PACKAGE OF PRACTICES

High Density Plantation of Apple

(Ad hoc-Version-II)

Himachal Pradesh
Horticulture Development Project
(World Bank Funded)

PREFACE

The State has emerged as a leading producer of fruits and offseason vegetables but productivity level of the fruit crops in Himachal Pradesh is far below the international standards, due to various factors viz. (i) limited access to appropriate production technologies, including elite planting materials, (ii) insufficiently developed water management systems, (iii) challenging research system and extension services, (iv) high post-harvest losses, paired with low value addition, exacerbated by inadequate storage, processing, and marketing capabilities. The sectoral, institutional and policy challenges needs to be addressed systematically, if full potential of this industry is to be realized and translated into a sustainable development impact.

The HP Horticulture Development Project (World Bank funded) is being implemented in the State to support interventions designed to help the horticulture sector for improving productivity and build resilience against weather-related shocks, while improving market access and value addition of produce so that growers can produce as per the market need.

In the state, majority of existing temperate fruit plantations are of standard old varieties grafted on seedling rootstocks which are less precocious, irregular in bearing, less productive. To overcome the problems of low productivity in Apples, new varieties on clonal rootstocks are being imported, tested and evaluated in different agro-climatic conditions of the State. To improve the quality of the produce to make the orchards easily manageable with optimum planting density and planting design, different scion-stock combinations are being standardized, in collaboration with Dr Y S Parmar, University of Horticulture & Forestry, Nauni, Solan.

To improve the cultural practices as per international standards, the technical collaboration is also being extended by the International domain experts Dr. Jim Walker, Dr. David Manktelow, Dr. Ken Breen, Mr. Jack Hughes Dr. Mike Nelson Dr. Rashmi Kant of the New Zealand Plant and Food Research Institute.
The version –II of the Adhoc Package of Practices has been compiled by incorporating inputs of both the University Scientists who are actively involved in the research work for development of PoP and International Experts of the New Zealand Plant and Food Research Institute, so as the officers of the Department and farmers take maximum benefits from this document.

Debasweta Banik (IAS)
Project Director, HP HDP

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1. INTRODUCTION

In Himachal Pradesh, majority of existing temperate fruit plantations are on seedling rootstocks and planted under low density. The package of practices for those plantations have been developed by the University. Trees on seedling rootstocks are more vigorous, having long gestation period, and low in productivity, therefore, high density is considered as most important method to achieve high productivity. The trees on dwarfing and semi-dwarfing rootstocks are more precocious, easily manageable, and produce more fruits of better quality. When high density orchards are to be established, training and pruning, irrigation, fertilization and other intercultural operations and orchard management practices are to be modified depending upon the density and climatic conditions. Based on the two years study on high density plantation and practices being followed by the other countries of the world the adhoc package of practices for apple has been compiled.

2. CLIMATE

The varieties of apple imported under the World Bank Project are high colouring strains and require slightly less chilling (800 to 1200 h) as compared to traditional Red and Starking Delicious cultivars. These varieties are highly suitable for cultivation in areas ranging between 1500-2500 m amsl altitude. However, these cultivars can be planted at high elevation in dry temperate zone of the state.

Warm daytime temperatures around 20-25°C at bloom time are ideal for good bee activity, rapid pollen germination and plentiful fruit setting. Fruit set is likely to be reduced if extended cold, wet and cloudy daytime conditions persist over bloom period.

3. TOPOGRAPHY AND SOIL

For high density plantation, the plants are raised on dwarfing and semi-dwarfing rootstocks thus the sites should be flat or with gentle slopes. Very steep and sloppy areas are not suitable for high density plantation especially for dwarfing rootstocks. The apple plants raised on dwarfing rootstock M9 should necessarily be planted in land having deep soil, and assured irrigation. Apple plants on semi-dwarfing rootstock MM106 and on semi-vigorous rootstock MM111 also require deep soil but can be planted in site having gentle slope land.

While planting, tree row orientation should be in North-South. The hill top site is generally not preferred for high density plantation particularly raised on M9 rootstock. The plants on MM106 rootstock should not be planted in clayey and water logged soil as it is prone to collar rot.

4. LAND PREPARATION

It is started about 1-2 month before planting and following points should be taken care during site preparation.

- Remove all the bushes, weeds, stones, and pebbles from the soil. Make terraces in the steep slopes
- Take soil sample from 0-30 cm and 30-60 cm depth to test soil fertility status and soil pH.
- Make proper provision of drainage in wet soil site. Use of cut-off drains, slightly raised rows or mounds to plant trees on and slightly depressed inter-rows may also help.
- Soil solarization and fumigation with fumigants is suggested for replant sites in flat lands.

5. CULTIVARS AND ROOTSTOCKS

5.1 CULTIVARS

Majority of apple cultivars which have been imported or proposed to be imported under the project are high colouring, standard and spur types, with pollinzers.

Fruit colour development increases with rising elevation. As a result, high colour sports may become too dark for the market preference. High colour strains should be selected for lower elevations and consideration given to less strongly coloured varieties for higher areas. Fruit size may also decrease with rising elevation. Gala strains may not reach adequate size at the highest elevation.

5.1.1 VARIETY GROWTH HABITS

Red Delicious selections can be categorised into 3 growth habits as follows:

Growth Habit or Type	Examples
Spur Type	Red Chief, Super Chief, Scarlet Spur-II, Red Cap Valtod, Schlect Spur
Semi-spur	Oregon spur, King Roat
Standard	Jeromine, Red Velox

Spur types are generally more compact and lower vigour trees than standards with semi spurs in-between. Tree size of spur types on M9 are likely to be too small in all but higher in deep fertile new soils. On the other hand, standard types of Red Delicious on moderate vigour rootstocks should grow into large trees. If these combinations are used, appropriately wide tree spacings should be chosen. Growth habit classifications can be subjective and are greatly influenced by rootstock and site factors.

Based on the different climatic conditions of the state, the cultivars suggested for different elevations are:

Zone (Altitude in ft amsl)	Cultivars
4500 to 6000	Scarlet Spur II, Jeromine, Red Cap Valtod, Red Velox, Super Chief, Schlect Spur, Gale Gala (P),
	Redlum Gala (P), other strains of Gala (P), Fuji (P), Granny Smith (P).
6000 to 7500	Red Velox, Jeromine, Gale Gala (P), Sun Fuji (P), Redlum Gala (P), Granny Smith (P).
Dry Temperate Zone	Jeromine, Red Cap Valtod, Red Velox, Super Chief, Schlect Spur, Gale Gala (P), Redlum Gala (P), other strains of Gala (P), Fuji strains (P),Granny Smith (P).

