchi planting. The orientation of rows should be in North–South direction.

5.3 Preparation of field, bed, planting pit and filling

- Deep ploughing should be done and raised bed (2 meter wide at bottom x 1.5 meter wide at top x 45 cm height) should be prepared one month before planting.
- Planting should be done in pits of 60 x 60 x 60 cm size dug about a month prior to planting and disinfected by intense solar radiation. Each pit should be filled with top soil mixed with farmyard manure (20kg), neem cake (1kg), and single super phosphate (500g). After filling the pit, watering is done to allow soil to settle down.

5.4 Planting

- Place the tree in the hole in such a way that it is slightly higher than ground level to allow for some sink.
- Do not place fertilizer in the planting hole as this can burn sensitive roots.
- Cut some leaves to reduce the rate of transpiration. This helps to reduce the transplanting shock and quick tree establishment.
- Planting should be done preferably during the rainy season but it can also be done during spring with availability of assured irrigation.
- Before planting the plant in the hole a soil from the basin of well growing tree of litchi should be mixed in the surrounding of young plant which contain mycorrhizae culture.
- Young trees need staking for avoiding breakage of limbs by wind. Use 50-80 cm long wooden sticks and tie the main branches with strings. Wooden sticks should be treated with chlorpyrifos @ 2 ml/litre for termite protection.

6. Canopy Management

6.1 Training

- Training of litchi tree during the initial stages is essential to provide the desired framework.
- Remove all branches below 30 cm.
- During the second phase, select 3-5 primary branches above 30 cm height in all directions. The selection of primary, secondary and tertiary branches should remain continuous during next three years.
- The orientation of primary branches should be towards periphery in all directions of the canopy at 60° angle with stem.
- Cut branches that compete with the central leader are together crisscross or having less than 45° angle.
- The centre height of plant should be restricted at 3.0 m.

6.2 Pruning

- Pruning in litchi trees has been found effective in terms of increasing productivity.
- Harvesting the fruit with the panicle along with 20 cm of twig induces new flush and improves the next year bearing.
- Besides bearing twigs, light pruning of other branches by heading back upto 20 cm should be done just after harvesting.

- Pruning of centrally growing upright branches should be done periodically (Once in 2-3 years) to facilitate proper aeration and light penetration inside canopy which would help in production of better yield and quality fruits.

7. Pollination

Litchi trees produce three types of flower viz. male, female and bisexual. The ratio of flowers vary with cultivar and season. The first flowers to open are male, followed by hermaphrodite functioning as females and pseudo-hermaphrodites functioning as males. It is the hermaphrodite flowers that pollinate and set fruit. Under Himachal Pradesh subtropical climatic conditions, the flowers in litchi trees emerge anytime from late January to March depending on the altitude and location. The flowering in litchi remains for about 21 days. Fruits take 60 days from setting to maturity.

Litchi needs cross pollination and honeybee is the main pollinator. 4-5 beehives (*Apis mellifera*) per hectare should be placed in the litchi orchards for improving fruit set.

8. Orchard Management

- The raised plant bed should be covered with mulching (plastic or organic mulch) to check the weed population, conserve the soil moisture and regulate soil temperature.
- Preferably organic mulching having 15-20 cm thick layer of uprooted weeds from the field is considered economic and better for production and quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree.
- Watering needs to be done regularly to maintain the soil moisture regime.

8.1 Intercropping

During the initial five years, the intercropping of different annual crops can be under taken as secondary crop as mentioned in the table to get additional income. The crops with synergy to litchi plants coupled with regional preference should be given priority. These interspaces can be economically utilized by growing suitable short duration intercrops as listed below:

Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

S. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergaurd, Parval, Colocasia, Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	–
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kideybeen (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chino podium, Coriander, Fennel, Fenugreek	–
5.	Fodder corps	Barley, Oat	Barseem, Jawar, Bajara

6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	–

9. Irrigation Management

The efficient application of water to achieve high yields in litchi orchards can be achieved with drip which maintains continuous moisture regime in the rhizosphere. The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers at 50 cm apart in each plant basin with 4.5 lph discharge. There should be a control unit/valve for each land holdings.

9.1. Irrigation Scheduling

Month	Irrigation (litres per tree biweekly*)						
	1 st year	2 nd year	3 rd year	4 th year	5 th year	6 th year	7 th year onwards
Jan.	0.75	2.0	4.0	7.0	9.0	12.0	14.0
Feb.	1.0	4.0	6.0	15.0	16.5	18.0	20.0
Mar.	1.3	5.0	12.0	15.0	16.5	18.0	20.0
Apr.	1.5	6.5	14.0	25.0	28.0	30.0	34.0
May	2.0	7.0	16.0	28.0	30.0	34.0	38.0
June	3.5	8.0	18.0	30.0	34.0	38.0	45.0
July **	1.2	4.5	10.0	19.0	22.0	24.0	26.0
Aug. **	1.2	4.5	10.0	19.0	22.0	24.0	26.0
Sept. **	0.75	2.5	5.0	8.0	12.0	14.0	16.0
Oct.	0.75	2.5	5.0	6.0	8.0	9.0	10.0
Nov.	0.75	2.5	5.0	6.0	8.0	9.0	10.0
Dec.	0.75	2.5	5.0	6.0	8.0	9.0	10.0

* Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions.

**During Rainy season from July to Sept sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops except failure of the monsoon. In bearing trees irrigation and fertilization should not be given for a period of two months before flowering i.e. mid-November to January which may otherwise interfere with the flowering period.

10. Nutrient Management:

10.1 Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months before mid February.

Age of plant (year)	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th year onwards
FYM (kg plant ⁻¹)	10	10	15	20	25	30	35

10.2 Nutrient recommendations: The amount of nutrients to be applied through fertilizers in high density orchard of litchi depends on the age of tree, condition of plant and type of soil. The nutrient dose (g/ tree) should be divided equally among the number of splits and applied

at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Age of plant (year)	Nutrient (g tree ⁻¹)*		
	N	P	K
1 st year	45	20	45
2 nd year	90	40	90
3 rd year	135	60	135
4 th year	180	80	180
5 th year	225	100	225
6 th year	270	120	270
7 th year onward	325	150	325

*Application of N, P and K should be based on soil/leaf test values.

Nutrient	After Harvest (July- Aug)	Pre-flowering (Jan-Feb)	Flowering to Fruit set (Mar-Apr)	Fruit (May-Mid June)	Total
N	25%	40%	20%	15%	100%
P	40%	30%	20%	10%	100%
K	25%	20%	25%	30%	100%

Cropping

- Soil application of chelated micronutrients of 20g borax, 20g copper sulphate, 20g manganese sulphate, 20g iron sulphate, 20g zinc sulphate and 40g magnesium sulphate per tree per year in the month of January-February along with FYM application should be given.
- For better fruit set and cropping, micronutrients should be applied as foliar spray of 0.2% (2g/L) solution of the needed nutrient (fruit set and pea stage).

Important stages for yield enhancement and quality improvement in litchi

Stage	Month	Details of work					
I	September	light tillage	Pruning of interior plant canopy	–	Need based compost and NPK application on the basis of soil test	–	Dicofol 2 ml/l (2 sprays at 15 days interval)
II	Oct -Dec	light tillage	–	Cypermethrin 1ml/l (Spray I)	ZnSO ₄ 0.2% , Urea 2% (1 spray)	–	
III	Jan-Feb	–	–	Cypermethrin 1ml/l (10-15 days after first spray)	–	–	Cypermethrin 1 ml/l (one spray)
IV	Mar-Apr	light tillage	–	Cypermethrin 1ml/l	Micronutrient application @ 2ml/l (12-15 days after spray 1)	Borax 2.5 g/l (2 sprays at 15 days interval)	–

V	May-June	–	–	–	Micronutrient application @ 2ml/l	Borax 2.5 g/l	–
VI	June-July	–	Light pruning along with harvesting	–	–	–	–

11. Harvesting

- The fruits are harvested in bunches along with twigs having leaves. This enhances storage life of the fruits.
- The harvesting time of litchi is during peak summer season therefore, the fruits are picked early in the morning after drying of the dew.
- The harvested fruits are stored in shade to avoid discoloration.
- Harvesting during the rains is avoided as the wet fruits are damaged early.

Maturity Indices

The litchi fruits must be harvested at appropriate maturity time for sending to distant and local markets. Litchi is a non-climacteric fruit and therefore it does not ripen after harvesting. The fruits harvested at immature stage do not ripen properly and develop insipid taste.

- Skin colour is the most reliable criteria for assessment of harvest maturity. The fruit is said to be ready for harvesting when the pericarp becomes uniform red, (just at colour break stage i.e. the orange colour has disappeared completely or almost completely) and the protuberances have become smoother.
- For local market, the fruits should be harvested at full maturity whereas for distant markets harvesting should be done when fruits start developing rose to pink colour.
- At maturity, the tubercles on litchi fruit become less pointed and the fruits attain maximum size.
- The ideal TSS : acid ratio for harvesting of the litchi fruits is 40 or above.

12. Yield

The litchi plant initiates fruit production at the age of 3-4 years and the yield increases each year. The average yield of 80-90 kg per tree is obtained from a full grown litchi tree under optimum management conditions.

13. Diseases

13.1 Leaf, Panicle and Fruit Blight

Causal organism: *Alternaria alternata*

Symptoms:

- It is an important disease of litchi nursery plants.
- The pathogen also causes panicle blight and fruit blight.
- Initially, the symptoms of disease are difficult to differentiate from potassium deficiency.
- Symptoms appear as light brown to dark brown necrosis on the tip of the leaf
- Later, the necrosis advances towards both the margins of the leaf and the affected leaves dry up completely.

Disease cycle and Epidemiology:

- Pathogen survives in diseased plants debris on which, it can persist for one to two years.
- Conidia formed on crop debris in soil act as primary source of infection.



Litchi leaf blight



Litchi panicle blight



Litchi fruit blight

- The conidia developed on primary spots act as secondary source of inoculum.
- Wind, water and insects help in spread of conidia to the neighbouring leaves\ plants.
- 20-25°C is the optimum temperature for infection by *A. alternata*.

Management:

Cultural Methods

- Collection and destruction of the infected plant debris.
- Follow crop rotation for at least two years

Chemical Methods

- Spray the crop with Copper oxychloride @3g / litre or Thiophanate methyl @ 0.5 g/litre or mancozeb (2.5g/litre) and repeat at an interval of 10 to 14 days.

13.2 Twig Blight and Anthracnose

Causal organism: *Colletotrichum gloeosporioides*

Symptoms:

- Necrosis of leaves on new shoots, foliar blight and tip dieback are major symptoms.
- The affected leaves give scorch appearance.
- On fruits, brown pinhead lesions appear that later turn to circular dark-brown to black sunken lesions on mature fruits.

Disease cycle and Epidemiology:

- Primary source of inoculum in the spread of the disease is in the form of mycelia in infected leaves, dried twigs and fallen debris. The pathogen can survive saprophytically for a long duration in dead tree parts. Conidia produced in acervulus serve as secondary source in the spread of the disease.



Litchi twig blight



litchi anthracnose

- Prolonged period of rainfall during flowering helps in severe outbreak of the disease.
- The temperature range of 30-32°C and relative humidity 80-95% are favourable for infection.

Management:

- Spray of Copper oxychloride (3g/litre) or Carbendazim (1g/litre) or difenconazole (0.5ml/litre) or azoxystrobin (0.25 ml/litre)
- Spray of fungicides before harvesting help in extending post-harvest life.

13.3. Fruit Rot

Causal organism: *Colletotrichum* spp

Symptoms:

Initially symptoms are seen on injured portion of the fruits. The decayed areas get depressed and rot gradually penetrates deep into the pulp. Fruits emit an odour of fermentation.

Disease cycle and Epidemiology:

- Primary source of inoculum in the spread of the disease is in the form of mycelia in infected leaves, dried twigs and fallen debris. The pathogen can survive saprophytically for a long duration in dead tree parts. Conidia produced in acervulus serve as secondary source in the spread of the disease.
- Prolonged period of rainfall during flowering helps in severe outbreak of the disease.
- The temperature range of 30-32°C and relative humidity 80-95% are favourable for infection.



litchi fruit rots

Management:

Cultural Methods

- Prevention of physical injuries during harvesting.
- Precooling and maintenance of the optimum temperature and relative humidity during storage and transport of fruits is effective.
- Use of Corrugated Fibre Boxes of 2 kg capacity for stacking for transportation.

Chemical Methods

- Spray of carbendazim (1g./litre) 15-20 days before harvest.

13.4 Root Rot and Wilt

Causal organism: *Fusarium solani*

Symptoms:

- A slow decline and a sudden death of plant occurs.
- Symptoms can occur in the whole tree or just one or two branches.
- Wilting of branch occurs followed by the decline of new growth on the affected branch in sometime. Tips may die without wilting.
- There can be temporary recovery but subsequent death. Parts of the tree flush and grow, while other sections die.
- Root rot occurs and kills the tree in some areas.
- Internal red discoloration of roots occurs and leaf shed never occurs.



litchi fruit rots

Management:

Natural/ Biological Methods

- Apply castor cake or neem cake as manures along with biocontrol agents like *Trichoderma harzianum*, *T. viride*, *Pseudomonas fluorescens* etc.

Chemical Methods

- Drench rhizosphere soil with hexaconazole (1ml/litre) or carbendazim (1 g/litre).
- Do not plant litchi trees on waterlogged soils or in low-lying field.

14. Insect Pest Management

There are number of insect-pests infesting litchi. Important insect-pests prevalent in sub tropical zone of Himachal Pradesh are listed below:

14.1 Litchi fruit borer *Conopomorpha sinensis* Bradley Gracillariidae :Lepidoptera

Host : Also known as the litchi stem-end borer in China and the litchi fruit borer in Thailand, is the major pest in most seasons.

Life Cycle:

- *C. sinensis* lays yellow, scale-like eggs 0.4 x 0.2 mm long on the fruit any time after flowering, as well as on new leaves and shoots.
- Both litchi and longan are affected. The eggs hatch in three to five days, with the larva immediately penetrating the fruit, leaf or shoot. They tunnel through the flesh of the fruit that often fall from the tree.

Damage:

- Litchi fruit and shoot borer causes losses to fruit and shoot, to the tune of 24-48% and 7-70% respectively.
- The insect damage the newly emerged shoot during the Sept-Oct resulting in failure of shoot to bloom.
- Female moth lays eggs on shoots, flowers buds; calyx and newly emerged caterpillars enter inside the fruit through peduncle and in shoots through cortex region of the new shoot.



Adult Moth



Borer infestation



Larvae damage

Management:

- Bearing trees should be inspected during early flush development and sprayed if necessary. The leaf flush before flower initiation is very important as it supplies the carbohydrates needed for fruit development. If 30 to 40 percent of the larvae are parasitised, spraying is not recommended. Young, non-bearing trees do not need to be sprayed either. This also allows the parasitoids to build up in the orchard.
- Spray with spinosad (0.25ml/l) or cypermethrin (1ml/l) or indoxacarb (0.25ml/l) or imidacloprid (0.5ml/l) or cyantraniliprole (0.25ml/l) or chlorantraniliprole (0.3ml/l) at pre bloom stage.
- Spray litchi plants at fruit set and repeat spray twice with the pesticides listed above at any interval of 15 days.

14.2 Erinoose mite *Aceria litchii* (Keiffer) Acari : Eriophyidae

Host: Litchi

Damage:

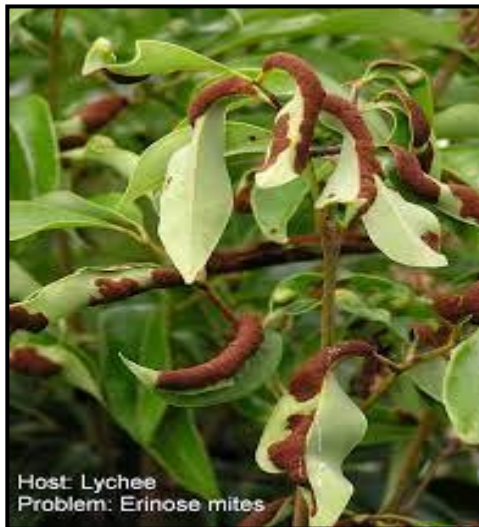
- The mites attack new leaves causing a felt-like erineum to be produced on the under-surface.
- This forms as small blisters but may eventually cover the entire leaf, causing it to curl.
- In severe cases, whole terminals may be deformed.
- The young erineum is silver-white, changing to light brown and dark reddish-brown, and eventually black.
- The greatest numbers of mites are found in the intermediate stages.
- Many leaves are ruined if infestations are severe. This generally causes no problems in established trees, but can debilitate young orchards. There can also be a problem if the mite moves from leaves onto the developing flowers and fruit. Fruit set can be disrupted or the fruit deforms. Such fruit are unmarketable.



Microscopic view of Mite



Mite infestation in Litchi



Severe infestation of litchi mite

Life Cycle:

- Females lay eggs singly on the leaf surface amongst the erineum induced by their feeding.
- The eggs are only 0.032 mm in diameter, spherical and translucent white.
- The mites are also small, only 0.13mm long and pinkish-white.
- All stages have only four legs, but are quite mobile and move easily from old leaves to infest new flushes. Their feeding stimulates the production of the erineum where they shelter and feed.
- Numbers vary with the cycle of shoot growth, and are highest in summer and lowest in winter.
- Planting material obtained as marcots may be infested if they have been taken from trees with the mites.
- Later infestations occur when the mites are moved around the orchard by direct contact between trees, or carried around by orchard workers, wind and bees.

Management:

- Numerous species of predatory mites, particularly those from the Phytoseidae, have been recorded with *A. litchii*.
- Branches infested with the mite should be cut off and burnt.

- The mites can be controlled by applying insecticides when they move from the older leaves to a new flush. The leaves should be checked regularly for symptoms over summer and autumn.
- Chemicals recommended include are fenazaquin (0.5ml/l) or fenpyroximate (0.5ml/l) or spiromesifen (0.5ml/l).

15. Physiological Disorder

15.1 Fruit Cracking

Fruit cracking is dominant disorder in litchi causing 5-70% losses. It is seen in orchards experiencing moisture stress after fruit set and if the drought is severe enough, fruit development is affected.

Symptoms:-

- The symptoms may vary from short cracks, generally skin deep to larger ruptures extending to most of the length of the fruit.
- As the underlying aril gets exposed to dry air, it withers rapidly.
- The cracks on the skin may be longitudinal or horizontal.

Causes :-

- This may occur as a varietal character.
- The disorder is promoted by high temperatures, low humidity and low soil moisture conditions during fruit development. Sharp fluctuations in the day and night temperature coupled with heavy irrigation after dry spells contribute towards fruit cracking.
- Deficiency of nutrient like Calcium and Boron.
- Hot wind during summer and over maturity of fruits.