(*P=Pollinizer variety)

5.2 ROOTSTOCKS

Rootstock selection needs to take account of a number of inter-related factors:

- Variety vigour and growth habit
- Elevation – tree vigour usually decreases with increasing elevation
- Fertility - more vigorous rootstocks are more suited to lower fertility.
- Soil water and aeration – trees usually grow best in loamy soils because they have the best condition of good water holding capacity and freedom from poor drainage and aeration. Water can easily become a limiting factor in lighter, sandy soils and tree growth more likely to be restricted if soils

become dry. Soils with high clay content have higher water holding capacity which favours their drought tolerance but are more likely to adversely affected by waterlogging and/or poor root aeration in winters of higher rainfall

Rootstocks suggestion

For lower elevation and flat land: M9, MM106
For higher elevation and gentle slope: MM111, MM106

6. LAYOUT, PLANTATION AND PLANTING DENSITY

- Layout of an orchard should be done in such a way that tree rows are oriented in the north-south directions for better light penetration than east-west direction.
- In flat land, for the plants raised on dwarfing and semi-dwarfing rootstocks planting should be done in a rectangular system where row widths are approximately 0.5m wider than the in row tree spacing, improves orchard access. In steep land having gentle slope, the planting on MM111 should be done in terrace. A typical terrace width of approximately 3m wide allows for a single row of trees on moderately vigorous rootstock planted in the middle of the terrace to allow access to all sides of the tree.

The planting density and spacing depend upon the scion and rootstock combination and fertility of the soil and training system.

Suggested planting distance and training system

Variety/rootstock combinations	Planting distance			Training system
	Row to Row (m)	Plant to Plant (m)	No. of plants/ha	
Standard (Jeromine, Red Velox , Gala and Fuji rootstock (M9) strains)/ dwarfing	2.5	1.0 -1.5	4000- 2666	Tall Spindle
Spur type (Super Chief, Scarlet Spur-II, Schlect Spur, Red Cap Valtod)/ Semi-dwarfing on rootstock (MM106)	2.5	1.0 -1.5	4000-2666	Mini centre
Standard/ Semi dwarf	3.0	1.75m	1900	Tall Spindle or Mini Centre

Spur type/ Semi vigorous rootstock (MM111)	3.0	1.75m	1900	Mini Centre Tall spindle

Note: Since the plants of pollinizer varieties are of standard type, therefore, for plantation in spur type orchard, they should be used on one rank below vigour of the rootstocks. For example, for spur type on MM106, use pollinizer varieties on M9 and for spur type on MM111 use pollinizer varieties on MM106.

The plants on dwarfing rootstock M9 are planted at close spacing; therefore, it is advisable to dig the trenches of 1-meter-wide and 0.9 m deep instead of pits of $1m^3$. However, for plantation of trees which are raised on semi-dwarf (MM106) and semi-vigorous (MM111) rootstocks, pits of 1 m^3 size are dug in the month of November. Pits or trenches should be filled with top soil, well mixed with 30 kg of fully rotten FYM and half kg of Single Super Phosphate per pit. The planting is done from December to February; although, early planting in December is desirable. The graft union should be 18-20 cm above ground level to avoid collar rot. At the time of planting, the pollinizer varieties (at least 3-4) are planted in the proportion of 25-33 per cent for better pollination and fruit set. It is advisable that after planting of two rows of main variety, the third row should be of a pollinizing cultivars.

7. TRAINING AND PRUNING

In medium and high density orchards on clonal rootstock, the main principles of training and pruning are-

- To encourage rapid canopy development
- To minimise the pruning of young trees in favour of early intervention (pinching out of unsuitable growth) and branch training (to maximise the use of available branches).

In high density orchards, the trees are to be trained either with Tall spindle or Mini Centre systems. While doing the training and pruning of trees in these planting systems, the following points are to be kept in mind.

- Keep only weak and horizontal branches. Remove upright and strong growing branches.
- Make monthly thinning cuts, tipping cuts only in special situations such as forcing of laterals in an area devoid of branches.

- Make 'Duch' or bevel cuts on branches > 3-4 years of age to recycle back to axis.
- Tie or put weight on branches as much as possible especially new succulent branches in the late summer.

7.1 TALL SPINDLE SYSTEM

FIRST YEAR

The nursery plants having well developed feather or branches above 60 cm from the ground with wide crotch angle, no heading back is done. However, the imported plants kept for post entry quarantine for one year don't develop good feathers with wide crotch angles; so, remove all feathers at planting by giving Dutch cut and head-back leader to 60 cm above grafting point to encourage the development of feathers. In spring, new branches will emerge and remove all branches up to 60 cm of the soil surface. In summer at 1-2 cm growth, rub off second and third buds below the new leader. At 5-10 cm extension growth, attach clothes pins to new side shoots on leader to promote wide crotch angles. In July, the branches should be spread or tied down below horizontal planes. Install support system. In dormancy, remove the scaffolds that are more than ½ the diameter of the leader at the insertion point using a bevel cut. Keep a single leader removing other competitive shoots. Keep single scaffolds by removing forks. Bend uprights along the scaffolds that are appropriate for fruiting wood under adjacent branches to weaken them.

Notching

Bending of branches by 1-meter spreader

Pinching

Bending of branches by tying with Rope

SECOND YEAR

Follow notching to induce side shoots on the leader

- At 8-15 cm growth, pinch out all the shoots in the top half of last year's growth by removing the growing tips

- Repeat pinching as new shoots appear or previously shoots regrow. Thin crop to single fruit spaced 15-20 cm apart.
- In dormancy, remove only large scaffold, and broken branches using renewal pruning concepts. Select the leader by removing competitive shoots and keep single ends of the scaffolds removing all forked ends. Remove all vigorous upright suckers along the scaffolds.
- Prune up ends of scaffolds to appropriate shoots that should not interfere with management operations and support the crop load.

THIRD YEAR

- At 8-15 cm growth, pinch out the new shoots in the top half of the last year's leader that can be reached from the ground
- In early summer, thin out fruits to singles so that they are at least 10-15 cm apart or are appropriate for the tree size
- Tie tree to stakes with permanent tree tie at the top of the stake to support crop load on the leader
- In July, follow light summer pruning by removing just a few shoots to open up the tree
- In dormancy, remove all broken branches, cut the scaffolds to facilitate soil management operations
- Remove large branches that do not fit the system
- Remove uprights and weak hanging shoots and suckers
- Tie tree to the top of the stake or top wire with permanent tree tie if not done in the previous season

FOURTH YEAR

- In early summer (15-20 days after full bloom), apply chemical thinning and/or follow up with hand thinning, if desired
- In July, follow summer pruning to open canopy and optimize fruit quality.

7.2 MINI CENTRAL LEADER SYSTEM

FIRST YEAR

- In poorly branched tree, head-back the leader to 75 cm from the soil surface to promote the growth of new lateral branches
- At 5 cm shoot growth, clothes pins are attached around the leader above the young shoots to force them to grow horizontally

- After 3-4 weeks, remove the clothes pins
- Remove shoots close to ground i.e. below 60 cm crown height

SECOND YEAR

- If 4 scaffold branches have developed, head-back the leader by removing 1/3rd or 2/3rd of last year's growth depending upon tree vigour
- If only 1 or 2 scaffold have developed in bottom tier, then head back the leader keeping 4-5 buds (10 cm- 20 cm) above scaffold already developed
- Scaffold branches should be headed back by, removing 1/^{3r}d of last year's growth.
- 5-10 cm extension growth, attach clothes pins to lateral shoots developing on last season growth.

THIRD YEAR

- Head back the leader 1 m above the top most branch of bottom tier of branches to promote second tier
- Remove vigorous branches between first and second tiers of branches.
- At 5-10 cm growth, attach clothes pins to lateral shoots developing on 1year old growth to enforce crotch angles
- In late July remove clothes pins

FOURTH YEAR

- Head back the leader removing 1/3rd of last year's growth
- Remove excessive vigorous non-scaffold limbs, particularly those competing with the leader
- In July, when bottom scaffold branch length is approaching one half of row spacing respread them with 1 m spreaders to 80° from vertical
- In August, follow light summer pruning to encourage light penetration and maintain the pyramidal tree shape

FIFTH YEAR

- Do not head back the leader.
- Remove all shoots competing with the leader.
- Remove large one or two branches between first and second tier scaffold limbs.

- In July–August, follow light summer pruning to encourage light penetration and maintain the pyramidal tree shape.

MATURE TREE

- Limit tree height as per row distance i.e. maintain the tree height 90% of the distance from row to row.
- Remove longest branches between tiers.
- Remove the least desirable bottom tier scaffold so that not more than four limbs remain.
- Prune back the lower tier scaffolds to a side branch to facilitate the movement if required.
- During 12^{th} to 15^{th} year, remove second tier East and West growing branches to create palmette or flat fan type top canopy.

7.3 TIMING OF CROP AND CANOPY MANAGEMENT PRACTICES FOR YOUNG TREES

Cultural practices		Approximate time											
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Check height of rootstock union	Should be at least 10-15 cm above ground	Best time	Best time	Best time	OK time	OK time	OK time	OK time					
Define the leader	To single tip. Bevel cut removal of competing branches	Best time	Best time	Best time									
Low Branches	Remove all branches below 2' (minimum) 3' (ideal)	Best time	Best time	Best time									
Notching	Horizontal cut through bark above bud to encourage growth				Best time	Best time							
Hand thin	Max 2 fruit per cluster, ideally 1					Best time	Best time	OK time					
Summer prune	Remove excess upright shoots						Best time	Best time	OK time				
Bend branches	To below horizontal to encourage spur formation							Best time	Best time	OK time	OK time	OK time	

Best time OK time

7.4 TREE SUPPORT

M9 has a weak root system and trees are not considered self-supporting. This means that trees are likely to fall over when they are carrying crop and factors like wind and rain reduce stability. A tree support system for trees on M9 is considered necessary throughout the world. This can either be individual tree stakes or more commonly posts and wires. Tree support systems can also incorporate anti-hail nets.

The moderately vigorous rootstocks (MM111, M7 and M793) require less structural support to keep trees vertical and in some situations (low wind velocity, firm soils and shorter trees) may be self-supporting.

8 ORCHARD SOIL MANAGEMENT

The orchard soil management programme will be influenced by the availability of irrigation, soil types, cropping pattern and rootstocks used.
As M9 is shallow rooted, non-drought tolerant rootstock, it is easily affected by any intercrops or weeds that compete for soil moisture. The moderately vigorous rootstocks, on the other hand, are less affected by competition for moisture and intercrops could be considered once trees are established (>3 years old).

Organic mulches which decay over time and contribute to soil fertility and organic matter are compatible with high density growing systems. Be careful of using pine needles as mulch as they reduce soil pH and can be phytotoxic.

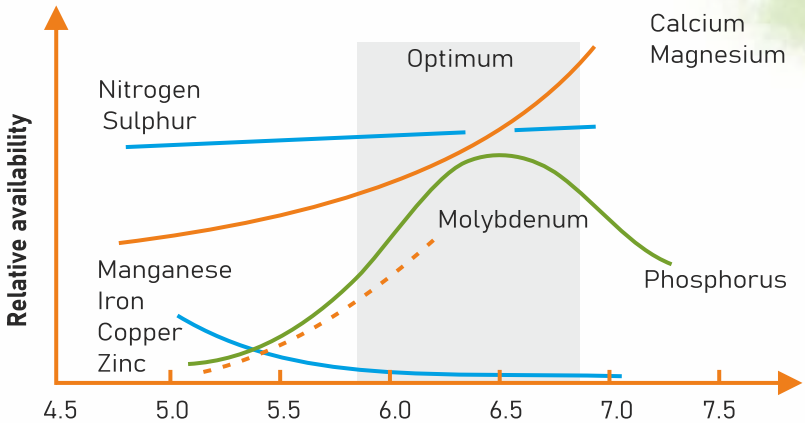
Manual weed control is safe for young trees. Only non-translocated herbicides should be considered for young trees (<3 years old) because chemical can be absorbed by bark and foliage. Herbicide should not be sprayed onto any parts of the apple tree (and immediately washed off with copious quantities of water if they are) as it will kill or deform the tree.

In high density due to close planting no intercrops are suggested and the orchard area should be kept clean and basin area should be mulched with hay or black plastic mulch., followed by post emergence herbicide Glyphosate @ 800ml/ 200ltr of water & 700-800ltr solution required for one hectare area; in July-August for controlling the weeds in the orchard.

9. NUTRIENT MANAGEMENT

9.1 SOIL pH

The first stage of effective nutrient management is ensuring soil pH is within the range of between 5.8 and 6.5. Maintaining the pH within this range ensures there is optimum nutrient availability for plant uptake. Low pH can result in high solubility of some nutrients, such as manganese, leading to toxic levels within the plant. High pH can lead to deficiencies due to low solubility of nutrients and subsequent low plant uptake.



Ground lime is used to raise soil pH. How much is required and how quickly it will work will be influenced by the quality of the lime and its particle size, and soil characteristics.

At tree planting – If lime is required for a new planting, it will be more effective by mixing with the soil in the tree basin area prior to planting.

Existing plantings – apply lime to the tree basin, which can be lightly mixed in. Care must be made not to dig too deep as this will damage fine tree roots near the soil surface.

To raise the pH by 0.1 pH unit - approximately 100 g/m^2
(handful) of good quality lime
For example: Soil pH is 5.5 and you want to raise this to 6.0 (0.5 unit)
Tree basin is 2m X 2m wide = 4 m^2
100g lime X 5X 4 = 2000g /tree (2.0 kg/tree)

However, this can vary depending on soil type. A sandy soil requires less lime, and a clay soil can require more lime to make the same change.

It can take 12 to 18 months for the lime to be fully dissolved, and raising pH, depending on how finely the lime is grounded. The finer the lime the earlier it is effective.