Management:-

- Apply calcium @ 2 g/l as spray and Gibberellins @ 20 mg/l.
- Spray NAA@ 20 mg/litre.
- Constant moisture and appropriate humidity are needed at the time of fruit maturity. Irrigation at 30-40% depletion of available soil moisture is quite helpful in reducing cracking of fruits.
- Installation of drip as well as micro sprinkler below the canopy area has been reported to be effective in reducing the fruit cracking.
- Mulching plays a big role in stabilizing the temperature and moisture level in root zone.
- Planting wind break around the orchard provides protection from desiccating hot winds.
- Boron sprays in the form of Boric acid @ 2g/l at the initial stage of aril development with enough soil moisture in the root zone checks fruit cracking significantly.

15.2 Sunburn

Sunburn also known as lesion browning or pericarp necrosis is a serious problem in litchi producing areas. Climatic factors and cultivars in particular growing areas are determinants for incidence and severity of sunburn.

Causes

- This disorder is physiologically related with PPO (Poly-phenol Oxidase) activity.

- Sunburn is pronounced in ill managed orchards having sandy or sandy loam soils or light soils receiving/exposed to high temperature ($>40^{\circ}\text{C}$) and very less RH ($<50\%$).

Management

- Irrigation at regular interval during the fruit growth and ripening stage reduces the sunburn.
- Planting wind break around the orchard provides protection from desiccating hot winds, thereby reduce sunburn.
- Irrigation through sprinkler system during hot hours increases humidity, cools the orchard atmosphere and thus decreases the incidence of sunburn.
- In light and sandy soil only light irrigation with increased frequency (4-5 days interval) is found beneficial.
- Feeding trees with sufficient quantities of organic manures particularly compost, FYM, cakes, green manure, vermi-compost along with applied irrigation at regular interval during fruit development and ripening stage have been found useful.

15.3 Retarded/ Underdeveloped Fruits

- The fruit size remains smaller than the normal and juice content or aril development is also very poor. This type of fruits remain in glossy pale green in colour for a longer period, and reddish colour appears and drop prematurely.
- Lack of proper fertilization because of less visits of pollinators may lead to improper fruit set and retarded fruit growth. Insect-pests attack and physical jerk also cause retarded or underdeveloped fruits.
- Lack of moisture during developmental stage promotes the development of retarded fruits.

Management

- Ensure proper nutritional management of orchard.
- Putting enough number of honey bee colonies during flowering to fruit set stage increases fruit set with better fertilization leading to normal and healthy fruit growth.
- Spraying plain water in early morning hours of the day during the advanced stage of growth and development have been found highly effective in better growth of fruit and quality.
- Arrangements of sprinklers system of irrigation has also been found to be effective in reducing this disorder.

16. Post-Harvest Management

16.1 Grading

The quality of litchi for export Should be:

- (i) Fruit sound, fresh in appearance, clean, free from any visible foreign matter, free from pests and damage and abrasion.
- (ii) Should have minimum equatorial diameter of 23 mm.
- (iii) Should comply with the residue levels of heavy metals, pesticides and other food safety parameters as laid down by the Codex Alimentarius Commission for exports.

16.2 Packaging

- The litchi bunch must include more than three attached and well-formed fruits. The branch must not exceed 15 cm in length.

- The fruits are packed in wooden boxes, baskets or cardboard boxes for sending to local or distant markets.
- Cardboard boxes are generally used for export of litchi fruits.
- The most commonly used packing size for litchi fruits is 10-20 Kg/ pack. Each bunch inside a box is packed separately.

16.3 Storage

- Litchi fruits can be stored at room temperature for 3-4 days, thereafter, the fruits start turning brown.
- The fruits can be stored for 3-5 weeks by packing in perforated polythene bags at 90- 95 % relative humidity.
- Fruits treated with 2% sodium hypochlorite can be stored satisfactorily in perforated polythene bags at 0-30⁰ C for 25 days.
- Controlled atmosphere storage (3-5% O₂ and 3-5% CO₂) reduces skin browning and slows down the losses of ascorbic acid, acidity, and soluble solids. Exposure to oxygen levels below 1% and/or carbon dioxide levels above 15% may induce off-flavors and dull grey appearance of the pulp.

GUAVA

1. Climate

In Himachal Pradesh, guava is extensively adapted to sub-tropical regions from 410 to 1200 m of altitude amsl. The guava tree grows well in a temperature range of 23-38°C but below 15°C, the plant growth slows down. It can tolerate extended drought, however it is vulnerable to severe frost (lower than – 2°C) affecting especially the young trees.

2. Topography and Soil

Guava is a hardy tree with deep root system. The best productivity of guava is achieved in loamy soils with good drainage. Heavy clay soils are not suitable for guava planting. The sloppy wastelands characterized with undulated topography of subtropical regions are also considered good for its cultivation. However, on sloppy terrain there is quick depletion of moisture, thus necessitating frequent irrigation. Under such situations contouring and terracing with one-meter wide flat strip should be followed for better productivity.

3. Recommended Cultivar

Cultivars Shweta, Lalit, Sardar, Allahabad Safeda, Hisar Safeda and are best suited for cultivation in the subtropical areas of the state.

1. Shweta :

Fruits are round weighing 225 g, white pulp with good keeping quality and round shaped fruit.

2. Lalit :

Fruits are round in shape with pink coloured pulp. The TSS is around 11-12° Brix.

3. Sardar:

Fruits are spherical and meaty, seeds are soft and in plenty, pulp is white and tasty, contains 130 mg vitamin C/100 g pulp.

4. Allahabad Safeda:

Fruits are big in size, round, smooth skin, white pulp, soft, firm, light yellow and on ripening develop very sweet taste, pleasing flavour

and have few seeds. It is the most popular variety in India and is the progenitor of many Indian varieties.

4. Propagation

Wedge grafting technique has been standardized and adopted for commercial mass multiplication of guava in nursery with more than 95% success. The polybag raised, grafted plants have better success and growth on farmers' field.



Shweta Fruit



Lalit Fruit



Sardar Fruit



Allahabad Safeda fruit

4.1 Wedge Grafting

Raising seedling rootstocks

- a) Remove the seeds from ripe guava fruits during August-September. Wash the seeds thoroughly to remove the pulp from the fruit and dry the seeds under shade. Seeds can be stored in a sealed container for planting later.
- b) Guava seeds are placed in hot water for 5 minutes to break seed dormancy.
- c) Place the seed in potassium nitrate solution (2g/l) for three hours for enhancing seed germination rate.
- d) Fill the seedling trays with potting mixture and place two or three seeds in each cell, cover seeds slightly with the medium.
- e) Seeds can also be sown in raised beds under protected structure.
- f) Apply water until medium is wet. Place the seedling trays in warm covered place. Germination takes place in 2-4 weeks depending upon the temperature.
- g) Transplant to polybags when the seedlings have at least two sets of leaves (15 cm high).
- h) Root pruning of main secondary roots should be done at the time of transplanting for better establishment.
- i) A light fertigation should be done with NPK 19:19:19 (1.0g/l) as a starter solution immediately after planting.

Grafting

- Easiest method of grafting in guava is wedge grafting. It produces a very strong joint which can withstand under windy conditions. Grafting is easier than air layering.
- Scion should be one year old hard wood i.e. available at the base of guava shoot.
- Two (2-3 cm long) cuts are given on each side of scion to prepare wedge.
- Head back the rootstock 22-25 cm above the pot medium surface, then cut a slit 2-3 cm down the centre of stem.
- Wedge of scion should be slipped into the slit cut of rootstock. Line up the surface of scion and stock at least on one side so that the union of scion and stock feels smooth, if not possible on both the sides.
- Wrap the graft with grafting/budding tape (12 mm wide). Start from 1cm below the bottom end of joint and move upward, be sure to completely cover upto 1cm above the top of the joint if necessary give a second wrap moving the tape downward along the joint.
- Place the newly grafted seedlings in a 50 % shade net house.
- Put a polythene cap over the grafted plant. Two weeks after grafting the terminal bud will start growing. As leaves start to develop from scion bud, the cap should be removed.

5. Layout and Planting

5.1 Spacing

Guava cultivars should be planted at 3 × 3 m for raising a high density orchard.

5.2 Layout

Orchard layout in North-South orientation on square or rectangular system of planting should be adopted for guava plantation.

5.3 Preparation of field, bed, planting pit and filling

- Deep ploughing should be done and raised bed (2 meter wide at bottom x 1.5 meter wide at top x 45 cm height) should be prepared one month before transplanting.
- A month prior to planting, pits measuring 60×60×60 cm should be dug and allowed to be disinfected by intense solar radiation. Each pit should be filled with top soil mixed with farmyard mature (20kg), neem cake (1kg), and single super phosphate (500g). After filling the pit, watering is done to allow soil to settle down. Irrigation is provided immediately after planting through drip. The best season for transplanting is rainy season, however, early spring planting can be done if there is assured irrigation.
- Young plants are prone to lodging and breakage due to strong winds, hence, staking should be done to keep plants straight and avoid damage. Wooden sticks (50-80 cm long) treated with chloropyrifos (2ml/litre) can be used for staking.



High density of planting of Guava in slopy undulating topotraphy

5.4 Planting

- During planting, care should be taken so as to ensure that the mark of potting mix on plant is a little bit above the ground level, so that some sinking of plant after trans planting can be tolerated.
- Press the soil gently towards roots after filling the pit to half, fill the hole with water until it overflows, then fill it completely with soil.
- No fertilizer should be kept in the hole during planting, as this can harm delicate root system.
- Polybag raised plants can be planted without disturbing their root.

Raising of seedling rootstocks



Seed extraction method



Layout of sheet for seed drying



Guava seed drying



Seed treatment with potassium nitrate



Seed sowing on raised bed



Seed germination



Seedling ready for transplanting



Root pruning of seedling



Planting of seedling in the poly bag



Seedlings ready for grafting

Wedge Grafting



Heading back of seedling and preparation for wedge grafting



Preparation of scion wood



Preparation of 'V' shape cut on scion bottom



Insert scion on rootstock



Wrapping of stock-scion union with polythene



Capping of polytubes



Successful Grafts

6. Canopy management

6.1 Training and pruning:

In early years of planting, strong framework of the plant has to be developed by allowing widely angled branches and removal of weak crotch angles.

During training period heavy heading back cuts should be done to maintain vigour of shoots. Productive plants need pruning to maintain the appropriate size and shape. Proper training & pruning practices help to increase yield, quality of produce and reduces the incidences of pests and diseases.

6.2 Crop regulation for winter guava production

The primary blooming season for guava in Himachal Pradesh is early spring (March/April) which production crop harvested in rainy season. The rainy season crop is usually infested with fruit fly, produce is poor in quality and insipid in taste. Whereas, the bloom during June-July (mrig bahar) produces winter crop during November-February-March which is considered to be of premium quality. To induce flowering during July, pruning should be done in May (depending upon the microclimatic condition) and second pruning should be done during August-September end to reduce excessive shading and improving fruit size. Both type of pruning i.e. heading back and thinning out should be done so that sunlight must reach interior canopy area throughout the growing and cropping period.



Training of Guava under High density planting



Developed canopy under High Density Planting

TRAINING AND PRUNING SCHEDULE FOR HIGH DENSITY ORCHARDING OF GUAVA

High Density Planting



Field Planting
(3.0×3.0m)



Heading back the trees at a height of 60 cm from the ground level after 3 months of planting



New shoots emerge below the cut point and lowermost shoot should be 30cm above the ground



Retain 3-4 shoots (equally spaced in all directions) 15cm apart and 30 cm above ground level



**Prune the shoots after 3-4 months of shoot growth
(Cutting back to 50% of their total length (shoot length should be 70-80 cm) i.e. upto 35-40cm heading back**



After winter (1st fortnight of February) Shoot pruning should be done by heading back to 50% of their total length (shoot length should be 70-80 cm)



During 1st fortnight of May Shoot pruning should be done by heading back to 25% of their total length (shoot length should be 70-80 cm)



For winter season fruiting, Shoot pruning during 2nd fortnight of May-June to induce cropping



During end of August-1st fortnight of September pruning of non-bearing shoots to 25% of total shoot length and thinning out of crowding shoots should be done)



Continue shoot pruning (50%) during May-June every year for winter cropping and to maintain the tree shape and size

7. Pollination

The flowers of guava are bisexual, self-pollinated and do not require any pollinizer. 4-5 bee colonies/ha can be maintained in the orchard for better fruit set and proper cropping.

8. Orchard soil management

8.1 Mulching

The bed should be covered with mulching (plastic or organic mulching) to check the weed population, conserve the soil moisture and regulate soil temperature. Preferably organic

mulching having 15-20 cm thick layer of uprooted weeds from the field is considered economic and better for production and quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree.

8.2 Intercropping

During the initial two years, the intercropping of different annual crops can be under taken as secondary crop as mentioned in the table given below to get additional income. Inter-cropping should be avoided during rainy season

Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

Sr. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergaurd, Parval, Colocasia , Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kideybeen (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chino podium, Coriander, Fennel, Fenugreek	
5.	Fodder corps	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	
8.	Fruit	Strawberry	

9. Irrigation management

- Adequate irrigation supply is critical at fruit development stage to get better yield and quality of fruits. In the reproductive phase water stress is beneficial at the time of flower bud differentiation, but during the plant growth water stress should be avoided.
- Drip irrigation systems provide the most efficient and economic management to achieve high productive yields in guava orchards. This system is recommended for commercial guava orchards. Drip has a very high efficient water use and provides a good control of fertilizer application. For young trees use one drip line 40cm away from trunk while for trees older than 3 years use one drip line on each side of the tree row 60 cm away from trunk.



Surface and sub-surface drip irrigation system

9.1. Irrigation Scheduling

Proper moisture regime should be maintained during vegetative growth to ensure good flowering and fruit development. In high density planting, in-line drippers are well suited. The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers at 50 cm apart in each plant basin with 4.5 lph discharge. There should be a control unit/valve for each land holding. The irrigation schedule is given below for guava orchards and it is applicable for drip irrigation.

Irrigation schedule

Year	Irrigation (litres per tree biweekly*)
1 st	4-6
2 nd	10-15
3 rd	18-22
4 th and above	25-30

*Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions. During Rainy season from July to Sept sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops except failure of the monsoon. Irrigation should not be given after harvesting until 10 days before pruning i.e. end of May to 1st week of June for winter crop during 3rd year onwards.

10. Nutrition Management

10.1 Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement 15 days before pruning.

Age of plant (year)	1 st	2 nd	3 rd	4 th year onwards
FYM (kg plant ⁻¹)	10	10	15	20

10.2 Nutrient recommendations: The amount of nutrient to be applied through fertilizers in high density orchard of guava depends on the age of tree, condition of plant and type of soil. The fertilizer dose (g/ tree) should be divided equally among the number of splits and applied at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Age of the Tree (year)	Nutrient (g tree ⁻¹)*		
	N	P	K
1st year	120	60	60
2nd year	240	120	120
3rd year	360	180	180
4th year onwards	480	240	240

*Application of N, P and K should be based on soil/leaf test values.

Stages of nutrient application:

Stage of application	N (%)	P (%)	K (%)
After fruit harvest	40	60	20
During fruit set	40	40	20

Fruit growth	20	-	60
Total	100	100	100

Cropping

- Soil application of chelated micronutrients of 20g borax, 20g copper sulphate, 20g manganese sulphate, 20g iron sulphate, 20g zinc sulphate and 40g magnesium sulphate per tree per year in the month of January-February along with FYM application should be given.
- For better fruit set and cropping, micronutrients should be applied as foliar spray of 0.2% solution of the needed nutrient (fruit set and pea stage).

11. Harvesting

Maturity Indices

The maturity of guava fruits is determined by its TSS : acid ratio, specific gravity and skin colour. TSS: acid ratio ranging from 26.0-36.0 with specific gravity <1.0 and light green to yellow colour depending upon variety and distance of transport should be considered for determining proper stage of harvesting. Harvesting should be done through hand picking with staggered harvest as per maturity of fruits.

12. Yield

10-15 kg fruit can be harvested during 2nd year of planting and 30-35 kg during 4th year of plants.

13. Diseases Management

Important diseases of guava prevalent in sub tropical zone of Himachal Pradesh are listed below:

13.1 Fruit canker

13.2 Styler end rot

13.3 Red rust

13.1 Fruit Canker

Causal organism: *Pestalotiopsis psidii*

Symptoms:

- Canker develop on young green and mature fruits.
- Infection generally occurs on green fruits.
- Symptoms also appear on buds, calyx and leaves as small, circular spots.
- Scabby, minute, brown or rust- coloured lesions of 2 to 4 mm diameter appear on the fruit, which are unbroken and circular and later tear open the epidermis in a circinate manner.
- These scabby lesions later develop raised margins and cankerous spots develop in great numbers.
- The fruit breaks open in severe cases and the seeds are exposed.
- Market value of fruits is reduced as fruits become hard, malformed and mummified.



Guava Fruit Canker

Disease Cycle and Epidemiology:

- Dormant mycelia serve as primary source of inoculum while, air borne conidia serve as secondary source of inoculum.
- A bug *Helopeltis antonii*, which punctures the young fruit for sucking juice, damages and exposes the fruit to infection by the pathogen.
- Optimum disease development requires a humid atmosphere (80-100%) and higher temperature (25-30°C)
- Disease does not occur below 15°C and RH 50%.

Management:**Cultural methods**

- Summer irrigation + Nutritional management reduces the disease.

Chemical methods

- Since the wound by insect predisposes the fruit to infection, spray the young fruits after pollination with a suitable systemic insecticide.
- Three or four sprays with Bordeaux mixture (10g copper sulphate + 10 g lime per litre of water) or copper oxy chloride (3g per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water is effective to check the disease.

13.2 Styler End Rot

Causal organism: *Phomopsis psidii*

Symptoms:

- Initial symptoms of the disease appear as circular, water soaked lesions at styler end.
- The lesions turn dark brown and increase up to 2 cm in diameter.
- Softening of the tissue occurs and entire fruit rots in a week to 10 days time.



Styler end rot affected fruits

- Numerous closely aggregated small, white or light grey pycnidia develop on infected area
- The infection reduces the nutritional value of fruits

Disease cycle and Epidemiology

- The disease appears in December and spreads fast during February- March
- Conidia are the sources of infection.
- Normally, alpha conidia are the infectious conidia and are produced above 20°C while beta conidia are produced at lower temperatures
- Both types of conidia are inter convertible and change into one another depending upon the prevailing temperature conditions

Management**Cultural methods**

- Collect and destroy the infected fruits from the planting area.

- Application of calcium chloride @ 400g per 100 litre of water in December (2nd and 4th week) should be done.
- Light Interception and distribution should be maintained in canopy through pruning and training.

Chemical methods

- Spray copper oxychloride (3g per litre of water)

13.3 Red Rust

Causal organism: *Cephaleuros virescens*, *C. parasiticus*

Symptoms:

- Symptoms of leaf and fruit spots are more pronounced than rust symptoms
- Spots on leaves may be scattered or crowded, numerous or few and vary from mere specks to big patches
- The fruit lesions are dark green to brown or black in colour and smaller than leaves.