Sixteen essential nutrient elements (C, H, O, N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B, Mo and Cl) required by plants are obtained from the soil, water and air. Thirteen of these elements are supplied by the soil. Six of these nutrients (N, P, K, Ca, Mg, S) are required by plants in relatively large amounts and are usually added to the soil through fertilizer or lime. These are called macronutrients. The remaining 7 elements (Zn, Cu, Fe, Mn, B, Mo and Cl) supplied by soil are required in very small amounts and are termed micronutrients.

While most of the nutrient elements required by the plants are present in the soil, there is generally insufficient supply to meet tree requirements so the shortfall is usually supplied by fertilizers. The sources of nutrients and forms used by the plant are as below:

Element	Symbol	Source	Form Used
Macronutrients			
Oxygen	O	Air/Water	O_2
Hydrogen	H	Air/Water	H^+, OH^-,H_2O
Carbon	C	Air/Water	CO_2, H_2 CO_3
Nitrogen	N	Soil	NO_3^-, NH_4^+
Phosphorous	P	Soil	HPO_4^{2-}, $H_2PO_4^-$
Potassium	K	Soil	K^+
Calcium	Ca	Soil	Ca^{2+}
Magnesium	Mg	Soil	Mg^{2+}
Sulphur	S	Soil	SO_4^-
Micronutrients			
Iron	Fe	Soil	Fe^{2+}, Fe^{3+}
Manganese	Mn	Soil	Mn^{2+}
Boron	B	Soil	H_3BO_3, BO_3^-
Molybdenum	Mo	Soil	MoO_4^-
Copper	Cu	Soil	Cu^{2+}
Zinc	Zn	Soil	Zn^{2+}
Chlorine	Cl	Soil	Cl^-

The soils being cropped for long time are unable to supply the required amount of nutrients and due to introduction of high yielding varieties and intensive cultivation, the plants usually show the deficiency symptoms of many nutrients.

9.2 NUTRIENT FUNCTION AND DEFICIENCIES SYMPTOMS

9.2.1 NITROGEN

Functions: Nitrogen is a constituent of amino acids, amides, proteins, enzymes, vitamins, coenzymes and plant hormones. It imparts vigour to the plant and dark green colour to the foliage. Nitrogen is required for cell division and respiration. It delays plant maturity due to which tissues remain succulent in nature. Nitrogen also governs the utilization of phosphorus, potassium and other essential elements. It is a very mobile element.

Deficiency symptoms: General chlorosis, chlorosis progresses from light green to yellow. Entire plant becomes yellow under prolonged stress. Shoots short, thin, upright and spindly, leaves small, normal in shape with pale yellowish green colour in early stage followed by orange, red purple, yellow tints starting with the older leaves, Blossoming and fruiting reduced, fruits small with marked reddening and poor storage qualities.

9.2.2 PHOSPHORUS

Functions: Phosphorus is component of sugar, phosphates, nucleic acids, nucleotides, coenzymes, phospholipids, phytic acid, etc. It is mostly found in younger parts viz. flowers, maturing fruits and seeds. It enhances crop maturity, root growth, activity of rhizobia and formation of nodules in legumes. It plays a key role in reactions involving ATP and cell division. Phosphorus is required in photosynthesis and carbohydrate break down and transfer of energy within plant.

Deficiency symptoms: Shoots short, thin, upright and spindly, leaves small, with dull purple and bronze tints, early defoliation of older leaves, blossoming and fruiting reduced, bud break in spring may be delayed.

9.2.3 POTASSIUM

Functions: Potassium improves the efficiency of sugar use in plant system. It

helps the plants to overcome the stresses due to environment like frost tolerance by decreasing the osmotic potential of cell sap. K regulates the supply of CO_2 by controlling opening of stomata. Young leaves, shoot tips and meristematic tissues are rich in K. It is involved in cell division. It improves the colour, flavour and fruit size.

Deficiency symptoms: Growth restricted and branches die back, leaves bluish green with slight marginal and interveinal chlorosis, followed by marginal scorching either brown or greyish brown colour, blossoms heavy in early stages but yields are poor, fruits small with poor fruit quality.

9.2.4 CALCIUM

Functions: Calcium is present in leaves as calcium pectate. Calcium is required as a cofactor by some enzymes involved in the hydrolysis of ATP and phospholipids. It is very important for chromosome flexibility and cell division. Calcium helps in the uptake of N, Fe, Zn, Mn and B. Good calcium nutrition is a pre-requisite for healthy orchard.

Deficiency symptoms: Death of the growing points followed by die-back, scorching and upward rolling of leaf margins, margin ragged in appearance with tip leaves being affected first.

9.2.5 MAGNESIUM

Functions: Magnesium is a constituent of chlorophyll and protoplasm. It is involved in photosynthesis. It is an activator of many enzymes. Mg is required non-specifically by large number of enzymes involved in phosphate transfer. It is essential for formation of carbohydrates, fats and vitamins. It also stimulates phosphorus uptake and transport.

Deficiency symptoms: Severe defoliation of terminal shoots progressing from base to tip, purple tinting and marginal or interveinal chlorosis of older leaves, leaves and fruit show heavy drops towards the end of growing season.

9.2.6 SULPHUR

Functions: Sulphur is present in sufficient quantity in leaves. It is a component of cystine, methionine, proteins and fatty acids. Sulphur is also a constituent of

lipoic acid coenzymes-A, thiamine, pyrophosphate, glutathione, biotin, and adenosine-5′- phosphosulphate and 3′ phosphoadenosine-5′-phosphosulphate. Sulphur retards protein synthesis, imparts hardness and vigour to the plants.

Deficiency symptoms: Growth restricted, stiff, woody, thin and upright, yellowing of the leaves and orange and red tinting with some necrotic spotting between the main veins with tip leaves affected first.

9.2.7 BORON

Functions: It is immobile in plant system. It plays a role in flowering, pollen germination, pollen tube growth and fruiting. It helps in the translocation of sugars from leaves to enhance photosynthesis. Boron also acts as a catalyst in physiological processes viz, cell division, differentiation and development.

Deficiency symptoms: Shoots show multiple buds and rosettes and fail to elongate in normal manner, die back, and bark rough, pitted and split, leaves show thickening, cupping, yellow veining or complete yellowing, corky vein and defoliation, fruits small misshapen, corky spot or corky core, cracking of fruits.

9.2.8 IRON

Functions: Among the micro-nutrients iron is abundantly present in soils. Iron is a constituent of cytochromes and non-haeme iron proteins. It acts as a catalyst in the formation of chlorophyll and co-factor of several enzymes. It helps in various reactions of respiration, photosynthesis and reduction of nitrates and sulphates. It has a role in N_2^- fixation also. The improved Fe^- polyflavonoid activity enhances the biosynthesis of pigments like xanthophylls and carotenoids.

Deficiency symptoms: Die back of the shoots and branches, young leaves show network of green veins on a yellowish green background, severely affected leaves may be straw yellow, have few if any green veins and may show marginal or tip burning.

9.2.9 ZINC

Functions: Zinc is required for the synthesis of tryptophan which is a precursor of auxin-Indole acetic acid (IAA). It regulates the equilibrium between carbon dioxide, water and carbonic acid. Zinc is essential for carbohydrate and phosphorus metabolism and synthesis of proteins. It is a constituent of alcohol

dehydrogenase, glutamic dehydrogenase, lactic dehydrogenase, carbonic anhydrase, alkaline phosphatase, carboxyl peptidase and other enzymes. Zinc improves integrity of the cell membrane and stabilizes sulfhydryl groups in membrane proteins involved in ion transport.

Deficiency symptoms: Buds along shoots fail to develop, leaves small and narrow (little leaf), distorted, wavy margins and tend to form rosettes at tips of shoots, foliage sparse throughout the tree with somewhat better growth towards the shoots tips than at the lateral nodes and spurs, blossoming and fruiting reduced, fruits small, pointed and misshapen.

9.2.10 COPPER

Functions: Copper is associated with the mechanical strength to cell wall. It is required in oxidation-reduction reactions, photosynthesis, respiration, carbohydrate/nitrogen balance, chlorophyll and vitamin A formation, biosynthesis and ethylene activity in ripening of fruits. Copper proteins have been found in lignifications, anaerobic metabolism, cellular defence mechanism and hormonal metabolism.

Deficiency symptoms: Die back of the shoots with the dead areas curling downwards, wither tip with tip leaves affected first, leaf margins burnt and ragged with some cupping. In milder stages and interveinal chlorosis of growing leaves resembling iron deficiency may occur, rosetting of leaves may occur due to short internodes, defoliation progresses from the tip to the base of the shoots.

9.2.11 MANGANESE

Functions: Manganese accumulates in leaves more than in seeds. It is required for photosynthetic evolution of O_2, nitrogen metabolism, chlorophyll synthesis and breakdown. It is required for the activity of some dehydrogenase, decarboxylase, kinase, oxidase, peroxidase, and non-specifically by other divalent cation activated enzymes. It is also required for ascorbic acid synthesis. Mn is involved in the production of amino acids and proteins.

Deficiency symptoms: Die back of twigs and branches, interveinal chlorosis progressing from margins towards midrib with older leaves may be affected before the tip leaves, early defoliation particularly in the top of the tree, fruits colour poorly.

9.2.12 MOLYBDENUM

Functions: Molybdenum plays an important role in nitrogen metabolism. It is a constituent of nitrate reductase and xanthine oxidase. Mo assists in the formation of proteins, starch, amino acids and vitamins.

Deficiency symptoms: The leaf blade may fail to expand in the growing leaves. Yellow spots develop on the lamina and gum on the lower leaf surface which turns black. Large interveinal chlorotic spots appear on mature leaves. The severely affected leaves may fall and tree may become completely defoliated. The yellow patches on leaves coalesce into larger areas, extending all along the leaf margin, leaving the central portion yellowish green.

9.3 FERTIGATION & IRRIGATION SCHEDULES

9.3.1 FERTIGATION

(I) Adhoc fertigation schedules for high density apple plantation:
Recommended dose (N-P_2O_5-K_2O) 35-17.5-35 g/tree/year
(In 14 splits at weekly interval starting from 15th March till the end of June)

Age of plant(years)	Fertilizer requirement (g/plant/split)		
	N	P_2O_5	K_2O
1	2.5	1.25	2.5
2	5.0	2.5	5.0
3	7.5	3.75	7.5
4	10.0	5.0	10.0
5	12.5	6.25	12.5
6	15.0	7.5	15.0
7 and above	17.5	8.75	17.5

In addition, apply FYM @5 kg/ plant or vermicompost @ 2.5 kg/ plant (one-year-old) and increase the amount progressively upto 7 years i.e 35 Kg FYM/ plant and 17.5 kg/plant vermicompost.

(II) In surface application: Apply 35, 17.5 and 35 g/plant N, P_2O_5 and K_2O for one-year-old plants, respectively. Increase the amount by same amount for progressive increase in age up to 7th year i.e. 245, 125 and 245 g/plant N, P_2O_5 and K_2O.

In case N application is made through urea apply lime @ 60g and 425 g/plant in one and seven-year-old plants, respectively to neutralize the acidity.

(III) Micronutrient spray schedule :

Foliar spray schedule of Zinc, Boron and Calcium

Nutrient element	Salts	Quantity (g) per 100 litres of water	Spray interval	Time of spray
Zinc	Zinc sulphate	500	1-2 sprays at 15 days interval	May-June
Boron	Boric acid	100	-do-	2 sprays, one at pink bud stage & another after petal fall in May-June
Calcium	Calcium chloride	500	-do-	1st spray 45 days beforeharvest & 2nd spray after 15 days 1st spray

Note: Spray above chemicals separately and mix hydrated lime equal to half quantity of zinc sulphate, i.e. 250 g/100 litres of water

9.3.2 IRRIGATION

Irrigation schedules (Litre /plant)

Months	Quantity of irrigation water (litre)*						
	1st yr	2nd yr	3rd Year	4th Year	5th Year	6th Year	7th year & above
March(Bi-weekly)	5.0	5.0	7.5	7.5	7.5	10.0	10.0
April(Bi-weekly)	7.5	7.5	7.5	10.0	10.0	12.5	12.5
May(Bi-weekly)	12.5	12.5	12.5	15.0	15.0	15.0	15.0
June(Bi-weekly)	15.0	15.0	15.0	17.5	17.5	20.0	20.0
July**	--	--	--	--	--	--	--
August**	--	--	--	--	--	--	--
September(Weekly)	5.0	5.0	7.5	7.5	7.5	10.0	10.0
October(Weekly)	5.0	5.0	7.5	7.5	7.5	10.0	10.0
November(Weekly)	5.0	5.0	7.5	7.5	7.5	7.5	7.5

* Volume of water for one square meter tree basin and increase with the increase in the size of basin.

** In July and August, irrigations should be given as per schedule of May in case there are long dry spells.

In Micro irrigation system, four emitters/plant each having a discharge rate of 4 litre/hour.

Under conventional surface irrigation, a total of 8 irrigations, each of 4 cm (40 litre water for a tree basin of 1.0 m^2) at 20 days' interval in March and April and at 10 days' interval during May and June.

10. DISEASE AND INSECT PEST MANAGEMENT

10.1 MANAGEMENT OF DISEASES

Spray schedule recommended for management of insect pest and diseases for normal seedling based orcharding by the University and Directorate of Horticulture on year to year basis may be followed for high density plantation of apple. However, the specific disease management practices along with disease symptoms and integrated management practices are recommended as below.