Epidemiology and Disease cycle

- Humid weather is conducive for disease development
- The alga first spreads between cuticle and epidermis followed by penetration of the epidermal cells.
- Necrosis occur in the affected cells.

Management

Chemical methods

- Spraying the leaves in every 3 to 4 weeks with a mixture containing 340 g copper oxide, 340 g hydrated lime and 680 g ZnSO₄ in 227 litres of water.

14. Insect Pest Management

There are number of insect-pests infesting guava. Important insect-pests prevalent in sub tropical zone of Himachal Pradesh are listed below:

14.1 Guava fruit fly *Bactrocera dorsalis* Tephritidae : Diptera

Host

- It is one of the major pests of guava in India. It also infests guava, peach, citrus, ber, banana, papaya and so on.

Symptoms & Damage

- Semi ripe fruits with decayed spots.
- Dropping of fruits. Damage to semi ripe fruits is caused by both maggot and the adult.
- The oviposition punctures made by the female serve as entry for fermenting organisms.
- Maggots feed on the pulp and convert the pulp into bad smelling discoloured semi liquid mass, unfit for use.
- The fruits develop brown rotten patches on them and fall to the ground eventually.

Life Cycle

- Adult fly is a brown or dark brown with hyaline wings and yellow legs.
- Eggs are laid in small clusters of 2-15 just beneath the skin of the fruit. About 200 eggs are laid by a single female during a period of 1 month.
- Egg period is 2-3 days in March and April and prolonged up to 10 days in winter.
- Maggots become full grown in 6-29 days depending on the season.

- Maggots come out of the fruits and pupate in the soil. Entire life cycle takes about 25 days in the tropics.

Management

- Collection and destruction of fallen, rotten fruits. Collect and destroy infested fruits. For destruction infested fruits, dig a pit of 2-3 feet depth, collect all the dropped fruits and put them into pit and cover the pit with soil.
- Raking under the trees to expose the pupae of the pest to natural enemies.
- Mixing of carbaryl 10D in soils @ 50-100 g/tree.
- Install pheromone traps in the orchard at mid of canopy height @ 15 trap per ha.
- Foliar spray with malathion 2 ml/l + gur 20 g a month before harvesting the fruit crop, repeated after 15 days.
- Spray Spinosad @ 0.25 ml/l or Chlorantraniliprole (0.25ml/l) before ripening (walnut stage) and 15 days after first spray.
- Spray flubendimide/cypermethrin @ 0.25ml/l per month before harvest of crop.
- Post-Harvest Control (Heat treatment techniques):
- Hot water treatment: Submerging fruits in hot water at 43 to 46.7°C for 35- 90 min.
- Double dip method: Immersion of guava fruits in water at 40°C for 20 minutes, followed by 10 minutes at 46°C to get 100 per cent mortality of *Bactrocera dorsalis* eggs.

14.2 Bark eating caterpillar *Indarbela tetraonis*, *Indarbela quadrinotata* Metabelidae : Lepidoptera

Host: Guava, Mango, Litchi, Orange, Pomegranate, Loquat, Mulberry, Moringa, Rose and Eugenia.

Symptoms of Damage

- Young trees succumb to the attack. Caterpillars bore into the trunk or junction of branches make zig zag galleries.
- Presence of gallery made out of silk and frass is the key symptom.
- They remain hidden in the tunnel during day time, come out at night and feed on the bark.
- Under severe infestation, flow of sap is hindered, plant growth arrested and fruit formation is drastically reduced.

Life Cycle

- Adult emerge in summer and lays 15-25 eggs in clusters under loose bark of the trees.
- Eggs hatch in 8-10 days.
- Larvae make webs and feed by making zig zag galleries on the wood filled with frass and excreta and later bore inside the wood.
- Larval period is 9-11 months and pupates inside the stem.
- Pupal stage is 3-4 months.

Management

- Kill the caterpillars by inserting an iron spike into the tunnels.
- Injecting Spinosad 1.6 ml or kerosene oil in the ratio of 1:3 into the tunnel by means of a syringe and then the opening of the tunnel is plastered with mud.

- Dip a small piece of cotton in any of the fumigants, like chloroform or petrol or kerosene. Introduce into the tunnel and seal the opening with clay or mud.
- Spray spinosad 0.2ml/l or cypermethrin (1ml/l) or cyantraniliprole (0.3ml/l) or chlorantraniliprole (0.3ml/l).

14.3 Guava mealy bug *Ferrisia virgata* Pseudococcidae: Hemiptera

Host : It is otherwise called white tailed mealy bug /striped mealy bug . It is a widely distributed species in tropical and subtropical countries. It also infests bhindi, amaranthus, coccinia, colocasia, lab lab, tomato, brinjal, cashew, anona, guava, amla, grape, tobacco, pepper, cotton, betelvine.

Symptoms & Nature of Damage

- Nymphs and adults remain clustering upon the terminal shoots, leaves and fruits and suck the sap which results in:
 Yellowing, withering and drying of plants or shedding of fruits *etc.*
 Formation of sooty mould due to honey dew excretion.
 In dry weather they may move down below ground and inhabit the roots.

Life Cycle

- Female bug is apterous with two long prominent waxy filaments at the posterior end and a number of waxy hairs over the body covered with waxy powder.
- In the posterior end of the body, the dorsum has a prominent blackish patch.
- It has the habit of encircling itself by secreting thin glassy threads of wax specially when its population is less.
- Reproduction takes place both sexually and parthenogenitically, the latter being more common.



Mealy Bug on fruit



Nymphs clustering upon the terminal



- Mating takes place only once and lasts for about 12-23 minutes.
- The female lays the eggs in groups which lie under its body.
- Fecundity ranges from 109 to 185 during an oviposition period of 20-29 days.
- Incubation period is about 3-4 hours.

Management

- Deep summer ploughing up to base of the tree trunks, after harvesting to expose eggs of mealy bugs.
- Dusting chlorpyrifos 5D or Malathion 5D around tree and incorporating in to the soil.
- Spraying with acetamiprid 0.5 ml/l or imidachloprid 0.5 ml/l or chlorantraniliprole 0.3 ml/l, when severe mealybug infestation noticed on the twigs.
- Wrapping 25 cm wide, 400 gauge polythene sheets on the tree trunk 30 cm above ground level and pasting grease over it to prevent migration of freshly hatched first instar nymphs during winter (Nov-Dec) from soil to trees, one week before their emergence.

- Crawlers collected beneath the polythene sheet may be scraped with a knife.

15. Physiological Disorder

Cracking of guava takes place during winter months. Calcium chloride and Boric acid @ 400g and 100 g, respectively in 100 litre water should be sprayed. Two sprays should be done in November month at fortnight interval.

16. Post-Harvest Management

16.1 Grading

The fruits are mostly graded as per the size and colour.

16.2 Packaging

For local markets fruits are packed in baskets/crates, whereas for distant transportation fruit are packed in corrugated fibre boxes with proper cushioning using paddy straw/dried grass/guava leaves/rough paper etc. Being a delicate fruit, it requires careful handling during harvesting and transportation with proper ventilation.

16.3 Storage

The shelf life of guava is short, therefore, proper storage for long distant market is required. Mature green and partially ripe guavas are stored at 8-10⁰ C for 2-3 weeks while fully ripe guavas can be stored at 5-8 ⁰ C for 1 week at 90-95% relative humidity.

POMEGRANATE

1. Climate

Pomegranate is one of the most robust fruit, grown in a wide range of climate i.e., tropical, subtropical, arid and temperate regions. It can be grown successfully up to an altitude of 1200m above mean sea level. Pomegranate behaves as deciduous in temperate regions and evergreen or partially defoliated in tropical and subtropical areas, which also varies with cultivar. Annual rainfall of 1,000 mm with long, hot and dry summer and mild winter are conducive for its growth. The optimum temperature of 38°C is considered ideal during fruit development and maturity. However, pomegranate can easily endure temperatures up to 48°C along with desiccating winds.

2. Topography and Soil

Pomegranate performs best in deep, alluvial soils and grown successfully in sandy to sandy loam soil. Light soils having pH 6.5 to 7.0, electrical conductivity 0.5 to 1.5 dsm⁻¹ and organic carbon >1.0 percent are considered ideal for pomegranate cultivation. Pomegranate produces good quality coloured fruits in light soils. Undulated topography is common on hills of the state, so contour / terrace planting should be done at least in one-meter wide strip.

3. Recommended Cultivar

3.1 Bhagwa

Bhagwa is one of the most important cultivar grown in Himachal Pradesh on account of its dark red arils, attractive red coloured skin, soft seeded aril, good sugar:acid blend of juice and 13-14°B TSS. The fruits become ready for harvesting within 170-180 days after full bloom.



Bhagwa

4. Propagation

Pomegranate plants are mostly multiplied through cutting however in southern parts of the country, pomegranate is propagated through air-layering. In North India, where pomegranate behaves as deciduous plant, it is propagated mainly by hardwood cuttings. Pomegranate plants multiplied through vegetative means viz., stem cuttings and air layering are susceptible to challenging diseases and pests of pomegranate like bacterial blight, wilt and nematodes. Therefore, the production of quality planting material free from these maladies is of utmost importance. Nowadays, plant production through tissue culture technique has become more popular as the tissue cultured plants are uniform and free from insect-pest and diseases.



Pomegranate Cuttings

4.1 Cuttings (Hardwood)

Pomegranate plants are successfully multiplied by hardwood and semi-hardwood cuttings under mist system. Semi-hard wood cuttings of 6 month to one year old, pencil thickness and 20-25 cm length perform better. Hard-wood or semi-hard wood cutting



Root trainer raised cuttings

planted during winter season gives higher success rate. Under North Indian conditions cuttings are planted in February and July under mist system. In July, cutting should not be taken from the lateral branches producing flowers and fruits.

Pomegranate cuttings dipped in IBA (2500 ppm) for 5 minutes produce fibrous root system, which helps in better establishment of plants under field conditions. Pomegranate cuttings planted in different media viz., mixture of cocopeat and sand (4:1) or cocopeat alone promotes fast rooting and performs better. While planting, we should always treat and sanitize the cuttings with Antimicrobial compound 2-bromo-2-nitro-1,3-diol @ 500mg/litre (0.5g/litre) + carbendazim @ 1.0 g/litre for 5 minutes to reduce pests and disease infection.



Pomegranate Nursery

4.2 Tissue culture

The demand of quality planting material of pomegranate is increasing day by day, for which large scale multiplication of pomegranate plants through tissue culture is required and it is highly successful in pomegranate. Tissues culture plants are free from all kind of infection (nematodes, wilt and bacterial blight) and are true-to-type. Synchronized flowering and fruiting make tissue cultured plants more suitable for mechanical cultivation which results in better quality and high yield. It provides disease-free planting material for introduction of pomegranate to non-traditional areas. Although, this technology requires high initial investment, more care and skilled man power.

5. Layout and planting

5.1 Spacing

Pomegranate should be planted at 3.0m × 3.0m spacing, accommodating 1,111 plants/ha of Bhagwa.

5.2 Layout

Pomegranate plants should be planted in square or rectangular planting systems. The orientation of the plants should be in North–South direction.



Field Preparation



Field Layout



Pit layout

5.3 Preparation of field, bed, planting pit and filling

- Deep ploughing should be done and raised bed (2-meter-wide at bottom $\times$ 1.5-meter-wide at top $\times$ 45 cm height) should be prepared one month before planting.
- In hilly terrain, contour/terrace (1meter width) system of planting should be adopted on undulated sloppy topography.
- A pit size of 60 $\times$ 60 $\times$ 60 cm size for planting should be dug one month before planting and exposed to intense solar radiation.
- Pit should be filled with mixture of top soil, farmyard manure (20kg), neem cake (1kg) and single super phosphate (500g).
- Irrigation must be provided immediately after filling the pits to allow soil to settle.
- Planting can be done during winters or rainy season.
- Staking with wooden sticks should be provided to keep the young plants straight and avoiding damage of shoots by winds. Use 60-80 cm long wooden sticks and tie the main branches. Wooden sticks should be dipped in chloropyriphos (2 ml/l) solution for termite protection.



Raised Bed Technology



Preparation of Pit



Multi-stem system

6. Canopy Management

6.1 Training and pruning

6.1.1 Multi-stem training system

- Healthy saplings of 5-6 months old age should be planted and trained in multi-stem training system (3-4 stems) to avoid loosing stems/plants due to infestation by stem borer or any other disease.
- Training operation to develop structural framework should start after 3 months of planting, when plants attain a height of 45-60 cm which may vary from place to place
- For multi-stem system, 3-4 healthy suckers should be allowed to develop and other suckers must be removed regularly.
- All the branches up to 30 cm height should be removed.
- During the second



Training of Bhagwa plants (8-9-month age)

phase, select 3-5 primary branches above 30 cm

height in all directions. The selection of primary and secondary branches should remain continuous during the next year up to February month.

- The orientation of primary branches should be toward peripheral canopy at about 60° angles with stem.

Pruning

- Pruning should be done during winter months by removing dried twigs, inter-mingled branches, water shoots and sprouts.
- All upright growing shoots should be removed during growing period.
- To induce cropping, heading back of tertiary branches/shoots of 5 mm thickness should be practiced during winter season.
- Hard pruning of thick shoots should be discouraged.
- Major pruning is practiced during winter months and light pruning of new growth should be done during fruit setting by removing all the new water shoots and water sprouts.
- Immediately after training and pruning, apply Bordeaux paste on the cut ends (>10 mm thickness) of the plants.

Operations to be done during pre-pruning & pruning

- Spray 1.0 % Bordeaux mixture 2 days before defoliation.
- Prune the twigs carefully.
- Sterilize the secateurs with sodium hypochlorite (2 to 3 ml/l), frequently.
- Remove weeds and suckers.
- The fallen leaves/pruned shoots from the orchard must be collected and burnt.

7. Pollination

- The major crop of pomegranate in the subtropics of Himachal Pradesh should be taken from the flower flush of April-May (Ambe bahar). The flowers opening from June onwards should be removed as they appear. The flowers are on current year's growth found mostly in clusters, terminal or in axils of the leaves. Pomegranate plants carry hermaphrodite, intermediate and staminate flowers in three flushes on new and old growth. The females can be identified by the miniature fruit/bulged structure at the flower base which is the swollen ovary at the base of the bloom.

8. Orchard Management

- The bed should be covered with mulch to check the weed population, conserve the soil moisture and regulate soil temperature. Preferably organic mulching having 15-20 cm thick layer of uprooted weeds and dry grasses from the field is considered economic and better for quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree, keep mulch 10-30 cm away from the trunk. Mulching should be done in the month of February which helps in conserving moisture and reducing weed growth.
- During the initial two to three years, the intercropping of different annual crops which do not complete with main crop can be under taken as mentioned in the table to get additional income during initial years.

- Intercultural activities like weeding, irrigation and de-suckering should be performed regularly. Fast growing and non-productive suckers should be removed as early as possible so as to reduce the competition for nutrition, irrigation and light.
- The pomegranate orchards must be kept neat and clean from weeds as they may act as alternate host for several insect-pest and diseases.
- Collect the dried infected fruits and twigs regularly and burn them properly to reduce the disease and pest inoculum in the orchard.

Crops recommended for intercropping under high density planting

Sr. No.	Crops	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergaurd, Parval, Colocasia, Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	
3.	Legumes	Lentil, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kideybeen (Rajmash), Chickpea
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chino podium, Coriander, Fennel, Fenugreek	-
5.	Fodder corps	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	-

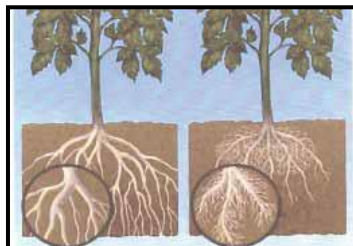
9. Irrigation management

Pomegranate requires regular optimum moisture regime in the rhizosphere right from flowering to harvesting. The water requirement of crop development and maturity period ranges from 28-45 litre/tree/biweekly. Excess or deficit moisture situation lead to cracking of fruit along with poor yield and quality. So, uniform moisture in between field capacity and wilting point is optimum. Fertigation is the most efficient way of supplying water and nutrients to the plant roots. In this, the inputs are effectively utilized by plants as these are placed near crop root zone.

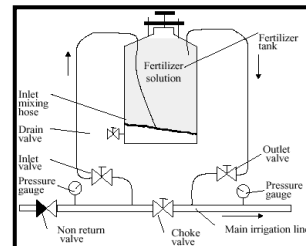
The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers at 50 cm apart each in the plant basin with 4.5 lph discharge. There should be a control unit/valve for each farmer holdings.



Water Harvesting Pond



Water pattern in Drip irrigation system



Fertigation system

9.1. Irrigation scheduling

Irrigation (litres per tree biweekly*) schedule for Pomegranate

Period	Age of plant (Years)				
	1	2	3	4	5
October	1.0	2.0	4.0	10.0	18.0
November	0.75	1.5	3.0	8.0	16.0
December	0.75	1.5	3.0	8.0	16.0
January	1.5	3.0	5.0	12.0	25.0
February	1.5	3.0	6.0	12.0	25.0
March	1.5	3.0	7.5	12.0	25.0
April	1.5	4.0	7.5	15.0	30.0
May	2.0	5.0	10.0	18.0	35.0
June	3.0	6.0	14.0	20.0	35.0
July**	2.0	3.0	7.5	15.0	25.0
August**	2.0	3.0	6.0	12.0	20.0
September**	1.5	2.0	6.0	12.0	20.0

* Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions.

**During Rainy season from July to Sept sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops except in the event of failure of the monsoon. During rainy season moisture content underneath the mulch should be maintained at optimum level. Irrigation should be given once in a week on the basis of soil moisture content keeping in view of the rains due to western disturbances.

10. Nutrition management

10.1 Manure

Well decomposed FYM should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months before mid-February.

Age of plant (year)	1 st	2 nd	3 rd	4 th	5 th year onwards
FYM (kg plant ⁻¹)	10	10	15	20	20

10.2 Nutrient recommendations

The quantity of nutrients to be applied in through fertilizers HD orchard of pomegranate mainly depends on the age of plant, condition of plant and soil type. The nutrient dose (g/

tree) should be divided equally among the number of splits and applied at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Fertigation Schedule for first 18 months (Till first Flowering)

1-18 Months Oct. to March (Days)	Duration (Days)	N=375g/Tree	P=187g/tree	K=166g/tree
October-December	90	42	21	20.5
January-March	90	42	21	20.5
April-June	90	83	42	31.3
July-September	90	83	42	31.3
October-December	90	62.5	30.5	31.3
January-March	90	62.5	30.5	31.3

Fertigation schedule for 19-24 months (Till first harvest)

19-24 Months April to September (Days)	Duration (Days)	N-63 g/Tree	P=62g/tree	K=146g/tree
April-Mid May	45	21	31	31
Mid May-June	45	21	31	31
July-August	60	21	0	84

Fertigation schedule for first 25-36 months (Upto three years)

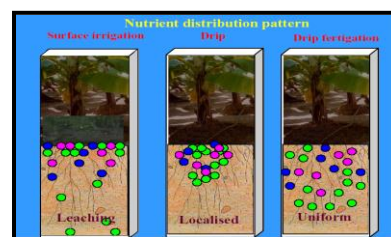
25-36 Months	Duration (Days)	N-625 g/Tree	P=250 g/tree	K=300 g/tree
October-December	45	187.5	100	25
November-December	45	No need of fertigation and irrigation		
January- February	58	187.5	75	50
March- May	90	187.5	75	75
June-July	90	62.5	0	75
August	30	0	0	75

Cropping

In hilly terrains of Himachal Pradesh, single crop of pomegranate w.e.f., August to October depending upon the altitude/microclimate is being taken up by the farmers on account of deciduous behaviour of the plants in Northern India.