Diseases	Management practices
(I) Apple scab **Causal organism:** *Venturia inaequalis* The symptoms of scab are produced on all the aerial parts like leaves, petioles, blossoms, sepals, fruits and pedicels but less frequently on bud scales. The early symptoms normally appear as small dull olive-green patches mainly on the underside on young leaves during the early spring. Later, as the disease progress, darker spots develop on both the surfaces of the leaves. Young lesions are velvety brown to olive-green and have indistinct margins. When several lesions coalesce on young leaves they become curled, dwarfed	1. Practice field sanitation to reduce the initial inoculum. Collect and destroy the fallen leaves in winter. Also spray urea (5%) at pre-leaf fall stage. 2. Follow proper pruning of the trees to allow free air movement and rapid drying of foliage. 3. Follow the fungicidal spray schedule recommended by the University and Department of Horticulture.

and are distorted. Small superficial corky lesions or large patches develop on the fruit surface. Severe early attack also results in serious cracking and formation of mis-shapen fruits.

(II) Premature leaf fall/ Marssonina blotch

Causal organism: *Marssonina coronaria*

Disease symptoms appear both on leaves and fruits.
On upper surface of mature leaves initially dark green spots later becoming dark brown in colour appears.
Appearance of large number of lesions turn leaf colour to yellow, which fall of pre-maturely.
Small dot like structures (3-5mm size acervuli) are also seen in such lesions. Dark brown, oval, depressed, spots develop on fruits which turn almost black in colour. Fruit tissue below these spots is often soft, but

1. Collect the fallen leaves and fruits from orchard floor and destroy them preferably in a composting pit.

2. Follow appropriate pruning allows adequate air circulation and help to reduce disease development.

3. Initiate spray of recommended fungicides at least in the first fortnight of June and repeat at an interval of 20 days.

4. Recommended fungicides are Mancozeb (0.3%), Carbendazim (0.05%), Propineb (0.3%), Dodine (0.075%), zineb (0.3%),

not corky as in case of scab.

thiophanate methyl (0.05%), ziram (0.3%) etc.

(III) Powdery Mildew

Causal organism: *Podosphaera leucotricha*

The disease symptoms are observed immediately after bud-burst when all the freshly produced tissues are completely mildewed and resulting flowers and leaves appear as white rosette. Infected lateral buds may produce completely mildewed side shoots in the same manner. From the mildewed surfaces numerous spores are released which infect young unexpanded leaves, young buds, lateral buds on new shoots and growing points.

Pollinizning cultivars are more susceptible.

1. A combination of special winter and spring pruning is necessary to keep disease under the check.
2. In severely affected orchards one-year-old shoots should be removed with top few buds up to 2-3 inches in winter.
3. At the pink bud stage the diseased blossoms and leaves should be pruned in the wee hours avoiding shaking of twigs.
4. A spray schedule comprising four sprays starting at dormant stage, green tip stage, petal fall and 20 days after the third spray with carbendazim(0.05 %) or hexaconazole(0.05%) or difenoconazole (0.015%) are recommended.

(IV) Leaf Spots and Blight

Causal Organism: *Alternaria mali, Alternaria alternata, Phyllosticta spp.*

Spots of various shapes and sizes develop on the leaves in summer and rainy season. Premature defoliation follows yellowing of the diseased leaves thereafter.

1. Destroy diseased shoots and other pruning material and plough fallen leaves in soil

2. Primary infection (2-3 weeks after petal fall) can be checked by giving protective sprays with mancozeb (0.3%), propineb (0.3%), whereas, dodine (0.075%), hexaconazole (0.05%) or difenoconazole (0.015%), or flusilazole (0.025%) are highly effective at post -infection stage.

(V) White Root Rot

Causal organism: *Dematophora necatrix*

1. The infected site should be avoided for planting new trees as far as possible, else, before

On the foliage the symptoms are premature chlorosis, Smalling of leaves and fruits and cessation of shoot growth. Rapid spread and development of pathogen may result in bronzing of foliage and premature defoliation. These symptoms are similar to those produced by other soil- borne pests and pathogens and thus underground diagnosis of the disease is required for confirmation.

The rotting starts from the fine roots, which further extends to the upper roots ultimately reaching the tree trunk. After a few days of infection, the roots are covered with white cottony mycelial growth of the fungus, which may extend to adjacent areas. Subsequently, the mycelium on the roots turns greenish grey or black and aggregate to form thick hyphal strands. In advance stages, the roots are completely devoured and diseased seedlings or trees are easily uprooted from the soil.

planting trees in infested sites, soil sterilization with formalin should be done.

2. Infected soil should be kept fallow with frequent cultivation of crops like maize to starve the pathogen.

3. Drainage in the orchard should be improved as the disease progress is faster in waterlogged areas.

4. Application of organic amendments such as neem cake and deodar needles or green manures should also be practiced.

5. The acidic soil should be amended by applying lime for some years.

6. Use of various chemicals as a deep drench in soil is very effective for its management. Soil drenching with carbendazim (0.1%) or aureofungin (0.02%) + copper sulphate (0.02%) with the onset of rainy season has been recommended

(VI) Collar Rot

Causal organism: *Phytophthora cactorum*

Collar rot symptom often appears near the graft union of the plant, but sometimes may originate on the lower trunk or at the pruning wounds. The bark in the diseased plant parts is discoloured and turns into a moist rot in which necrotic tissues eventually turn dark brown and develop an alcoholic odour. Wood beneath the necrotic bark is stained dark brown and such staining may extend beyond the edge of the lesion. Bark above ground dries out and eventually splits away from the wood. In the subsequent years infected trees become unthrifty with pale, sparse leaves; fruits remain small and colour prematurely and there is little or no shoot growth. Death of the tree usually follows, especially where the tree has been girdled.

1. Grafting point should be kept at least 18-20 cm above the ground level.

2. General management orchard practices such as improved drainage around the tree base, removal of crop effuse and avoiding injury to the stem during field operation are helpful in restricting the disease spread.

3. Putting sand around the stem upto one-foot area upto 10 cm depth does not allow the water to stand and thus avoid the infection by pathogen.

4. Scarification of wounds near the collar region and application of fungicidal paints including Bordeaux paint or any other copper paint are useful to check the spread of infection in disease trees. Drenching with mancozeb (0.3%) during the month of April and October is effective to control the disease.

(VII) Seedling Blight

Causal organism: *Sclerotium rolfsii*

It can infect and kill up to 3 years old trees, the infected plants show blightening of leaves, which upon inspection at the base of plant near soil line normally reveals the presence of mustard seed size light to brown coloured sclerotia specially during July- August.

1. Nursery site must be rotated every 3-4 years.
2. Addition of neem and mustard cakes @ 2 t/ha is also helpful in lowering the disease incidence.
3. Soil solarization by spreading transparent polythene sheet for 60 days during summer months or sterilization of nursery beds with formalin is recommended.
4. Drench the nursery beds with hexaconazole (0.075%).
5. Removal and destruction of infected plants is mandatory to avoid further disease spread.