For better fruit set and cropping micronutrients should be applied as foliar spray of 0.2% (2g/litre) solution of the needed nutrient (two sprays in April at 15 days interval).

Recommended soil application rates of chelated micronutrients are: about 20g borax, 20g copper sulphate, 20g manganese sulphate, 20g iron, 20g zinc sulphate and 40g magnesium sulphate per tree per year in February along with FYM application.



Nutrient distribution pattern

11. Harvesting

a. Maturity indices

Being a non-climacteric fruit, pomegranate fruits should be harvested after achieving proper maturity.

Sr. No.	Maturity Indices	Attributes
1	Fruit Colour	Reddish with waxy shining surface
2	Shape of crown and fruit	The bud at the anterior end of the fruit gets curved inside and becomes hard and dry at maturity. The fruit shape becomes compact.
3	Sound	The fruit gives a metallic sound when tapped.
4	Scratch	Properly mature fruits are easily scratched with finger nails
5	Maturity Period	The fruits become ready for harvest in 170-180 days after full bloom.
6	Aril Colour	The arils attain deep intensity of colour (Dark red- Bhagwa) with high juice recovery
7	Juice Colour	Red colour of juice in Bhagwa
8	TSS	12-14° Brix
9	Titrateable Acidity	Below 0.8%
10	TSS/acid ratio	It is one of the most reliable maturity indicators. Mature fruit have TSS/ acid ratio between 25 to 40

b. Harvesting, grading and packaging

- The fruit crop in pomegranate should be taken from second year onwards so as to allow proper growth and development of plants.
- Secateurs must be used for fruit harvesting at right maturity.
- After harvesting, the fruits should be collected in plastic crates and should be pre-cooled to remove the field heat and enhance the shelf life. Then, the fruits are graded and packed in Corrugated Fibre Board boxes. Grading is done to obtain a reasonable price in market. Cracked, damaged, diseased and infested fruits should be removed. The fruits are graded on the basis of their size, external appearance and quality.



Crop ready for harvesting

c. Crop and grade regulation

- A grown-up, well managed tree at three years age gives 80-100 fruits annually, and increases by ten percent annually of which 8-10% are of 'A' grade; 20-25% are of 'B' grade and the remaining are of 'C' and 'D' grades and cracked fruits. However, fully grown tree (4-5 years age) produces approximately 100-150 fruits per plants.
- After the fruit set, do not allow fruits to develop in clusters and keep only solitary fruits.
- Allow flower set on inner/thicker shoots to develop in to fruits, remove those which are developed terminally on weaker shoots.
- After fruit set, remove all the flowers coming thereafter.

d. Requirements for export:

Pomegranate must be carefully picked and have reached an appropriate degree of development and ripeness in accordance with criteria proper to the variety and/or commercial type and to the area in which they are grown. The development and condition of the pomegranate must be such as to enable them to withstand transport and handling, and to arrive in satisfactory condition at the place of destination. Size is determined in accordance with the weight or maximum diameter of the equatorial section of the fruit as shown in table below.

Provisions concerning sizing for export of pomegranate

Size code	Weight in grams (minimum)	Diameter in mm. (minimum)	Skin Colour and quality
A	400	90	Good attractive bright red colour and no spots on skin
B	350	80	Attractive red colour and spot free
C	300	70	Bright red and spot free
D	250	60	Fully ripe bright red and spot free
E	200	50	Fully ripe bright red and spot free

12. Yield

A fully-grown pomegranate tree of 5-6 years age will produce 200-250 fruits per plant under optimum management conditions.

13. Diseases

13.1 Bacterial Blight

Causal organism:

Xanthomonas axonopodis pv *Punicae*

Symptoms:

- On leaves one to several small water soaked, dark coloured irregular spots appear leading to premature defoliation in severe cases.
- Size of the spot varies from two to five mm in diameter consisting of necrotic centre of pin-head size.
- Spots are translucent which later turn light brown to dark brown and are surrounded by prominent water-soaked margins. Spots coalesce and give rise to large patches.
- Infection also occurs on stem and branches.
- Girdling and cracking of nodes occur on the stem following the brown to black spots around the nodes.
- Branches break down.
- Dark brown, irregular slightly raised spots with oily appearance are formed on fruits, which split open with L-shaped cracks under severe cases.



Host range: Pomegranate is the only natural host of this bacterium

Disease cycle and Epidemiology

- The bacterium survives on the tree.
- The pathogen survives for 120 days on the fallen leaves during the season.
- The primary infection is through infected cuttings and disease spreads through wind splashed rains.
- High temperature and low humidity favour the disease. Temperature of 30 to 34°C, relative humidity of 80 to 85% is favourable for multiplication of pathogen.
- Continuous/intermittent rainfall for a longer period, maximum temperature between 29.4 to 35.6°C and minimum temperature between 19.5 to 27.3°C and relative humidity from 63 to 87 % are favourable for the development and spread of the disease.

Management:

Cultural methods

- Pruning at correct stage would reduce the disease.
- Clean cultivation and strict sanitation is useful to reduce the disease incidence.
- Collect and burn the fallen leaves
- Spraying of 1 per cent urea solution to fallen leaves enhances the degradation
- Bleaching on to the fallen leaves reduces the inoculum

Chemical methods

- Spraying with Bordeaux mixture 1.0% (10g each of copper sulphate and lime / liter of water) or streptocycline@ 0.05% (0.5g per litre of water) or copper oxychloride at 0.3% (3 g per litre of water) controls the disease.

13.2 Cercospora Leaf Spot

Causal organism: *Pseudocercospora punicae*

Symptoms:

- On leaves and fruits, light zonate brown spots appear.
- These leaf spots are minute, brown in colour with yellow halo.
- Spots are scattered, circular or irregular and become dark brown with age.
- Spots on lower side are sunken with grey colour due to clusters of spore bearing structures.



Pomegranate cercospora spot on leaf and Fruits

- On sepals of the flower, minute, circular, black spots appear.
- On Fruit, black, minute and circular spots appear on rind.
- Market value of fruits is reduced as the spots grow old, become large, irregularly circular and depressed presenting an ugly look to the fruits.
- Black and elliptic spots appear on the twigs.
- The affected areas in the twigs dry up as become flattened and depressed with raised edge.

- Whole plant dies in severe cases.

Disease cycle and Epidemiology

- Infected leaves and diseased plant debris serve as primary source of inoculum
- Wind born conidia serve as secondary source of inoculum.
- The disease is serious during high humidity periods with temperature ranging between 20 and 27°C.

Management:

Cultural Methods

- Collect and destroy infected plant debris

Chemical methods

- Spray Carbendazim 1g/litre or Hexaconazole 1 ml/litre or Propiconazole 1 ml/litre and repeat at 10 to 14 days interval.

13.3 Anthracnose

Causal organism: *Colletotrichum* spp.

Symptoms

- Symptoms appear as small regular or irregularly shaped light violet or black leaf spots with yellow halos.
- Leaves initially turn yellow and then fall out.
- Symptoms appear on flowers as well.
- Both young and mature fruits develop spots which are initially circular, turning irregular with sunken centres, brown to dark brown and cover the fruit partly or completely.



Symptoms on fruits

- Minute, black dots representing acervuli are clearly visible on the fruits.

Disease cycle and Epidemiology

- The pathogen survives in affected plant parts as dormant mycelia
- Spreads through airborne conidia produced in acervulus.
- Mode of entry is through stomata
- The disease is severe during the months of August-September when relative humidity is high and the temperature ranges between 20-27°C

Management:

Cultural methods

- Removal of infected plant debris.
- On fallen leaves or affected plant parts, spray nitrogen solution or bleaching powder to enhance degradation.
- Pruning and burning of all affected branches followed by application of Bordeaux paste or Copper oxychloride paste on cut ends.

Chemical methods

- Spray the crop with systemic fungicides like Hexaconazole @1ml/litre or Carbendazim @ 1g/litre and repeat at 20 days interval.
- Foliar spray with Mancozeb (2.5 g /l) is also equally effective.

13.4 Fruit Rot

Causal organism: *Alternaria alternata*

Symptoms:

- Alternaria fruit rot is also known as black heart.
- Wounds must occur after flower initiation for the infections to occur.
- On fruits, small reddish-brown circular spots appear. As the disease progresses, these spots coalesce to form larger patches and the fruits start rotting.



Pomegranate Alternaria fruit rot

- The arils get affected which become pale brown to black and become unfit for consumption.

Host Range: Strawberry, hazelnut, pomegranate, date palm, kiwi, persimmon, okra, onion spinach, Amaranthus and many more

Disease cycle and Epidemiology:

- *Alternaria* species survive in diseased plant debris and can persist for one to two years.
- Primary infection takes place through conidia formed on crop debris in soil.
- Conidia developed on primary spots serve as secondary source of inoculum.
- Wind, water and insects help the conidia to disperse to the neighbouring leaves\ plants.
- The optimum temperature for infection of for *A. Alternate* ranges between 20-25°C.

Management:

Cultural Methods

- All the affected fruits should be collected and destroyed.

Chemical methods

- Spraying mancozeb @ 0.25% (2.5 g / litre) effectively controls the disease.

14. Insect Pest Management

There are number of insect-pests infesting pomegranate. Important insect-pests prevalent in sub tropical zone of Himachal Pradesh are listed below:

14.1 Pomegranate butterfly / Anar butterfly *Deudorix isocrates* Lycaenidae: Lepidoptera

Host : It is the most important and destructive pest of pomegranate and distributed throughout the country, also infesting guava, annona, apple, ber, citrus, litchi, tamarind, wood apple, soap nut, etc.

Symptoms & Damage

- Offensive smell and excreta of caterpillar at the entry hole.
- The affected fruits ultimately falling down.
- The fruit appears healthy but the caterpillar inside feeds on pulp and seeds just below the rind. It is only when the grown up caterpillar comes out, a round hole is seen through which juices come out.
- Feeding injury also causes rotting of the fruits. Up to 50% fruit damage is observed.

Life Cycle

- Butterfly is bluish brown with an orange spot on each of the forewings and black spots on the hindwings with a tail like extension at the lower margin of hindwings.
- It is active in bright sun.



Infested fruit

Adult

- Eggs are laid singly on calyx of flowers or tender fruits. Egg period is 7-10 days.
- Caterpillar is stoutly built dirty brown in colour, with light patches, a few short hairs and measures about 16-20 mm long.
- Larva after hatching bores into the fruit and feeds on the seeds. Entry hole heals up.
- A single fruit may harbour half a dozen caterpillars.
- Larval period is 18-47 days. The full grown larva comes out, secures the stalk of the fruit to the stem with a silky secretion, returns to inside of fruits and pupates on fruit stalk.
- Pupal period 7-34 days. Total life cycle takes about 1-2 months. There may be 4 overlapping generations in a year.

Management

- Destruction of fallen infested fruits checks the spread.
- Removal of flowering weeds especially of Compositae family.
- Though expensive, bagging of fruits with polythene or paper bags or cloth bags soon after the fruit set prevents the pest attack.
- Initiate the spray schedule with the onset of flowering with any of following insecticides:
- Cypermethrin (1ml/l) or spinosad (0.2ml/l) chlorantraniliprole (0.3ml/l) or indoxacarb (0.25ml/l)
- Repeat the spray at 15-20 day interval.
- About 3 to 4 sprays are needed for effective control of the pest, as it continues to attack flowers (flowering in pomegranate remains for a longer time).

14.2 Thrips *Anaphothrips oligochaetus* (flower and fruit thrips) *Rhipiphorothrips cruentatus* Leaf thrips *Scirtothrips dorsalis* Thripidae: Thysanoptera

Host : Pomegranate

Symptoms & Damage

- These are found through out country. *A. oligochaetus* infests flower stalks, sepals, petals and fruits with their rasping sucking type of feeding.



Microscopic view of Thrip



Adult Thrips



Thrips infestation on pomegranate



- As a result, flowers are shed and fruits show scab like rough surface.
- *R. cruentatus* and *S. dorsalis* lacerate the leaves and suck oozing out sap causing curling of leaves.

Management

- At flower bud initiation, foliar spray with acetamiprid (0.5ml/l) or imidacloprid (0.5ml/l) is effective.

15. Physiological Disorder

The major physiological disorders in pomegranate are fruit cracking, sun scald and aril browning. Proper management of these physiological disorders is essential to get good quality yield.

15.1 Fruit cracking:

Fruit cracking is a major problem in pomegranate growing areas and about 30 -50% fruit cracking has been observed during maturity. It also varies with variety, season and climate.

In fruit cracking, xylem and phloem tissue lose their ability to divide and enlarge. In summer, after a long dry spell when water supply or irrigation is resumed and meristematic tissue quickly resume growth but due to uneven growth rate fruit splitting occurs, while during winter fluctuating moisture and temperature causes cracking. Nutrients like boron, calcium, copper, zinc, molybdenum, manganese and potash are involved in different physiological activities during fruit growth and development. Deficiencies of nutrients along with imbalanced use of nutrients also cause cracking. In young orchard, fruit cracking is due to boron deficiency while in old orchard moisture imbalance and fluctuating temperature are major factors associated with fruit cracking. Fruits split generally when rains come or irrigation is given after a long dry spell.



Fruit Cracking

Management

Apply adequate and regular irrigation during fruiting season.

Spray of gibberellic acid @ 20 ppm (2g/100 litre), calcium chloride 2.0 % (20g/litre) and boron 0.2% (2g/litre) at fruit enlargement and 1 month before harvest can help in reducing cracking.

15.2 Sun Scald

During summers, sun scald is also a serious disorder in improperly managed orchards. Surface of fruits which are towards sunlight turns brownish black due to intensive scorching heat during hot months particularly during July.

Management

- Proper training and pruning is required to avoid the direct exposure of fruits to sunlight.
- Shading with 35% shade net is helpful in reducing sunburn on pomegranate fruit.
- Bagging of fruits with cover bags is also useful in minimizing sun sunscald problem. White colour bags are more efficient in reflecting sunlight.

15.3 Aril browning

It is due to delayed harvesting in which arils become brown and start rotting.

Management

- The harvesting should not be delayed beyond maturity period.
- The pomegranate fruits should be harvested as soon as they mature viz., between 170-180 days after blooming in Bhagwa.

16. Post-Harvest Management**16.1 Storage**

Pomegranate fruit can be stored for 2-3 months successfully at a temperature of 5-7°C with 90-95% relative humidity. This temperature range needs to be kept throughout the transport and further storage. The temperature should never go below the 5°C, otherwise it will result in chilling injury.

16.2 Packing & transportation

The pomegranates fruits are packed in white or red colored CFB boxes having 3-5 plies for domestic markets. The cut pieces of waste of newspaper are used as cushioning material for the fruits. The fruits can be shipped through road transport by trucks/lorries from orchards to the market.

PLUM

1. Climate

Plum is one of the important stone fruit cultivated in the mid hills region of Himachal Pradesh. The varietal requirements for chilling hours vary from variety to variety however varieties with chilling requirement less than 500 hrs can be grown successfully in subtropical condition experiencing annual rainfall of 100-125.

2. Topography and Soil

Plum can be grown successfully in wide range of soils.. However, well drained, deep, fertile sandy loam soil, are best for its the cultivation, with PH ranges from 5.5 to 6.5.

3. Recommended Cultivar

There is a wide diversity in plum cultivars but only few are suited to warm temperate climate of HP. The cultivars recommended for cultivation in mid-hill and low hill zones of Himachal Pradesh are: Frontier, Santa Rosa, Beauty, Red Beaut, Aloocha Purple, Black Amber, Kala Amritsari and Satluj Purple.

4. Propagation

Tongue grafting

Rootstocks:

Seedling: Wild peach or wild apricot seedling rootstocks

Clonal rootstock: Myrobalan B (vigorous), Pixie (dwarfing rootstock)

4.1. Rootstocks:

The plum are grown mostly on seedling rootstocks of wild apricot (Chulli), being the main rootstock for commercial plum propagation in India.

4.2 Propagation

Stratification : The plum seed requires a low temperature treatment ($<7^{\circ}\text{C}$) for 75-90 days, to break the dormancy. For this seeds are kept in the alternate layers of moistened sand.

Rootstock (seedling) raising:

- Remove the pulp and extract stones from ripe fruits, wash and keep under shade for 4-5 days to let the stones dry.
- Treat stones with ziram/thiram/captan (3g/kg of stones)
- Dried stones are stored in gunny/plastic bags in cool dry conditions until stratification during November-January.
- Place stones in alternate layers of moist sand at $\leq 7^{\circ}\text{C}$
- Stratification can be done using wooden boxes or placing seeds in well drained trenches.
- Seed dormancy is considered broken, as the seeds in upper layer start germinating.
- Remove stones or seeds carefully without causing any damage to radical or plumule from each layer.
- Germinated seeds are removed from cracked and un-cracked stones and are sown in separate beds already prepared in the nursery.
- Sowing should be done during 1st fortnight of February and sowing distance should be at $30 \times 15\text{cm}$.

Grafting:

- Tongue grafting is commercially adopted for propagation of plum. The grafting should be performed during winter months until first week of February before bud burst in scion cultivars.
- Seedlings which are 0.8 to 1.2 cm (pencil thickness) thick are good for grafting.
- Scion wood for grafting is taken from genuinely maintained mother plants of the variety, which are healthy, disease free and are one year old shoot.
- Scions should be packed in sphagnum moss after proper labelling and placed in bundles in cold store or buried in soil under shade until grafted.
- The grafting should be performed during February in low lying areas, whereas, for higher elevations March is suitable time.

5. Layout & Planting**5.1 Spacing**

Spacing of plum for high density cultivation is 4 x 4m, with a height up to 3.0 m canopy above ground level.

5.2 Layout

Square or rectangular planting systems should be adopted for plum planting. The orientation of planting should be in North–South direction.

5.3 Preparation of field, bed, planting pit and filling

- Deep ploughing should be done and raised bed (2 meter wide at bottom x 1.5 meter wide at top x 45 cm height) should be prepared one month before planting.
- Planting should be done in pits of 60 x 60 x 60 cm³ size and pits are dug about a month prior to planting and disinfected by intense solar radiation. Each pit should be filled with top soil mixed with farmyard manure (20kg), neem cake (1kg), and single super phosphate (500g). After filling the pit, watering is done to allow soil to settle down. Irrigation is provided immediately after planting by drip irrigation.