(VIII) Crown Gall and Hairy Root

Causal organism: *Agrobacterium tumefaciens, Agrobacterium rhizogenes*

Initially crown gall symptoms appear as small, round, soft overgrowths on the stem and roots, particularly near the soil line. As the galls or tumours start increasing in size, the surface becomes convoluted having dark brown outer tissues due to the death of peripheral cells.
Hairy root symptoms on young apple

1. Plant disease free plants in well drained areas.
2. Adopt cultural practice s to avoid injury to the roots or collar, and rotating contaminated sites with non-host monocots plants.
3. Dip healthy grafted plants in 1% copper sulphate solution for 1.5 hours.

trees are characterized by an extensive proliferation of adventitious roots, singly or in clusters, at the base of stem, crown and roots.	
(IX) Cankers Cankers may appear as sunken areas or swollen areas on infected branches. Most canker diseases are caused by fungi, but there are a few bacterial canker diseases. The fungi that cause canker diseases will often colonize the bark of newly planted trees under water stress. If a canker disease girdles the entire branch or trunk, all growth beyond the canker will die. Pink, stem brown, smoky blight, nail head and silver leaf are most common apple canker found in Himachal Pradesh. 	1. Remove and destroy infected plant parts, mummified fruits, dead twigs and pruned branches. 2. Avoid mechanical injuries. 3. Application of balance d fertilizers on the basis of leaf and soil analysis. 4. Properly irrigate during hot dry periods to avoid stress. 5. Protect plants from high and low temperature injuries. 6. Ensure effective control of insect-pests and diseases. 7. Sprays of carbendazim (0.05%) or captan(0.3%) at postharvest and late dormancy stage in the last week of February. 8. For treatment of wounds the canker portion is scarified upto healthy part with sharp edged knife during winters, cleaned with spirit and then paste or

paint is applied during the dormancy in winters month. Commonly used paste/ paints are'Chaubattia paste/ paint', 'Bordeaux paint' and copper oxychloride paint. A combination of cow dung, clay soil and water in equal quantity and addition of carbendazim (10 g/lt) is the cheapest way for controlling all types of cankers.

(X) Virus/Viroid Diseases

a) Apple Chlorotic Leaf Spot

The symptoms include translucent or chlorotic leaf spots with asymmetric leaf distortion, irregular diffused chlorotic rings and line patterns on leaves which are reduced in size and often drop prematurely. Symptoms on stem includes stunted growth, terminal die back of some clones and pitting of the xylem vessels with inner bark necrosis.

b) Apple Mosaic

Leaves of infected apple plants show different forms of mottling, the most common being the presence of a number of small irregular creamy or yellow spots that stand out conspicuously against the dark green colour of normal leaf tissue. These areas often become chrome yellow or white as the active season progresses. In a diseased plant all the leaves may not express symptoms. Affected leaves may be interspersed with normal leaves on individual shoots. Differences in virus strains and varietal sensitivity can cause variation in the severity of symptom expression.

c) Dapple Apple Viroid

Symptoms first appear as small circular spots in mid-July which stand out against the background colour on the young fruits. The spots on fruits remain greenish as the background colour develops and enlarges as the fruit matures; sometimes coalescing into large discoloured areas, especially at the calyx end of the fruit. Dappling of the fruits become more intense as the fruit approaches maturity.

Management practices

1. Use of disease free plant material for propagation.
2. Plant only healthy plants.
3. Destroy the infected plants.
4. Although, most of the viruses are unstable, yet use of disinfected farm implements like knives and secateurs for budding, grafting and pruning of each tree separately with rectified spirit.

10.2 MANAGEMENT OF INSECT PESTS

Pest	Management practices
(I) San Jose scale: Less infested trees show small greyish specks on the bark surface. Severely infested trees have the bark covered with grey layer of overlapping scales appearing as if sprayed with wood ash. On fruits red halo like discolourations are visible.	Spray Horticulture mineral oil 2% (20ml/L) is recommended at green tip stage of Apple bud development. Spray malathion 50EC @ 0.05% (1ml/L) or oxy-demeton methyl 25EC @ 0.025% (1ml/L) just after fruit set to kill the crawlers and newly settled scales. Repeat after 21 days if required.
(II) Woolly apple aphid: The pest lives in colonies both on the roots and aerial parts of the plant. On the aerial part it is seen as white woolly mass. Damage is caused by sucking cell sap from stem, twigs and roots resulting in gall formation. Affected plants loose vigour which affects yield as well as the quality.	1. Place granules of phorate (30g of 10CG) or carbofuran (50g of 3CG) at 5cm depth in the rhizosphere during April-May. 2. Manage root form of aphid by drenching the trees during October around collar region with chlorpyriphos 20EC @ 0.08% (4ml/L) using 4-5 L of insecticide emulsion.

	3. Spray chlorpyriphos 20EC @ 0.04% (2ml/L) or quinalphos 25EC @ 0.05% (2ml/L) in September- October to check the aerial infestation of the pest. Avoid spray during May-June when the predator activity is high. 4. Remove suckers/ water sprouts and cover the cracks, crevices, wounds and cut ends with anti-fungal/ bacterial paste. 5. Remove suckers/ water sprouts and cover the cracks, crevices, wounds and cut ends with anti-fungal/ bacterial paste.
(III) Phytophagous mites: Damage the foliage by feeding on green matter and sap causing loss of chlorophyll resulting affecting loss both quantitatively and qualitatively	Spray fenazaquin 10EC @ 0.0025% (0.25ml/L) or propargite 57EC @ 0.057% (1ml/L) or spiromesifen 240SC @0.007% (0.3ml/L) or hexythiazox 5.45% EC @ 0.012% (1ml/L of) at three week interval.
(IV) Borers: Causes damage to root, stem and shoots as a result of which plants become weak and may even die. The above ground borers are evident from the frass and faecal pellets or drying up of the terminal shoots. The borer infested trees loose upright posture become shanky, stunted and weak. The leaves of affected trees	1. For stem borer, clear the hole with flexible wire, insert cotton wick soaked in petrol or dimethoate 30EC @ 0.03%(1ml/L) and plug the hole with mud. Injection of dimethoate 30EC @ 0.03% (1ml/L) is also useful.For shoot borer management, clip off the terminal shoots with borer inside.

are small and pale green. Tree tilt due to severing of main roots 	2. For root borer management, collect and kill the grubs while preparing basins. Install a light trap near the orchard to collect and kill the beetles during June- August. Drench the tree basins during September-October with chlorpyriphos 20EC @ 0.08% (4ml/L). 3. In August, drench biofungicide, Metarhizium anisopliae (1x106 conidia/cm2) in tree basins @30g/L of water. Mix well rotten FYM/ vermicompost in basin before drenching
(V) Blossom Thrips: Very small yellow, pale brown and black slender insects feed within the floral buds and flowers. Fruit set gets affected.	Spray with thiacloprid 240SC @ 0.012% (0.5 ml/L) at pink bud stage, if the number of thrips is more than 15/flower.

11. MANAGED HONEY BEE POLLINATION

11.1 USE OF HIVE BEES FOR POLLINATION

- Three strong honeybee colonies per hectare are recommended for orchards having 25-33 per cent polliniser proportion.
- Place honeybee colonies in apple orchard at 5-10 per cent bloom.
- The colonies should be 6-8 bee frames strength with 3- 4 frames of brood having prolific queen.

PRECAUTIONS

- Place colonies in sunny and sheltered location.
- Do not shift colonies from one orchard to another if the distance is less than 5 km. Do not spray pesticides while the crop is in flowering.

MOVEMENT OF HONEYBEE COLONIES

- Provide proper ventilation by using entrance screens and even top screen in place of inner cover during hot days.
- Close all the cracks or openings in the hive.
- Nail all the movable parts of the hive properly or tie with migratory belts.
- Before packing the colony, remove frames of honey which are more than half sealed. The colonies should have sufficient food during long journey.
- Close the entrance in the evening when all bees have returned. Pack the inside of the hive to keep frames tight.
- Load the hive on to a vehicle and transport them (preferably at night).

11.2 USE OF POLLEN DISPENSER

Hive pollen dispenser are devices placed at the entrance of the hive and are so constructed that outgoing foragers are forced to walk through the pollen. This facilitates the adhering of pollen to the body of foragers and is effective in polliniser deficit orchard and in conditions when there is non synchronization of flowering. Fixation and use of pollen dispenser

- Pollen dispenser is fixed at hive entrance of A. mellifera strong colony.
- 2 g of dehisced pollen should be mixed with powdered dried anther husk in ratio of 1:1.
- The mixture should be kept in pollen dispenser daily at 0900 and 1100 h continuously for five days.

PREPARATION OF FUNGICIDE MIXTURES

1. Bordeaux mixture

Mixture of copper sulphate and lime is known as Bordeaux mixture

Copper Sulphate	1 Kg
Lime	1 Kg
Water	100 litre

- Crush the copper sulphate crystals into powder and soak in water in a mudpot or plastic bucket overnight.
- Soak lime in another vessel in 50 litres of water overnight.
- Pour the copper sulphate solution into the lime, slowly stirring the mixture all the while with wooden stick and add water to make 100 litre volume. Light sky blue colour mixture will be there.
- Test the mixture before use for the presence of free copper, which is harmful to the plant, by dipping an iron nail or blade for few minutes. If the blade shows a reddish brown colour add more lime till the blade is not stained on dipping
- Strain the prepared Bordeaux mixture through a cloth/strainer before spraying.

2. Bordeaux Paint

Bordeaux paint is applied for curing the deep and deformed wounds caused by cankers, gummosis, collar rot/root rot and to wounds resulting from surgical removal of crown gall or hairy roots from the stems of infected plants during dormant period. It is a suitable recommendation in areas or seasons which receive heavy downpour. It protects the treated part of the host against water for longer period, thus ensuring rapid healing of wounds.

Copper Sulphate	1 part
Lime	2 parts
Linseed oil	3 parts

- Heat the copper sulphate crystals on an iron sheet or in frying pan till it crumbles into a white amorphous form.
- Ground the heated crystals into a fine powder.
- Boil the linseed oil and allow it to cool

- Mix the copper sulphate powder thoroughly with lime dust and homogenised in 3 litres of cooled oil to make a thick paste
- Apply the paint to the plant parts with the help of a brush up to 1m from the base of the tree.
- Apply the paint during Feb-March, Sep Oct, and Dec-Jan to protect the plant from soil borne pathogen.
- Store the paste in a glass jar or other suitable non-metallic vessel for future use

3. Bordeaux Paste

The Bordeaux paste is the most effective wound dressing material for this purpose. The fine layer formed on the cut ends kills the pathogen from subsequent invasion and results in rapid healing of the wounds.

Copper sulphate	800 gram
Lime	1000 gm
Water	10 litre

- Crush the copper sulphate crystals into powder and dissolve in 5 litres of water in a mudpot or plastic bucket.
- Dissolve lime in another 5 litres of water.
- Pour the copper sulphate solution into the lime, slowly stirring the mixture all the while with wooden stick.
- Test the mixture before use for the presence of free copper, which is harmful to the plant, by dipping an iron nail or blade in it. If the blade shows a reddish brown colour add more lime till the blade is not stained on dipping.
- Apply the paste on cut ends of trees with a brush

Some do's and don'ts

- Use the Bordeaux mixture soon after preparation. It should not be stored for further use.
- Do not use metallic containers for preparing copper sulphate solution and lime suspension. Use wooden stick for stirring to get a homogenous mixture. Never use metallic stick.
- To avoid choking of the nozzle, it is advisable to strain the Bordeaux mixture through a cloth or a sieve before putting it into the spray tank.
- The Bordeaux mixture tends to sediment easily. Therefore, stirring

while using is desirable.

- It is not advisable to spray the Bordeaux mixture on fruit-laden trees as the spray may inflict russetting especially on apple and pear.
- In exceptionally hot days, when the plants are showing signs of temporary wilting or when it is raining, the Bordeaux mixture should not be sprayed, particularly on newly emerged tender foliage.
- After carrying out spray operations, the appliances should be thoroughly washed with plenty of water to remove any copper deposits.
- The left over Bordeaux mixture should not be dumped in the field as this may prove toxic to the subsequent sowings.

Preparation of spray solution

$$\text{Quantity of insecticide required} = \frac{\text{Volume of spray fluid} \times \text{Strength of the spray solution desired (\%)}}{\text{Strength of commercial formulation (\%)}}$$

e.g. Preparation of 100 litres of a 2.5% solution from an insecticide formulation containing 50% a.i.

$$= \frac{100 \times 2.5}{50} = 5$$

Therefore, 5 kg or 5 litres of insecticide formulation have to be mixed with 100 litres of water to obtain 2.5 % concentration.

Note

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Contributing Scientists: - Dr J S Chandel Dr J C Sharma, Dr Divender Gupta Dr Shalini Verma, Dr Harish Kumar.
Technical contributions by:- Domain experts of the New Zealand Plant and Food Research Institute.
Edited By:- Dr. Satish Kumar Sharma, Dr. G.S. Jhobta, Dr. Prabal, Dr. Archna

For more details, please visit our website **http://www.eudyan.hp.gov.in**

Project Director, Himachal Pradesh Horticulture Development Project
Dyerton Bizhub, Talland Bye Pass Shimla-171001 | Telephone: 0177 2674465, 2674937
Telefax: 0177-2674936 | Email:hdp-pd-hp@gov.in

Director, Horticulture, Himachal Pradesh, "Navbahar"
Shimla-171002 Telephone: 0177-2842390 | Telefax: 0177-2842389 Email: horticul-hp@nic.in

Director of Research, Dr Y S Parmar, UHF Nauni Solan -173230
Telephone 01792 252315(O), FAX 01792 252030 | dres@yspuniversity.ac.in , dresuhf@yahoo.com