5.4 Planting

- Planting of plum should be done during December -January when the plant is in dormant conditions.
- Inward sloping terraces in hilly areas facilitate soil conservation.
- Orchard layout should be done about two month prior to planting. On slopes, contour or terrace system of layout should be adopted, while in flat land square system of planting should followed.
- Place the tree in the hole so that the nursery soil mark is slightly higher than ground level to allow for some sink. Fill the hole upto half level with soil and press it gently towards the root.
- Fill the hole with water and allow it to drain before completely filling the hole with soil. Do not place fertilizer in the planting hole as this can burn sensitive roots.
- Apply a layer of organic mulch near the root zone of the plant and extending outward with age.

6. Canopy Management

Plum plants are slow in growth as compared to peach with respect to juvenile phase. It requires less pruning than peach. Therefore, their framework should be developed similar to

that of apple with modified leader system or open centre system. Pruning of mature trees should include removal of diseased and dried wood, removal of brush wood, elimination of weak crotches, thinning out of bearing wood to allow penetration of light and spray materials, etc. so as to keep the plant at reasonable height to cultural operations. Heading back and thinning out of shoots may also be done to develop either new growth or spurs for fruiting, as the case may be, with different varieties. Training is done to give a proper shape and to develop a strong framework of branches.

6.1 Training

- In general, open centre or modified leader system are practiced in plum.
- In varieties with spreading type of growth habit open centre system (suitable for mid hills of Himachal Pradesh) should be followed.
- Whereas, modified central leader training of plant keeping 4-5 scaffold branches is considered better to avoid scorching summer sunlight.

6.1.1 Open Centre System

- Cut back the plant at 40 cm above ground level after planting. The tree produces 3-6 laterals in addition to the central leader.
- During the 1st winter allow growth of 3-5 scaffold branches with wide crotch and remove rest all branches including the central leader.
- The branches are then headed back to 1/4th of the growth
- 2-3 secondary branches should be retained on primary branches during 2nd dormant pruning. Care must be taken so that each secondary leader is placed at about 30-40 cm distance from each other.
- Leader branches are pruned more severely to maintain staggered height of secondary branches.
- Avoid overcrowding of branching by developing branch leaders at different heights through severe pruning of vertically growing branches.
- This completes the formation of a head (crown) and the selection of secondary branches.

6.1.2 Modified leader system

- It takes 3 years for a plum plant to be trained on modified leader system.
- The transplanted plants (about 1.0 m high) should be cut back to 40-45 cm in the first half of the January, branches, if any on the main stem should also be pruned to short stubs.
- During the first dormancy, select 4-5 branches at 15-20 cm vertical height from one another around central branch axis and remove all other branches from the axis which at this stage is allowed to grow as leader.
- First branching should be maintained at least about 30 cm above the ground.
- During second year the primary branches will produce secondary limbs, as the plant grows new branches will come out from the first year extension growth.
- With tree growth in 3rd year many new shoots arise from primary and secondary shoots.
- Keep only the wide angled shoots which are evenly spaced and remove all other branches.
- Head back the central leader adjacent to outward growing lateral branch, when a good framework of the plant has been developed at the end of the year.
- As a result a plant trained on modified leader system becomes ready to bear fruit.

6.2 Pruning

- In general, plum varieties bear fruits on spurs, while some fruiting takes place laterally on one year old shoot. The spurs bear for 5-6 years. So, it requires pruning in each year to promote spur renewal.
- To obtain proper fruiting, plum trees should grow 25-30 cm every year. For this, head back to 50% and 25-30% thinning in Santa Rosa is done in Himachal.
- All the dried/dead, broken and diseased wood should be removed during pruning.
- The scaffold branches should start at least 30 cm above ground and other scaffold are kept at 15 cm away from each other in a spiral arrangement, branches with wide angle are retained others are removed.
- Head back the central leader in first dormant pruning allowing growth of scaffold branches which are pruned by removing 1/3rd growth. Other weak/unwanted branches arising from main stem are removed.
- 2-3 suitably spaced branches on primary scaffold are retained during second winter pruning which are pruned to 1/3rd-1/4th of their length.
- The undesired, weak and crowding branches are removed during pruning, besides water sprouts, dried/died, diseased and intermingling branches.
- A balance has to be maintained in vegetative and reproductive growth of the plant through pruning in bearing trees. Only light and corrective pruning is required during pre-bearing period.
- Heavy heading back should be avoided as it encourages, development of long upright water sprouts.
- Regularly remove all the water sprouts coming out from crown portion of the plant. Heading back of lengthy branches to 50% should be performed after cropping for 4-5 years.
- Bordeaux paste/paint should be applied on each cut which is thicker than thumb thickness (>10mm).

7. Pollination

- Most plum cultivars are self unfruitful/ partial fruitful and need pollinizers. Partially self fruitful cultivars such as Santa Rosa also get benefited in fruit set when planted with pollinizer.
- For Frontier, Red Beaut and Black Amber - Santa Rosa (P) and for Satluj Purple, Kala Amritsari (P) should be planted as pollinizer.
- Pollinizer should be planted as alternate plant in alternate rows for maximum yield. To ensure proper pollination and fruit set to get better yield, each alternate plant in every alternate row should be of pollinizer, with provision of 4-5 strong beehives per hectare.
- In case, the cultivars produce little or no pollen, a branch of pollinizing variety should be grafted on every tree.

* P- Pollinizer

8. Orchard Management

8.1 Mulching

The bed should be covered with mulching (plastic or organic mulching) to check the weed population, conserve the soil moisture and regulate soil temperature. Preferably organic

mulching having 15-20 cm thick layer of uprooted weeds from the field is considered economic and better for production and quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree.

8.2 Intercropping

During the initial two years, the intercropping of different annual crops should be under taken as secondary crop as mentioned in the table to get additional income. Inter-cropping should be avoided during rainy season

8.3 Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

Sr. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergaurd, Parval, Colocasia, Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	-
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kideybeen (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chino podium, Coriander, Fennel, Fenugreek	-
5.	Fodder corps	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	-

9. Irrigation Management

- Plums are shallow rooted hence need sufficient moisture during growing period. Irrigation at alternate day interval may be applied during March, April and May. No irrigation at full bloom stage and the ripening stage is given to avoid flower and fruit drop. There should be no irrigation given after June to January months.
- Adequate irrigation supply is critical at fruit development stage to get better yield and quality of fruits. Drip has a very high efficient water use and provides a good control of fertilizer application. For young trees use one drip line 40cm away from trunk while for trees older than 3 years use one drip line on either side of the tree row 60cm away from trunk.

9.1. Irrigation Scheduling

Adequate moisture is required during the vegetative growth for optimum flowering and fruit development. In-line drippers are well suited. The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers at 50 cm apart in each

tree basin with 4.5 lph discharge. There should be a control unit/valve for each land holdings. The irrigation schedule given below is recommended for plum orchards.

Irrigation schedule

Year	Irrigation (litres per tree biweekly*)
1 st	4-5
2 nd	6-10
3 rd	15-20
4 th	22-25
5 th and above	27-30

* Approx. amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions. Being deciduous, the plums do not require frequent irrigation during winter. During rainy season from July to September sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops, except in the event of failure of the monsoon.

10. Nutrition Management

10.1 Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months before mid February.

Age of plant (year)	1 st	2 nd	3 rd	4 th year onwards
FYM (kg plant ⁻¹)	10	10	15	20

10.2 Nutrient recommendations: The amount of nutrient to be applied through fertilizers in high density orchard of plum depends on the age of tree, condition of plant and type of soil. The nutrient dose (g/ tree) should be divided equally among the number of splits and applied at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Age of the Tree (year)	Nutrient (g tree ⁻¹)*		
	N	P	K
1st year	50	25	40
2nd year	100	50	80
3rd year	150	75	120
4th year	200	100	160
5th year onwards	250	125	200

*Application of N, P and K should be based on soil/leaf test values.

10.3 Stages of nutrient application:

Stage of application	N (%)	P (%)	K (%)
After fruit harvest	40	40	20
During fruit set	40	40	20
Fruit growth	20	20	60
Total	100	100	100

Cropping

Plum is deciduous plants which come into flowering in the month of February with creamy white coloured flowers on short spurs. For better fruit setting 2-3 varieties should be planted in the orchard. The bearing starts at the 4th year of plantation under normal conditions. For better fruit set and cropping micronutrients should be applied as foliar spray of zinc sulphate @ 2.5 g/ litre, boric acid 1g/ litre of water.

Improvement in Fruit Quality

Two foliar sprays of potassium nitrate @1.0% (1 kg/100 litre water), first spray after two weeks of full bloom and second 10 days thereafter, increases the fruit size and yield of plum. Care should be taken that no water stress should be there in the orchard at the time of spray.

11. Harvesting

Plum is a non-climacteric fruit and is considered mature when fruit has developed to its typical size and colour. Main harvesting season for plum in subtropics of Himachal Pradesh starts from second fortnight of May onwards in accordance to the altitudinal variations. Colour change from green to purple red/yellow (as per variety) is the first sign of fruit maturity. Harvest the fruit with intact pedicel at firm stage when ripe for local market. Whereas, fruit should have developed 50% colour for distant markets.

Handle the perishable fruits carefully. Use baskets padded with soft dry grass in bottom and on sides for picking of fruit. Keep fruits in shade immediately after harvesting and avoid injury. Fruit for nearby markets should be picked in early morning. Staggered pickings are required in plum due to non-synchronous maturity of fruits.

12. Yield

Plum plant starts bearing commercial fruits in 3-4 years of planting. The average yield per tree in 5th year is 10-15 kg whereas, during 7th year onward a well managed tree yields 30-35 kg fruits/plant.

13. Diseases

Plum is a hardy plant and crop is for short duration on tree which experiences very less incidence of any economically important diseases.

14. Insect Pest Management

There are number of insect-pests infesting plum. Important insect-pests prevalent in sub tropical zone of Himachal Pradesh are listed below:

14.1 American plum borer *Euzophera semifuneralis* Pyralidae : Lepidoptera

Host : peach, plum

Symptoms & Damage

- Larvae bore into the tree leaving reddish orange frass and gum pockets.
- The boring is most damaging to the scaffold crotches or graft unions of young trees.
- Vigorous trees will heal over, but with heavy, prolonged infestations, scaffolds may break with wind or a heavy crop.

Life Cycle



Larvae bore into the tree trunk

Adult moth

- The forewings of the adult moth are gray with brown and black markings.
- The wingspan is about 0.75 inch.
- Young larvae are white with a large, dark brown head.
- Mature larvae are about 1 inch long, dusky white, pinkish or dull green in colour.
- Reddish orange frass, webbing and gum pockets indicate their presence. They overwinter as mature larvae in a cocoon within the tree.
- There are three to four generations each year.
- Destruction of fallen infested fruits checks the spread.
- Removal of flowering weeds especially of Compositae family.
- Though expensive, bagging of fruits with polythene or paper bags or cloth bags soon after the fruit set prevents the pest attack.
- Initiate the spray schedule with the onset of flowering with any of following insecticides:
- Deltamethrin (0.0028%), cypermethrin (0.0075%), monocrotophos (0.036%), carbaryl (0.1%) or Cyantraniliprole 10.26OD @ .0075%)

Management

- Monitor young orchards in spring and summer for frass and gum pockets.
- If larvae are present, spray trees from 1 foot above the scaffold crotch to 1 foot below, two to three times during the growing season.
- The first application should be mid to late april and subsequent applications at 6 week intervals to kill adults before they can lay eggs.
- Remove and destroy infested wood or heavily infested trees.
- Spray cypermethrin (1ml/l), imidacloprid (0.5ml/l) or Cyantraniliprole (0.3ml/l)

14.2 Leaf curl plum aphid *Brachycaudus helichrysi* Aphididae : Hemiptera

Host : peach, plum

Symptoms & Damage

- Colonies of this pest cause leaves to curl tightly. Often only one limb or a portion of a limb is infested early in the year.
- Large amount of honey dew is secreted by this aphid.
- Tree growth and fruit sugar content can both be reduced by populations of this aphid.
- The leaf curl plum aphid is often found inside curled leaves.

Life Cycle

- Aphid is shiny and varies considerably in colour from green to brownish green or brownish yellow.



Aphid infestation



Adult aphids



Curling of leaves due to aphid infestation



- This aphid overwinters in the egg stage near the base of buds.
- In spring it rapidly builds populations on new foliage, causing affected spurs to develop tightly curled leaves.
- In May, the aphids migrate from the orchard to summer host plants in the family Asteraceae.

Management

- Several natural enemies are important in the control of aphids in the orchard, but aphid populations often require treatment.
- The best time to treat is during the dormant or delayed dormant period.
- If aphids are chronic problem in the orchard, apply a treatment early in dormancy, otherwise sample during dormancy to determine the need to treat.
- Spring treatment may also be made. After harvest, a zinc sulfate application will provide zinc to the trees as well as hasten leaf fall.
- Without the leaves on the trees, the aphid life cycle is disrupted. Zinc sulfate (36%) applied at 10-20 lb/acre can be applied in early to mid-october to help in this process.
- Biological control and spray of narrow range oil or neem oil are organically acceptable methods of controlling this pest.
- Spraying of methyl demeton (1ml/l) or acetamiprid (0.5ml/l) or imidacloprid (0.5ml/l) at seedling stage on fresh foliage twice at 10 days interval.

14.3 Mealy plum aphid *Hyalopterus pruni* Aphididae : Hemiptera

Host : peach, plum

Symptoms & Damage

- This aphid builds up in large numbers on the undersurface of leaves in spring and causes leaves to become slightly curled and stunted.
- High populations can devitalize the tree, retard growth and reduce sugar content of fruit.
- Honeydew dropping on fruit can cause fruit cracking.

Life Cycle

- Wingless mealy plum aphid adults are pale green or whitish green with three dark green longitudinal stripes on their backs.



Aphid infestation



Adult aphid



- Their bodies are covered with a white meal wax.
- The winged form has a dark thorax and transverse bands on the abdomen.
- Mealy plum aphids are often found inside the slightly curled up plum leaves.
- After overwintering in the egg stage near the bases of buds, the aphids hatch during bloom and develop into wingless adults.
- They will have from three to thirteen generations on plums.
- Wingless aphids that remain on vigorous growth of plum trees throughout the summer will not be capable of laying overwintering eggs in fall.
- Only the offspring of the winged adults that return to plum trees in fall lay the overwintering eggs.

Management

- Several natural enemies are important in the control of aphids in the orchard, but aphid population often require treatment.
- The best indicator of population is orchard history.
- The best time to treat is during the dormant or delayed dormant period.
- If aphid are a chronic problem in the orchard apply a treatment early in dormancy, otherwise sample during dormancy to determine the need to treat.
- Zinc sulfate (36%) applied at 10-20 lb/acre can be applied in early to mid-october to help in this process.
- Biological control and spray of narrow range oil or neem oil are organically acceptable methods of controlling this pest.
- Spraying of Neem cake solution 5% or neem oil 5% or imidachloprid (0.5ml/l) or cyantraniliprole (0.3ml/l) or chlorantraniliprole (0.25ml/l).

15. Physiological disorder

15.1 Control of Pre-harvest Fruit Drop

Pre harvest fruit drop in plum can be reduced by foliar application of NAA @ 10 ppm (1.0 g NAA dissolved in 10-15 ml alcohol and finally added to water to make final volume of 100 lt.) as twice i.e. one in 2nd week and second in 4th week of April. A spray of 100 ppm ethrel in 4th week of March i.e. when pit hardening has taken place can also reduce the fruit drop.

Caution :

- i. There should not be any water stress in the orchard at the time of spray of growth regulators.
- ii. Ethrel 100 ppm should be sprayed just after pit hardening and neither before nor later than this. Otherwise, it may increase fruit drop.
- iii. As the fruit growth is rapid during April, trees should be irrigated frequently.

15.2 Zinc Deficiency

During summer, the current season growth of symptoms of zinc deficiency can be seen in plum plants grown on light textured soils, Leaves in terminal portion of branches become narrow, small and show necrosis in interregional regions. A rosette like growth of leaves, which are in whorls is formed in growing tips. Twigs show symptoms of dieback and fruits remain

small in size and become hard if deficiency is prolonged. Zinc deficiency can be corrected by spraying 0.4% zinc sulphate (i.e. 400 gm zinc sulphate in 100 liter water)

16. Post-Harvest Management

Plum is highly perishable and prone to damage during transportation. Fruits can be stored at low temperatures to extend the shelf life of the fruit. Plum fruits can be stored in good condition for 25 days if harvested at proper maturity, kept at 0-3⁰c temperature and 85-90% relative humidity. Its fruit in refrigerated vans for marketing at distant location.

16.1 Size grades for plums

Grade	Fruit size (mm)	No. of Layers	No. of fruits/ Layer	Box (inner) Size cm
Special	42 and above	3	28-32	37x16.5x16.5
Grade I	36-42	4	38-43	-do-
Grade II	below 36	4	50-56	-do-

16.2 Packing

Each box is lined inside with old newspaper sheets, keeping the margin for overhanging flaps. Fruits are initially padded with wood-wool/pine-needles at the bottom. Paper-wrapped fruits are arranged in each layer and top layer is covered with paper by bringing together overhanging flaps. Top is nailed.

KIWIFRUIT

1. Climate

Kiwi is a deciduous vine which can withstand wide range of climatic conditions. The plants require a chilling below 7⁰ C for about 700-800 hours for breaking bud dormancy and production of quality fruits. High summer temperature (> 35⁰C), low humidity and high light intensity may cause scorching of leaves. Sun scald and heat stress are the main problems in its cultivation in lower areas.

In Himachal Pradesh, the vines can be grown successfully from 1000 m to 1,500 m above mean sea level. A rainfall of about 150 cm, well distributed throughout the year is adequate.

2. Topography and Soil

It can be grown on a wide range of soils but deep, well drained sandy loam soils are ideal. A soil pH slightly less than 6.9 results in maximum yield but higher pH up to 7.3 adversely affects the yield because of Mn deficiency. Heavy wet soils are not suitable as plants do not tolerate wet feet for long.

3. Recommended Cultivars

Kiwifruit is a dioecious plant which bears staminate and pistillate flowers on separate plants.

Pistillate Cultivars: Allison, Abbott, Hayward, Bruno and Monty

Staminate Cultivars: Tomuri, Matua and Allison

4. Propagation

Kiwifruit is propagated by several methods, but propagation through grafting is the most commercialized method of multiplication.

4.1 Grafting

- Kiwifruit vines are propagated by grafting and budding on seedling rootstock.
- Seeds of cultivar Bruno and Abbott are commonly used for raising the seedling rootstocks because of their good germination and strong seedling vigour.

Extraction of seeds

- For seed extraction soft, fully ripened and developed fruits are selected.
- After the removal of skin of the fruit, they are put in the jars for 3-4 days to liquefy the pulp. Seeds from the liquefied pulp are separated with the help of pulp extractor and dried under shade.
- The seeds having 4 to 6 per cent moisture content are stored at low humidity (30 to 50%) in an airtight container at a cool place (10°C). However, germination rate decreases with the increase in storage period.

Stratification

- Before sowing, the seeds are stratified for 4 to 6 weeks in layers of moist sand at 0° to 4°C temperature to break the dormancy.

Sowing of seeds and care of young seedlings

- The stratified seeds are sown in the nursery beds having growing medium of FYM: Soil: Sand and leaf compost in ratio 1:1:1:1.

- Since kiwifruit seeds are very small in size and should be mixed with sand for uniform distribution at the time of sowing.
- The seeds are sown 3.0 mm deep with hay grass and light irrigation is given. Sowing of the stratified seeds is done 12 to 15 cm apart in rows.
- After sowing the seeds, beds are mulched in the month of February.
- Young seedlings are very susceptible to damping off fungi. Soil should be sterilized and nursery beds should be drenched with Bavistin (1.5 g/l) at 15 days interval.
- Seedlings having 3 to 4 leaves are either transplanted directly in the nursery bed or polythene bags (10x10 cm), which are placed under shade and irrigated regularly.
- In direct transplanting, chances of mortality are much higher than transplanting the seedlings in polythene bags.
- With the onset of the monsoon i.e. in July, the seedlings from polythene bags are transplanted in the nursery beds, which become graftable within a year.

Time and method of grafting

- The kiwifruit seedlings attain graftable size in one year. The tongue grafting is done during dormant season.
- The scion wood is collected in December-January at the time of pruning, packed in moist moss grass, stored in a cool, shaded place until it is used for grafting and budding.
- Tongue grafting performed during mid January – mid February resulted 90-95 per cent survival.
- Chip budding during first week to mid of February also gives bud take success as high as 95 per cent.
- Shoots below the graft union should be removed regularly.

5. Layout and Planting

- Flat land with gentle slope is ideal for planting kiwifruit orchard. Steep land with sharp changes in contour is not suitable because of the difficulties in constructing trellis structures.
- Wherever possible, plant rows are oriented in a North-South direction to maximize the use of sunlight.

Spacing

The ideal spacing for proper growth and fruiting of kiwifruit vines is 5x3 m accommodating 666 plants/ha.

Digging of pits

- Planting should be done in pits of 60 x 60 x 60 cm³ size and pits are dug about a month prior to planting and disinfected by intense solar radiation. Each pit should be filled with top soil mixed with farmyard manure (20 kg), neem cake (1 kg), and single super phosphate (500 g). After filling the pit, watering is done to allow soil to settle down. Irrigation is provided immediately after planting by drip irrigation system.
- Planting is done in January-February, while in colder areas planting is done during early spring to reduce the risk of frost damage of the newly planted vines.
- It is important that the male plants are spread throughout the block with every female adjacent to a male in at least from one direction for better pollination and fruit set.
- This is achieved by 1:9 male to female ratio.

O	O	O	O	O	O
O	X	O	O	X	O
O	O	O	O	O	O
O	O	O	O	O	O
O	X	O	O	X	O
O	O	O	O	O	O
O	O	O	O	O	O
O	X	O	O	X	O
O	O	O	O	O	O
O-Female Plant X-Male plant					

Planting plan of male and female plants (1:9)

- After planting, the basins are covered with mulching (plastic or organic mulch) to check the weed population, conserve the soil moisture and regulate soil temperature.
- The vines are hard pruned to about 30 cm above ground level so as to promote vigorous growth after planting.

6. Canopy Management

6.1. Training

- T-bar trellis the most common and preferred method for training of kiwifruit vines.
- In T-bar trellis a spacing of 3 meters between rows and 5 meters between plants in each row is maintained for getting better fruit production of quality fruits.

Training on T-bars

- In T-bar fence, the pillars of iron or concrete about 1.8 m in height above the ground level are erected at a distance of 5 m from each other in a row.
- A cross arm (1.5 m) is fixed on each pole, which carries outrigger wires.
- The laterals arising from the main branch are trained on these wires. A strongly growing shoot is selected as the main trunk to carry the vine up to the wire.
- The vine is staked to provide support and is tied at frequent intervals to prevent wind damage and to avoid the twisting of vine around the stake.
- As soon as the vine attains a height of 2 m or reaches the wire, one permanent leader/arm is allowed to grow out in each direction along the centre wire.
- To achieve this, the leader is trained one way along the wire and a shoot slightly below the wire is selected and trained in the opposite direction as the second leader.
- Alternately, the main leader can be cut just below the wire to force the production of two leader growth, which can be trained as leaders in two opposite directions, along the wire.
- From the permanent leaders, fruiting arms 25-30 cm apart are selected at right angle along both sides of each leader.
- The first crop of fruit comes on these arms and later crop forms on laterals that develops from them.
- Fruiting arms should not be trained along outrigger wires, because shoots from then will compete with the fruiting arms which originate directly from the leader, result in a dense tangled growth which adversely affect management and performance of the vine.

6.2 Pruning

Kiwifruit vine bears fruit on current season's growth that originates from one year old wood. Only the basal buds at nodes 4 to 12 on the fruiting shoot produce fruits, so it requires open pruning, which allows access for pollinators during the flowering period, better penetration of sunlight and air movement around the vine.

The following principles should be kept in mind at the time of pruning kiwifruit vines:

- 1) The fruit is developed only on current season's growth arising from the bud developed in the previous year.
- 2) Only the basal buds of nodes 4 to 12 on current season's growth are productive.
- 3) Vine grows 2 to 3 m every year, which becomes overcrowded and tangled if not controlled by both summer and winter pruning.
- 4) The shoots developed on older wood by heading back will not fruit normally in the first season.

In the beginning, a lateral arising from main leaders is cut back in the winter so as to provide enough space for 4 to 5 fruiting shoots at an interval of 4-5 buds between two such shoots. Light summer pruning is done for shortening of fruiting arms, thinning out of criss-cross and shading shoots.

Dormant Pruning

- In dormant pruning, the fruiting lateral is cut back to 2.0 vegetative buds beyond the last fruit.
- In the second year, these vegetative buds will produce the fruiting shoots, which will be pruned again.
- The arms on lateral shoot are pruned and allowed to fruit for 3 to 4 years.
- After this the lateral is removed from the main branch and other laterals are selected and pruned accordingly so that the balance between vegetative and reproductive growth is maintained for the continuity in the fruit production.
- Dormant pruning is done during Jan-Feb. The cut portion of the shoots is pasted with Bordeaux paste.
- The shoots which grow from the first bud carries none or few flowers, thereafter, the number of flowers/shoot increases to a maximum of 4, 5, 6 which remain constant along the entire length of the left cane. The fruiting laterals which have lost their vigour and are overcrowded, are removed to encourage the development of new laterals.

Summer Pruning

- The summer pruning is done by shortening back of fruiting arms, thinning out of criss-cross tangled and shading shoots.
- The strong uprights or the shoots arising at undesirable points are pruned in spring when they have not grown too long.
- Summer pruning starts from spring continues throughout the growing season.

7. Pollination

- Kiwifruit begins flowering after 2-3 years of planting but sizeable crop is borne after 4-5 years.
- The cultivar Hayward takes more time to produce worthwhile crop due to low percentage of flowering shoots and lesser number of flowers per shoot as the chilling requirement of this cultivar is quite higher than other cultivars.

- Flowers first open in cultivars Bruno and Monty and last in Hayward. Lateral flowers on staminate vines open after the terminal flowers Allison (male) flowers quite early compared to late flowering pollinizer Tomuri to extend the staminate flowering period.
- The kiwifruit crop is highly dependent on pollination as the plants are functionally dioecious.
- One male is planted for every 9 pistillate plants for pollination. It is the most important factor determining the financial return to kiwifruit growers.
- The fruit size/ weight is closely related to the number of seeds and is much influenced by the pollination.
- Without good pollination, fruit will be small and not up to the marketable size.
- Although wind plays a role, kiwifruit is pollinated mainly by insects, of which the honey bee is the most important. Introduction of bee hives in the kiwifruit vineyards further increases the fruit set. 3-4 colonies are sufficient for one hectare plantation.
- To achieve regular cropping supplemental pollination (the artificial application of pollen by way of hand pollination) should be done for better fruit set and yield.

8. Orchard Management

8.1 Intercropping

During the initial five years, the intercropping of different annual crops should be undertaken as secondary crop as mentioned in the table to get additional income. Widely spaced litchi plantation has enough space in the early stage of establishment. The crops with synergy to kiwifruits plants coupled with regional preference should be given priority. These interspaces can be economically utilized by growing suitable short duration intercrops as listed below:

Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

S. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergourd, Parval, Colocasia, Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	—
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kidneybean (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chino podium, Coriander, Fennel, Fenugreek	—
5.	Fodder crops	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	—

8.2 Fruit Thinning

- All the Kiwifruit cultivars except Hayward bear heavily every year.
- It is, therefore, necessary to thin the crop which will also ensure consistency in obtaining good yield year after year.
- Therefore, in order to harvest a quality crop of good size and grade fruits, hand thinning is generally practised as chemical thinning was found ineffective in kiwifruit vineyards.
- The thinning should be carried out when the fruits attain a size of about wild pear (Kainth) fruits.
- While doing so, only 5 to 6 fruits should be retained per cane, whereas other undeveloped and unpollinated fruits are required to be removed.

8.3 Improvement of fruit size

Application of CPPU @ 5 ml/l at petal fall stage increases the size of fruits along with appreciable enhancement in fruit quality.

9. Irrigation Management

- Drip irrigation systems provide the most efficient and economic management to achieve high productive yields in kiwi orchards. Drip has a very high efficient water use and provides a good control of fertilizer application. For young trees use one drip line 40cm away from trunk, while for trees older than 3 years, use one drip line on each side of the tree row 60 cm away from trunk.
- Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree, keep mulch 10-30 cm away from the trunk. Dry leaves or straw are good mulching material. Mulching should be done in the month of February, which helps in conserving moisture and reducing weed growth.
- Adequate moisture is required during the vegetative growth for optimum flowering and fruit development. In high density planting, in-line drippers are well suited. The irrigation and nutrient schedule below is recommended for kiwi orchards and it is applicable for drip irrigation. The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers at 50 cm apart with 4.5 lph discharge. There should be a control unit/valve for each land holdings.

9.1. Irrigation Scheduling:

Year	Irrigation (litres per tree biweekly*
1 st	4-6
2 nd	8-12
3 rd	15-20
4 th and above	25-30

* Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions. Being deciduous, the kiwi does not require frequent irrigation during winter. During rainy season from July to Sept sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops except failure of the monsoon.

10. Nutrition Management

10.1. Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months before mid February.

Age of plant (year)	1 st	2 nd	3 rd	4 th year onwards
FYM (kg plant ⁻¹)	10	10	15	20

10.2. Nutrient recommendations: The amount of nutrients to be applied through fertilizers in high density orchard of kiwi fruit depends on the age of tree, condition of plant and type of soil. The nutrient dose (g/ tree) should be divided equally among the number of splits and applied at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Age of the Tree (year)	Nutrient (g tree ⁻¹)*		
	N	P	K
1st year	120	60	60
2nd year	240	120	120
3rd year	360	180	240
4th year onwards	480	240	300

*Application of N, P and K should be based on soil/leaf test values.

10.3. Stages of nutrient application:

Stage of application	N (%)	P (%)	K (%)
After fruit harvest	40	60	20
During fruit set	40	40	20
Fruit growth	20	-	60
Total	100	100	100

For better fruit set and cropping micronutrients should be applied as foliar spray of 0.2% solution of the needed nutrient (two sprays in July at 15 days interval). Recommended soil application rates of chelated micronutrients are: about 20 g borax, 20 g copper sulphate, 20 g manganese sulphate, 20 g iron sulphate, 20 g zinc sulphate and 40 g magnesium sulphate per tree per year in February along with FYM application.

11. Harvesting

- It takes atleast 4 to 5 years for a kiwifruit vine to start bearing worthwhile crop and about 8 to 10 years are required to reach full commercial production.
- Kiwifruit are readily harvested by snapping off their stalks at an abscission layer which forms at the base of the fruit. Fruit stalks remain on the vine.
- At least two pickings are normally made. The larger fruits are harvested first and the smaller fruits later having had the chance to improve in size and quality.

- The fruits are transported to the market in hard (High firmness) conditions which subsequently lose their firmness in about two weeks at room temperature to become edible.

a. **Maturity Indices**

- A maturity index of 6.2% total soluble solids or more has been established and found very satisfactory for kiwifruit harvesting.
- Days from full bloom to harvest (DFFB) for different kiwifruit cultivars can also be used to predict the optimum picking date.

Days from full bloom to harvest for different kiwifruit cultivars.

Sr. No.	Cultivar	DFFB to harvest under mid hill conditions
1.	Allison	193±4
2.	Abbott	190 ± 4
3.	Bruno	182±4
4.	Monty	192±4
5.	Hayward	202 ±4

- Besides this, at optimum maturity the hair present on the fruit skin can be removed very easily, which can also be used to judge the picking maturity.

12. Yield

The average yield of full grown kiwifruit vines ranges from 50-60 kg per vine under optimum management condition.

13. Diseases

13.1 Phytophthora Root and Crown Rot

Causal organism: *Phytophthora* spp.

Symptoms:

- Symptoms commonly occur in spring and appear as reduced terminal shoot growth, chlorotic and/or undersized leaves.
- Vines may collapse suddenly or alternatively, vines may decline slowly over a few seasons as temperatures increase in summer,
- Roots of infected vines exhibit a red-brown rot. Often a margin where healthy, white tissue meets diseased tissue may be found.
- Sunken areas are seen above ground on one or more sides of the lower trunk .

Disease Cycle and Epidemiology:

- The pathogen survives in soil and dispersed by irrigation water. Prolonged periods of saturated soil are optimal for the pathogen to infect roots.
- Disease development is more in poorly drained soils or where vineyards have flooded condition. Several species of *Phytophthora* attack kiwifruit roots and crowns.
- Pathogen survives in the form of oospores in the soil as well as in infected seed
- Abundant rainfall, high RH and warm weather are essential for initiation of disease.
- Sporangial formation and their germination by zoospores is favoured by heavy rains.
- After infection, sporangia are produced on the fruit surface and further spread by wind

- Temperature ranging from 22 -25° C along with high humidity (>80%) are conducive for disease development.

Management

Cultural Methods

- Good water management is essential.
- Planting should be done in well-drained soils
- Vineyard should be allowed to dry out between irrigations
- Collection and destruction of the infected leaves and fruits regularly.
- Proper draining of the field to avoid water stagnation.
- Apply pine needles/ grass mulch on the field floor before the onset of monsoon rains.

Chemical Methods

- Spray the crop with metalaxyl + mancozeb (2.5 g/litre) with the onset of monsoon rains followed by sprays of either mancozeb (2.5 g/litre) or copper oxychloride (3 g/litre) or Bordeaux mixture (8g each of copper sulphate and lime / liter of water) at 7 to 10 days interval.

14. Insect Pest Management

There are number of insect-pests infesting kiwi. Important insect-pests prevalent in sub tropical zone of Himachal Pradesh are listed below:

14.1 Brown headed leaf roller *Ctenopseustis obliquana* (Walker) Tortricidae: Lepidoptera

Host: Kiwi

Symptoms & Damage

- They web together leaf edges or leaves and fruit to form a shelter to live in often rolling the leaves into a tube.
- The caterpillars eat leaves and fruit.

Life Cycle

- **Eggs :** females lay eggs in smooth masses composed of up to 150 individual eggs. Egg development period is about 9 days.



Larvae



Larvae infestation

- **Larva :** early instar larvae web together shoot tips or roll leaves. Later instars feed on leaves, buds and fruits of the host plants. Larval period is about male 32 and female 36 days. Larvae exhibited 5 or 6 instars.
- **Pupa :** pupation occurs in the larva nest. Prepupal period is about male 3 and females 3 days. Pupal period is about male 16 and female 13 days. Late instar larvae are

approximately 20mm in length with conspicuous pinacula. The head is dark brown to reddish brown and maybe marked with faint red mottling.

- **Adults** : adults are brown to brownish grey with a variable wing pattern. Most individuals have several dark markings along the costa, including a remnant of the median fascia. Hind wings are mottled in both males and females. It completes 4-6 overlapping generations per year.

Management

- Closely examine blossoms and vegetative shoots in the vineyard during prebloom and bloom for the presence of caterpillars, webbed leaves or feeding damage.
- Application of *Bacillus thuringiensis* are acceptable in an organically certified crop.
- Use of pheromone traps.
- Spray of flubendiamide @ 0.1ml or chlorantraniliprole @ 0.3ml/l of water.

14.2 Green headed leaf roller *Planotortrix excessana* (Walker) Tortricidae: Lepidoptera

Host: Kiwi

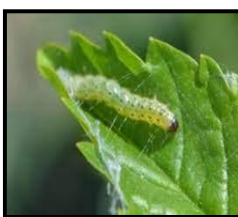
Symptoms & Damage

- They web together leaf edges or leaves and fruit to form a shelter to live in often rolling the leaves into a tube.
- The caterpillars eat leaves and fruit.

Life Cycle



Larvae



Larvae infestation



Rolling/curling up of

- **Eggs** : female lays eggs in masses that contain an average of 54 individual eggs. Egg masses of *Planotortrix excessana* have an opaque coating egg development, 11 days.
- **Larvae** : last instar larvae are approximately 25mm long and entirely green. The head is transparent light brown to green and may have faint brown mottling. The prothoracic shield is pale green with no lateral shading.
- **Pupa** : pupation takes place within the webbed foliage pupal period for male and female 18 days.
- **Adult** : fore wings are pale orange brown to dark reddish brown. Males are generally darker than females. Most individuals lack prominent wing markings except for a dark spot in the distal one third of the forewing. Adult life span, male 20, female 18 days. 90% eggs laid in 90 days.

Management

- Closely examine blossoms and vegetative shoots in the vineyard during prebloom and bloom for the presence of caterpillars, webbed leaves or feeding damage.
- Application of *Bacillus thuringiensis* are acceptable in an organically certified crop.
- Use of pheromone traps.
- Spray of flubendiamide @ 0.1ml or chlorantraniliprole @ 0.3ml/l of water.

14.3 Thrip *Heliothrips* spp. (Bouche) Thripidae :Thysanoptera

Host : Kiwi

Symptoms & Damage

- Thrips uses its mouth parts to rasp the leaf surface, rupture the epidermal cells and feed on exuding cell contents.
- Feeding spots turn yellow then brown and the surrounds become silvery where air enters the emptied cells.

Life Cycle

- **Eggs :** white, elongate and banana shaped. Females insert eggs inside plant tissues above the soil surface. The eggs are microscopic.



Thrips infestation



Adult thrip



- **Larva :** two larval instars, pre-pupa (3rd instar) and pupa (4th instar). Mature larvae approximately 1mm (0.04 in.) in length. Whitish larval stage with red eyes, turn yellowish in colour with maturity but retain red eyes.
- **Adults :** 1.3-1.7mm in length. Blackish-brown body with lighter posterior abdominal segment and white legs. Abdomen golden in newly emerged adults.

Management

- Adults thrips are easily detected on sticky insect traps and can provide an indication of the presence of thrips.
- White, yellow and even hot-pink traps will attract thrips, but blue traps are generally recommended as they trap fewer other insects and make detection of thrips easier.
- Remove all crop remains and weeds.
- Use hygienic plant propagation practices, and keep batches of plants separate to prevent thrips from infesting new seedlings or cuttings.
- Spraying of Neem cake solution 3ml/l or neem oil 2ml/l or imidacloprid (0.5ml/l) or cyantraniliprole (0.3ml/l) or chlorantraniliprole (0.25ml/l)

15. Physiological Disorder

15.1 Sun Scald or Sun Scorch

Fruits develop a typical sunken, brown, leathery scar over the affected surface due to exposure to the sun after being well shaded. This renders the fruit useless even for processing.

Management

To overcome this problem, the vines which have less foliage are thatched with hay grass to protect the fruit from direct exposure to sunlight.

15.2 Flats

This is a condition of the fruit when its width is greater than length. Such fruits are more likely to be produced on the two proximal flowering buds of a shoot or improper pollination. During the period of fruit set if the vegetative growth is retarded due to certain reasons, tends to increase the width of a fruit as opposed to its length. This problem has been observed more in Monty cultivar.

15.3 Water stain

A distinct darkened stain, often in streaks down the side occurs on the fruit due to deposition of tannins and other substances leached out of dead plant tissue by water, mainly rainfall, which later drips onto and trickles down should be reduced. Such stained fruits should be treated with a weak solution of citric acid to remove the blemishes.

16. Post-Harvest Management

16.1. Grading

- Kiwifruit is graded on the basis of fruit size and weight.
- In the international market, fruit weight of 70 g is minimum whereas, the fruit having 100 g weight are preferred.

16.2 Packing

- Cardboard boxes of 3-5 kg capacity are used for packing of kiwifruit.
- For export, the fruits are wrapped in poly films, packed in trays.
- 33 fruits of uniform size weighing 100 -105 g are accommodated in a tray.

16.3 Storage

- Kiwifruit has a long shelf life which can be extended further with timely picking and good storage.
- The fruits can be stored up to 8 weeks in cool and dry place at room temperature.
- The fruits can be stored for 4 to 6 months at a temperature of 0°C and 90% relative humidity.

PERSIMMON

The Japanese persimmon is a deciduous fruit tree and grows successfully from sub-tropics to wet temperate zone. At present it is grown on limited scale in sub-tropics of Kangra, Mandi and Chamba of Himachal Pradesh.

1. Climate

Persimmon grows successfully in subtropical and warm temperate climate. Fuyu cultivar of persimmon requires 200 chilling hours and can be successfully grown in subtropical regions. Persimmon is sensitive to cool summers which delays ripening process. High humidity during fruit ripening affects fruit quality. It produces better colour and sweetness when grown in the warmer areas.

2. Topography and Soil

Persimmon is a very hardy fruit plant which can be grown successfully in well drained sandy loam or loamy soil rich in organic matter. It prefers soil pH of 6.5-7.5. The soil should be deep (50-100 cm) and fertile.

3. Recommended Cultivar

Fuyu: Fuyu is a non- astringent variety with tomato shaped fruits and is a heavy producer. This is a raw eating type, so the fruits can be eaten even when they are hard. This large, round, flattened fruit has reddish-orange skin when ripe. The fruit is seedless and is excellent for raw eating. Incidences of fruit imperfections are low, yields are good and the tree is generally well adapted. Total soluble solids range from 18 to 19° B.

4. Propagation

4.1 Nursery Management

4.1.1 Rootstock

Amlok (*Diospyros lotus* L) is the most commonly used rootstock for persimmon. It shows resistance to low winter temperatures and drought. This rootstock imparts vigour and uniformity of development.

4.1.2 Propagation methods

For raising seedling rootstock, seeds of persimmon should be stratified at 1-5° C temperature for 90 days and then sown in the 1st week of April in raised nursery beds. The seeds show maximum germination at ambient temperature of 28 °C and take about 2-3 weeks to germinate. Grafting thickness of the rootstock is generally achieved in one year. Persimmon is commercially propagated by tongue grafting performed during mid-February to mid-March.

5. Layout and Planting

5.1 Spacing

The trees are planted at a distance of 4.0 x 4.0 m accommodating 625 plants per hectare.

5.2 Layout

Square or rectangular planting systems should be adopted in persimmon for planting. The orientation of planting should be North–South direction. The planting should be done by making contour terraces in areas having undulating topography.

5.3 Preparation of field, bed, planting pit and filling

- Deep ploughing should be done and raised bed (2-meter-wide at bottom x 1.5-meter-wide at top x 45 cm height) should be prepared one month before planting.
- In hilly terrain, contour/terrace (1 meter wide) system of planting should be adopted.
- Persimmon saplings should be planted in pits of 60 x 60 x 60 cm size. The pits should be dug one month prior to planting and exposed to intense solar radiation. Each pit should be filled with top soil mixed with FYM (20kg), Neem Cake (1kg) and Single Super Phosphate (500g). After filling the pits, watering should be done to allow the soil to settle down. Irrigation must be provided immediately after planting through drip lines.
- Planting should be done during January-February, when trees are dormant.
- Fruit plants should be planted immediately after uprooting from the field for better survival.
- Sprouted saplings should not be Planted as it results in poor survival.
- While planting, the graft union should be kept linear and 22 cm above the ground.
- Staking should be done to keep the plant straight and avoiding breakage of any shoots by winds.
- Use 60-70 cm long wooden sticks and tie the main branches with strings. Wooden sticks should be treated with chlorpyrifos (2 ml/litre) for termite protection before staking.

6. Canopy Management

6.1 Training and Pruning

6.1.1 Training

- Persimmon is trained to modified central leader system
- The trees should be kept low headed by heading back at 45 cm from the ground while planting.
- Strong framework of 4-5 primary shoots with wide crotch angle should be developed around the trunk, above 30 cm from the ground.
- In the next two years secondary and tertiary branches should be developed.
- The plants should be staked to keep in a straight position, which helps in selecting the well-spaced laterals in the coming season.

6.1.2 Pruning

- The broken and interfering branches should be removed.
- After developing the proper framework of the tree, little or no pruning is needed except removing dead, diseased, broken and interfering branches.
- Old trees may be given severe pruning to rejuvenate new growth for regular production.
- Remove dried/diseased fruits and twigs regularly and burn them completely to reduce the disease and pest inoculum in the persimmon orchard.

7. Pollination

The cultivar Fuyu is monoecious. Honey bees and wind are major pollinating agents and helps in increases fruit set. Placement of 4-5 bee hives per hectare helps in improving fruit set during flowering.

8. Orchard Management

8.1. Mulching

- Organic mulching (dry grass, dry leaves, uprooted weeds and farm residues) of 15-20 cm thickness should be done in the first week of March to check the weed population, conserve the soil moisture and regulate soil temperature.
- The bed should be covered with mulching (plastic or organic mulching) to check the weed population, conserve the soil moisture and regulate soil temperature. Preferably organic mulching having 15-20 cm thick layer of uprooted weeds from the field is considered economic and better for production and quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree.

8.2 Intercropping

- During the initial four years, the intercropping of below annual crops should be under taken as secondary crop as mentioned in the table to get additional income.

Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

Sr. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergaurd, Parval, Colocasia , Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kideybeen (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chino podium, Coriander, Fennel, Fenugreek	
5.	Fodder corps	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals Crops/Oilseeds	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi
7.	Flowers	Marigold, Gladiolus	

9. Irrigation Management

- Adequate irrigation supply is critical at fruit development stage to get better yield and quality of fruits. In the reproductive phase water stress is beneficial at the time of fruit bud differentiation, but during the active growth period water stress should be avoided.
- Flower and fruit drop can be reduced to greater extent by avoiding irrigation at full bloom stage and the ripening stage. Irrigation should not be given during December and January months.
- Drip irrigation system provide the most efficient and economic management to achieve high productive yields in persimmon orchards. For young trees use drip lines 40cm away from trunk while for trees older than 3 years use drip line on each side of the tree row 60cm away from trunk.
- Apply mulch to cover the root zone in accordance to spacing of plantation around the tree, keep mulch 10-30 cm away from the trunk. Straw and dry leaves are good mulching material. Mulching should be done in the month of February, which helps in conserving the soil moisture and reducing weed growth.

9.1. Irrigation Scheduling

Adequate moisture is required during the vegetative growth for optimum flowering and fruit development. In high density planting, in-line drippers are well suited. The irrigation and nutrient schedule below is recommended for persimmon orchards and it is applicable for drip irrigation. The drip line should be laid out at the time of planting of orchard with two drip lines having two inline drippers 50 cm apart in plant basin with 4.5 lph discharge. There should be a control unit/valve for each land holding.

Drip Irrigation

Age of plant (Year)	Irrigation (litres per tree biweekly*)
1 st	4-6
2 nd	8-10
3 rd	12-18
4 th and above	24-28

* Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions. Being deciduous, the persimmon does not require frequent irrigation during winter. During rainy season from July to Sept sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops except failure of the monsoon.

10. Nutrition Management

10.1 Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months before mid-February.

Age of plant (year)	1 st	2 nd	3 rd	4 th year onwards
FYM (kg plant ⁻¹)	10	10	15	20

10.2 Nutrient recommendations: The amount of nutrients to be applied through fertilizers in high density orchard of persimmon depends on the age of tree, condition of plant and type of soil. The nutrient dose (g/ tree) should be divided equally among the number of splits and

applied at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Age of the Tree (year)	Nutrient (g tree ⁻¹)*		
	N	P	K
1st year	120	60	60
2nd year	240	120	120
3rd year	360	180	180
4th year onwards	480	240	240

*Application of N, P and K should be based on soil/leaf test values.

Stages of nutrient application:

Stage of application	N (%)	P (%)	K (%)
After fruit harvest	40	60	20
During fruit set	40	40	20
Fruit growth	20	-	60
Total	100	100	100

a. Cropping

For better fruit set and cropping micronutrients should be applied as foliar spray of 0.2% (2g/l) solution of the needed nutrient (fruit set and pea stage). Recommended soil application rates of chelated micronutrients are: about 20g borax, 20g copper sulphate, 20g manganese sulphate, 20g iron sulphate, 20g zinc sulphate and 40g magnesium sulphate per tree per year in February along with FYM application. Many cultivars are susceptible to fruit drop and calyx cavity if N levels are too high when fruits are sizing. Nitrogen levels should be reduced if these problems are evident.

11. Harvesting

- Clip the fruit with secateurs from the tree and calyx should remain attached to the fruit.
- The fruit must be harvested carefully to avoid blemishes and bruises, as they reduce the market value of the fruit.
- Fruits must be harvested in two to three pickings, depending upon the fruit size and colour.
- Persimmon can be harvested in the month of August to October depending upon the altitude.

a. Maturity Indices

Colour:

- Fruit skin colour changes from green to orange or to yellowish-green or yellow
- TSS should range between 18-19⁰ B.

12. Yield

A fully grown tree produces approximately 80-120 kg fruit per tree/year under adequate cultural practices adopted.

13. Disease Management

13.1 Cercospora Leaf Spot

Causal organism: *Cercospora* sp.

Symptoms:

- On both leaf surface, small dark brown spots.
- The spots are angular in shape as are limited by the veins.
- Severely affected leaves fall readily.

Disease cycle and epidemiology:

- The pathogen survives in the infected plant debris in the form of mycelium or stromata.
- The pathogen can also overwinter in the form of infected seed in areas where fruit infection occurs.
- Primary infection occurs through overwintering stromata.
- Dispersal of conidia occurs via wind and rain splashes to the leaf surface where they germinate and cause infection.
- High humidity (>95%) and temperature (20-25°C) are favourable for disease development.

Management:

Cultural methods

- Collection and burning of the infected plant debris.
- Follow crop rotation and maintain proper drainage in the field.

Chemical methods

- Spray carbendazim (1g/litre) or thiophanate methyl (1g/litre) or combination of mancozeb (2.5 g/litre) + carbendazim (0.5g/litre) or difenoconazole (0.3 ml/litre) and repeat at the interval of 10 to 14 days.

13.2 Bitter Rot / Anthracnose

Causal Organism: *Colletotrichum gloeosporioides*

Symptoms:

- On leaves and fruits spots occur and cause early dropping of leaves and fruits

Disease cycle and Epidemiology:

- Primary source of inoculum are infected leaves, dried twigs and fallen debris. Also, pathogen can survive saprophytically for a long time. Secondary source of inoculum are conidia which further spread the disease.



Persimmon anthracnose fruit



Persimmon anthracnose leaves

- Rainfall for a long time during flowering results in severe infection.
- Continuous rain, temperature 28-30°C and high humidity favours the development of disease

Management:

Cultural methods

- Take cuttings from healthy plants.
- Collect fallen diseased leaves and remove blighted blooms

Chemical methods

- Spray copper oxychloride (3g/litre) or carbendazim (1g/litre) or difenconazole (0.5ml/litre) or azoxystrobin (0.25 ml/litre)
- Spray of fungicides before harvesting help to increase post-harvest life.

13.3 Crown Gall

Causal organism: *Agrobacterium tumefaciens* (syn. *Rhizobium radiobacter*)

Symptoms:

- Around crown, large galls (swellings) develop with smaller marble-size galls on larger roots.
- In advance stages, plant will turn yellow and become stunted and sickly.
- The galls can form on both the roots and the trunk of a tree and they can also form at graft unions or at the base of the trunk at the root crown, just below soil level.
- Over the time, galls, affect the growth, health and vigour of the plant. Galls interfere with the flow of water and nutrient in the plant, as they effectively cut off the bark in the site of infection.
- Reducing the flow of water and nutrients in a plant leads to slow growth, stunting of the size of the plant, deficiency symptoms such as chlorosis and a decline in the overall health of the plant

Disease Cycle and Epidemiology:

- The bacterium can persist in the soil in decomposing plant debris for long periods of time, it may live saprophytically (living on dead organic matter) in soil for up to two years.
- Without wounds on trees and plants, no galls can form.
- These bacteria mainly live in the outer portions of primary galls, which can break off and fall to the soil, spreading the bacteria.
- The central part of the gall is dead and contains no bacteria.
- Secondary galls may also form without any bacteria present on other parts of the plant or around other wounds.
- Crown gall bacteria can overwinter both in the galls and in the soil and reinfect any plant wounds they come in contact with, completing the disease cycle.
- High humidity and warm conditions favour the development of disease

Management:

- There is no known cure for crown gall disease and the best control is prevention.

Cultural methods

- Disinfect pruning tools between cuts.

- Use either a solution of 70% alcohol and 30% water, or a 10% bleach solution (1 part bleach with 9 parts water).
- Remove existing galls with a sharp pruning knife, destroying the infected plant tissue and treat the wound with a chemical.

Biological methods

- A non-pathogenic (non-disease causing) strain of the same bacterium (*Agrobacterium radiobacter strain 84*) has been used to protect plants against infection by crown gall bacteria in the soil.
- Plants are dipped into a suspension of the protective *Agrobacterium radiobacter* strain 84 at planting time to keep plants free from disease but control cannot cure plants which are already infected.

14. Insect Pest Management

There are number of insect-pests infesting persimmon. Important insect-pests prevalent in sub tropical zone of Himachal Pradesh are listed below:

14.1 Mealy bug *Pseudococcidae citri* Pseudococcidae : Hemiptera

Host: persimmon

Symptoms & Damage

- Long tailed mealybugs feed by sucking out plants sap from leaves and stems.
- Honeydew and sooty mould further disfigure infested plants, which may eventually be killed.



Mealy bugs



Secretion of white



Honeydew secretion on fruit



- These pests also secrete a fluffy white wax which also detracts from the appearance of infested plants.

Life Cycle

- **Egg:** the long-tailed mealybug reproduces sexually, each female laying 75-200 eggs (the number being dependent on the host plant).
- **Nymphs:** Nymph is similar to the larger adult female except that the filaments around the edges are shorter.
- **Adult:** the body of the female is yellow, with a dorsal brownish stripe and covered by white waxy dust. The body is elongated, 2.5-4.0 long, with 17 pairs of marginal wax filaments. The anal pair, which is longest, may exceed the pest's entire length. Antennae 8-segmented.

Management

- Natural enemies of mealy bug, Parastiods – *Anagyrus nigricornis*, Predators – Brown lacewing.
- On small infestations on house plants, a 70% or less solution of isopropyl alcohol in water may be dabbed directly on mealybug with a cotton swab to kill them or remove them.
- A variety of oil fungicides are safer to use horticultural oil, jojoba oil and neem oil are few all purpose oil sprays used.
- Spraying of Neem cake solution 10 ml/l or neem oil 10ml/l or imidachloprid (0.5ml/l) or cyantraniliprole (0.25ml/l) or chlorantraniliprole (0.3ml/l)
- **Weakest link:** A newly hatched nymph of the pest is the weakest stage for its management.
- At flower bud initiation, imidacloprid (0.5ml/l) or cyantraniliprole (0.25ml/l) or acetamiprid (0.5ml/l) at emergence of inflorescence stalks and before flower opening (anthesis),

14.2 Persimmon psylla *Trioza diospyri* Psyllidae : Hemiptera

Host: persimmon

Symptoms & Damage

- They suck plant juices and excrete sticky honeydew on which dark sooty mould may grow.
- Nymphs secrete white fluffy material and cause terminals to twist and they turn into galls..
- Excessive honeydew may damage plants or property below the infested foliage.

Life Cycle

- Persimmon psylla is a small insect about the size of large winged aphids.



The cast skin of mature psyllid nymph



an almost mature psyllid nymph



Excretion of white wax on twigs



- Adults hold their wings high over their bodies and they jump readily
- Nymphs are flattened and less active than adults and they secrete a white fluff.
- Females lay eggs that hatch and develop through five growth stages before maturing into winged adults.
- Development from egg to adult takes only a few weeks in spring.

Management

- Minimize shearing or clipping of terminals during the growing season.
- Shearing stimulates new growth preferred by psyllids for feeding and egg laying.
- Prune plants just above branch crotches and nodes instead of shearing off terminals.

- Spraying of Neem cake solution 40ml/l or neem oil 60ml/l or imidachloprid 0.5ml/l or Cyantraniliprole @ 0.3ml/l or chlorantraniliprole @ 0.3ml/l
- Horticultural oils suppress adult and immature persimmon psyllids without leaving a toxic residue that might harm beneficial insects and mites.
- Apply nitrogenous fertilizers to the crop after four and half months as early application of these fertilizers causes more infestation of the pest.
- **Weakest link:** A newly hatched nymph of the pest is the weakest stage for its management.

At flower bud initiation, imidacloprid 17.8SL@ 0.036% or Cyantraniliprole 10.26OD @.0075%) or methyl demeton 25EC @ 0.025% at emergence of inflorescence stalks and before flower opening (anthesis)

15. Physiological Disorders

15.1. Fruit Drop

Fruit drop is one of the major physiological problem, which occurs due to number of causes including excessive fruit rot, lack of pollination, water stress, excessive nitrogen application and insect damage. The first wave of drop occurs in early June just after petal fall and continues up to late July.

Management

- Ringing, blossom thinning, and optimum nitrogenous fertilizer applications reduce fruit drop.
- Excess drop of fruit can be controlled by application of GA₃ @ 100 ppm (10g/100 litre) at full bloom stage.

15.2 Calyx cavity

- It is a major problem in persimmon. The signs of this disorder are sparse space or cavity that occurs directly beneath the calyx of the fruit. This cavity becomes a habitat for mealy bugs and fungal growth. The incidence of calyx cavity appears to be less on trees which have heavier crop loads and where fruits have been pollinated.

Management

- The avoidance of excessive N and K fertilizers, especially in later spring/summer and close to harvest
- Thinning early in the season to enhance calyx growth and optimizing pollination.
- Avoid sites with deep, fertile and poor-draining soils, which are likely to encourage this disorder.

16. Post-Harvest Management

16.1 Grade, sizes and packing

An ideal size of persimmon fruit cultivar Fuyu ranges between 220-250 g and 150 g is minimum marketable size.

16.1.1 Fruit counts:

Fruit counts range from 12 to 28 pieces of fruit per tray with most fruit packed to a count of 16 to 20 with an average weight of 3.5- 4.6 kg per tray. Larger fruit e.g. counts of 12 when packed into smaller tray will generally produce higher tray weights i.e., 4.6 kg.

16.1.2 Count sizes:

4.0 kg tray can accommodate - 12, 14, 16, 18, 20, 23, 25, 28 fruits

- Small sized fruits (25 or 28 per tray)
- Medium sized fruits (20 or 23 per tray)
- Large sized fruits (12 to 18 per tray)

Smaller fruit are packed loose in 10 kg containers.

16.2 Storage

Persimmon is sensitive to chilling at temperatures less than 5°C will shows flesh browning and softening. Exposure to ethylene aggravates chilling injury at these temperatures. Persimmon fruits can be stored for 2-3 months at 0-2 °C temperature, with 90-95 % relative humidity.

PECANNUT

Pecan nut is one of the most important nut crop grown in Himachal Pradesh. It is mainly grown in mid hill and subtropical areas of state. It is becoming popular due to its high economic returns and adaptation to mid-hill zone. Due to its high nutritional value, health benefits and high economic returns, pecan farming has great future in Himachal Pradesh.

1. Climate

Pecan nut trees can grow under warm agroclimatic conditions and are well adapted to subtropical areas. It also thrives well in regions having short, cold winters and long and hot summers. This nut requires 8-9 months growing season for good flowering & cropping. It thrives well under winter frost. It prefers 80 to 150 cm annual rainfall which prevails under subtropical to mid hill zone.

2. Topography and soil

Pecans can be grown on wide range of soils, however, they grow well in fertile, drained, well aerated, deep sandy loam soils, rich in organic matter. The soil pH of 6.2 to 6.5 is ideal for its cultivation.

3. Recommended cultivar

For profitable pecan farming, it is essential to plant pecan cultivars that comply with the high standards concerning adaptability to the region, disease tolerance, kernel percentage, yield, nut size and shape, appearance and taste of the kernels.

Cultivars: Mahan, Nellis, Burkett, Western Schley, Wichita, Mazester.

4. Propagation

Pecan is propagated by budding on seedling rootstocks raised in polybags.

Raising of rootstocks : Seeds from best performing trees should be used to raise the plants. Pecan seed should be stratified in layers of moist sand below 4°C for 3 to 4 months. Seeds should be sown in polybags during February-March in subtropics. Nursery operations from seed sowing to sale of plants should be performed under protected condition to acquire better growth and save time. Budding should be performed during July-August and polybag raised plants may be planted during rainy as well as winter months.

5. Layout and Planting

Planting should be done at 6×6m in square system. Planting is done during winter season or polybag raised plant can be planted in rainy season.

6. Canopy Management

- To get the proper shape and size, it is essential to carry out training and pruning in pecan nut.
- Plants are generally trained to central leader system.
- The lowest branch should be kept to a height of 60 cm from the ground level.
- All 5-6 primary branches should be developed spirally at a distance 20-30cm from one above another.
- Wide crotch angle should be developed in between central leader and primary branches.

- During the initial 4 years of planting, frame work should be developed.
- After development frame work, light pruning on matured pecan nut trees should be done.
- Heavy pruning is not recommended as it results in vigorous vegetative growth.
- Dead, damaged, dried, diseased, overcrowding & intermingled branches should be removed
- Central leader should be headed back at 3 m height.

7. Pollination

2-3 varieties should be planted in the orchard for proper cropping.

8. Orchard Management

8.1. Mulching

- Organic mulching (dry grass, dry leaves, uprooted weeds and farm residues) of 15-20 cm thickness should be done in the first week of March to check the weed population, conserve the soil moisture and regulate soil temperature.
- The raised plant bed should be covered with mulching (plastic or organic mulch). The bed should be covered with mulching (plastic or organic mulching) to check the weed population, conserve the soil moisture and regulate soil temperature. Preferably organic mulching having 15-20 cm thick layer of uprooted weeds from the field is considered economic and better for production and quality of the produce. Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree.

8.2 Intercropping

- During the initial four years, the intercropping of different annual crops should be under taken as secondary crop as mentioned in the table to get additional income during initial years.

Crops for intercropping under high density planting of different fruit crops in sub-tropics of state.

Sr. No.	Name of Crop	Inter Crops	Not be grown as Intercrops
1.	Vegetable	Cabbage, Cauliflower, Pea, Broccoli, Radish	Potato, Tomato, Brinjal, Okra, Cucumber, Pumpkin, Bottleguard, Bittergaurd, Parval, Colocasia , Chilli, Capsicum
2.	Spices	Turmeric, Ginger, Onion, Garlic, Coriander, Fennel, Fenugreek	
3.	Legumes	Lentil, Chickpea, Horse Gram (Kulth)	Beans, Soyabean, Blackgram (Urd), Greengram (Moong), Kideybeen (Rajmash)
4.	Leafy Vegetable	Mustard, Spinach (Palak), Chino podium, Coriander, Fennel, Fenugreek	
5.	Fodder corps	Barley, Oat	Barseem, Jawar, Bajara
6.	Cereals	Wheat, Barley, Linseed	Maize, Sugarcane, Ragi

	Crops/Oilseeds		
7.	Flowers/Fruit	Marigold, strawberry	Gladiolus,

9. Irrigation Management

- Pecan nut is very sensitive to water stress and it needs adequate irrigation supply particularly from flowering to fruit development stage to get better yield and quality. In the reproductive phase water stress is beneficial at the time of flower bud differentiation, but during the plant growth water stress should be avoided.
- No irrigation at full bloom and the ripening stage be given to avoid flower and fruit drop. There should be no irrigation during December and January months.
- Drip irrigation system provides the most efficient and economic management to achieve high productive yields in persimmon orchards New bullet for young trees use one drip line 40cm away from trunk while for trees older than 3 years use one drip line on each side of the tree row 60cm away from trunk and there after the laterals should be shifted upto 1m away from the trunk with increasing age of the tree.
- Apply mulch to cover the root zone in accordance to the spacing of plantation around the tree, keep mulch 10-30cm away from the trunk and expand it to 1m away from the trunk with increasing the age of the tree. Dry leaves or straw are good mulching material. Mulching should be done in the month of February which helps in conserving moisture and reducing weed growth.

9.1. Irrigation Scheduling:

Adequate moisture is required during the vegetative growth for optimum flowering and fruit development. In high density planting, inline drippers are well suited. The irrigation and nutrient schedule below is recommended for pecannut orchards and it is applicable for drip irrigation. The drip line should be laid out at the time of planting of orchard with two drip lines having three inline drippers at 50 cm apart in each basin with 4.5 lph discharge. There should be a control unit/valve for each land holdings.

Drip Irrigation

Year	Irrigation (litres per tree biweekly*)
1 st	3-5
2 nd	6-8
3 rd	10-12
4 th	15-20
5 th	25-28
6 th	32-35
7 th	38-40
8 th	42-45
9 th	46-48
10 th and above	48-50

* Approx. Amount of irrigation water may vary by 10-15 percent depending upon soil, climate and prevailing weather conditions. Being deciduous, the pecan nut do not require frequent irrigation during winter. During rainy season from July to Sept sufficient rainfall occurs in the subtropics of the state. Therefore, under such situations there is no need of irrigating the crops except in case of failure of the monsoon. During February-June assured irrigation supply is necessary for better cropping.

10. Nutrition Management

10.1. Manure: Well rotten farmyard manure should be applied along with 50% P through single super phosphate (SSP) in the basin by band placement during winter months before mid February.

Nutrient recommendations:

The amount of nutrients to be applied through fertilizers in high density orchard of persimmon depends on the age of tree, condition of plant and type of soil. The nutrients dose (g/ tree) should be divided equally among the number of splits and applied at weekly intervals. For proper growth and higher yield, following nutrient doses should be applied:

Age of plant (year)	Nutrient (g tree ⁻¹)*			FYM (Kg)
	N	P	K	
1 st	75	35	75	20
2 nd	150	70	150	30
3 rd	225	105	225	40
4 th	300	140	300	50
5 th	375	175	375	60
6 th	450	210	450	70
7 th	525	245	525	50
8 th	600	280	600	90
9 th	675	300	675	100
10 th and above	750	300	750	100

*Application of N, P and K should be based on soil/leaf test values.

10.2. Stages of nutrient application:

Stage of application	N (%)	P (%)	K (%)
After fruit harvest	40	60	20
During fruit set	40	40	20
Fruit growth	20	-	60
Total	100	100	100

Cropping

Pecan nut have high micronutrient requirements. Recommended soil application rates of chelated micronutrients are 20-50g borax, 20-50g copper sulphate, 20-50g manganese sulphate, 20-70g iron sulphate, 20-75g zinc sulphate and 50-100g magnesium sulphate per tree per year. These micronutrients should be applied in February along with FYM application. Many cultivars are susceptible to fruit drop and calyx cavity if N levels are too high when fruits are sizing. Nitrogen levels should be reduced if these problems are evident.

11. Harvesting

- Most of the pecan nut cultivars are ready for harvesting in the month of October.
- Pecan nut should be harvested when the husk splits open and separates from the nuts.
- Early harvesting should not be done for better quality of nuts.

12. Yield

An average yield of 5-7 kg in fifth year, 20-30 kg 7-8 years and 70-80 kg in 18-20th years and 130-150 kg nuts can be harvested from a well managed pecan orchard.

13. Diseases

13.1 Leaf Blotch/Leaf Spot Disease

There is development of spots on leaves and rounded dead spots on green nuts. Distal portion of branches developed symptoms of canker.

Management

Copper-oxychloride (600g in 200litre water) should be sprayed before opening of leaves and on fortnight interval until leaves developed fully.

14. Insect Pest Management

Borer

This pest infests the stem. Imidacloprid (1ml/l) in tree basin around stem during November-December as irrigation water along with mechanical control.

15. Physiological Disorder

15.1 Blank Nuts

Poor fruit set due to lack of moisture along with micro-nutrient deficiency during flowering and fruit development period cause blank nuts. So, for better cropping continuous moisture regime and suggested nutrient scheduling should be followed.

16. Post-Harvest Management

Nuts should be dried in sunlight and stored at room temperature (20-25⁰C). Nuts can be stored for period of one year at room temperature.

NUTRIENT AND WATER MANAGEMENT IN NURSERY

The most important aspect of nutrition is to allow vigorous tree growth without causing root bounding and allowing immediate tree set in the field after planting. In order to maximize tree growth, growers should apply nutrients and biostimulants foliarly in an attempt to boost nutrition and produce high quality trees able to sustain biotic and abiotic stresses after transplanting into the field. Growers should be vigilant for monitoring of irrigation and nutrient scheduling in the nursery.

Irrigation of rootstock seed beds

Innovative irrigation methods are needed to increase irrigation efficiency and eliminate the drawbacks of overhead irrigation. Overhead irrigation favours leaf diseases, low application efficiency, results in excessive fertilizer loss with potential for contamination of soil, ground water, and water level. Drip irrigation, an irrigation method that applies water to the top of containers/polybags/pots.

The raising of polybag raised nursery in the protected cultivation having under drip fertigation system, fogger, fan and pad system has been considered a high value of high efficiency. In drip irrigation system little water is lost by percolation, reducing the leaching of nutrients to the soil and reducing the potential of environmental contamination by salinization. Water requirements determination and scheduling depends on water retention, atmospheric relative humidity and temperature. Sensor based technology can be used to measure soil moisture which is a promising technologies to optimise nursery tree production.

Irrigation of transplanted and grafted trees

The irrigation management methods commonly used in commercial nursery production are soil- or weather-based methods. Drip irrigation system using drippers with multiple outlets connected to microtubes is the most effective system for the production of nursery trees in pots, which are characterized by simplicity of operation and maintenance. The system can have one emitter with one or multi outlet small tubes to route the water from emitter to the trees. These small tubes are called distribution tubes. Most trees are watered daily to maintain substrate/growing media at field capacity and to minimize leaching. In nutrients rigid schedule based on timer should not be used because they do not take into consideration water demand, conditions and plant growth stage.

N, P, K, Ca, Mg, S fertilization in nurseries

Fertilization in nurseries uses granular, controlled release, and or water soluble fertilizers (fertigation) and liquid manure. It is recommended to maintain adequate concentrations of N, P, K, Ca, Mg, S and micronutrients to stimulate the growth and sprouts of seedling that will produce buds for grafting. The package of fertilization is given below:

1. One litre starter solution 2% NPK (19:19:19) solution should be used just after planting.
2. Liquid manure having 10 kg of fresh cow dung, 5 litre of cow urine and 250 g of jiggery (gud) and 100g of chickpea flour (beson) in 100 litre of water. The solution should be kept for 5-7 days for fermentation and thereafter applied @ 225ml/plant at fortnightly intervals starting from 1month after planting the plants.
3. It is recommended to maintain adequate quantity of macro and micronutrients to stimulate the growth of sprouts that will produce the buds for grafting. In general, a nutrient solution containing the concentration N (20g), P (2g), K (15g), Ca (14g), Mg (3), and S (2g) per 100L of water is considered ideal using fertigation. Nutrient solution @ 100 ml per plant should be applied biweekly.

LITERATURE CONSULTED

1. Package of Practices of fruit crops. Dr. YSP University of Horticulture & Forestry, Nauni-Solan, H.P.
2. Package of Practices of fruit crops. Punjab Agricultural University, Ludhiana, Punjab
3. Gorakh Singh, Vishal Nath, P.K. Ray and H.S. Singh. 2012. The litchi. FAO, New Delhi. 217 p.
4. Ajay Kumar. 2006. Studies on the effect of soil and foliar application of zinc and boron on fruit set, retention, quality, cracking and yield of litchi cultivar Dehradun. Ph.D thesis. Dr. YSP University of Horticulture & Forestry, Nauni-Solan, H.P. 119p.
5. Annual report. 2020. All India Coordinated Research Project on Fruits. IIHR Bangalore.
6. Chauhan, J.S., Chandel, J.S. and Negi, K.S.. Kiwifruit cultivation. Dr. YSP University of Horticulture & Forestry, Nauni-Solan, H.P. 35p.
7. C.P.A., Reju M. Kurian Iyer. High Density Planting in Tropical Fruits: Principles and Practice. IBDC Publishers.
8. Milind S. Ladaniya. Citrus Fruit - Biology, Technology and Evaluation. Elsevier publishers.
9. Ghosh, SP. Citrus fruits. 2007. Indian Council of Agricultural Research, New Delhi. 93p.
10. ICAR-NRCL. Annual Report 2019. ICAR-National Research Centre on Litchi. Muzaffarpur, Bihar, India. 91p.
11. Radha, T., and Mathew, L., 2007. Fruit Crops. New India Publication Agency. New Delhi, India. 429p.
12. Kumar R., Meena R., Sharma B.D. and Saroj P.L. 2018. Production technology of pomegranate in arid region. CIAH/Tech./Bull. No. 65, ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan, India.
13. Chandra, R., Suroshe, S., Sharma, J., Marathe, R. A. and Meshram, D.T. 2011. Pomegranate growing manual. NRC Pomegranate/Tech./ Bull, National Research Centre on Pomegranate (Indian Council of Agricultural Research) NH - 9, Kegaon, Solapur - 413 255 (MS), India.
14. Pal, R.K., Sharma, J., Babu, D., Singh, N.V. and Gaikwad, N. 2017. Pomegranate revolution in India-A success story of ICAR, ICAR-NRC on Pomegranate, Solapur. 14p.
15. Package of Practices for Fruit Crops published by Directorate of Extension, Sher-E-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu-180 009
16. Thind, S.K., Mahal, J.S. 2021. Package of practices for cultivation of fruits. Directorate of Extension Education, Punjab Agricultural University, Ludhiana.
17. POMEGRANATE: Cultivation, Marketing and Utilization. Technical Bulletin No. NRCP/2014/.... ICAR-National Research Centre on Pomegranate, Solapur- 413 255 (Maharashtra)
18. Agmark Standards - Directorate of Marketing & Inspection. <https://dmi.gov.in>.
19. Agricultural and Processed Food Products Export Development Authority (APEDA), <https://www.apeda.gov.in>
20. Package of Practices for Fruit Crops published by Directorate of Extension, Y S Parmar University of Horticulture & Forestry Nauni, Solan HP

Web Sources Consulted

krishi.icar.gov.in
niphm.gov.in
indiancropdiseases.com
coin.fao.org
rvskvv.net
hortportal.org
www.dpi.nsw.gov.au
<http://www.agric.wa.gov.au/>
<http://www.agrifarming.in/>
iwmp.mn.gov.in
www.nrclitchi.org
www.ijcmas.com
imrfjournals.in
cish.res.in
www.yspuniversity.a c.in
ipm.ucanr.edu
pt.scribd.com
<http://www.nhm.nic.in/>
content.ces.ncsu.edu
Diseases of Fruits and Vegetables Volume II, 2004.
<http://www.yourarticlelibrary.com/>
jhs.iihr.res.in
orihort.in
<http://www.phytojournal.com/>
krishikosh.egranth.ac.in
<http://www.fao.org/>
nhb.gov.in
<http://www.wanatca.org.au/>
agritech.tnau.ac.in
iihr.res.in
www.adb.org
tree-disease-treatments-mesa-az.com
ciah.icar.gov.in
<http://www.biosecurity.govt.nz/>
<http://www.i-scholar.in/>
<http://www.hillagric.ac.in/>
aicrp.icar.gov.in
<http://www.ipm.ucdavis.edu/>
<http://www.angrau.ac.in/>
<http://www.mangifera.org/>
nsdl.niscair.res.in
www.ijcse.com
agricoop.nic.in
isasat.org
Pollination Biology Vol 1, 2015.
sph.iihr.res.in
Abiotic Stress Physiology of Horticultural Crops, 2016.
hau.ernet.in
enam.gov.in
www.cabi.org
www.itfnet.org