HIGH DENSITY APPLE CULTIVATION IN JAMMU REGION

Jointly published by
Faculty of Horticulture and Forestry
& Directorate of Extension
Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha.

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FOREWORD

Prof. B.N. Tripathi
Vice Chancellor
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Horticulture is an important sector in Jammu and Kashmir UT and this industry is instrumental in strengthening the financial condition of the UT, in reducing poverty and creating employment for the locals. The farm operating families comprising about 7 to 7.5 lakh households are directly involved in cultivation of fruit crops. In Jammu and Kashmir, UT, horticulture generates around INR 10,000 crores each year and is the source of livelihood of more than 7.5 to 8 lac families, thus being a key player in generating employment. This sector adds about 9% to the Gross State Domestic Product. Every hectare of orchard generates 400-man days each year. According to government figures, Jammu and Kashmir UT, exports around 20 lakh metric tons of apple every year with the harvest of apples is about 10 MT/ha and there is scope to increase the cultivation to 45 MT/ha if high-density apple farming practices are adopted. With different apple varieties being grown in Jammu and Kashmir UT, the cultivatio n of apples will further increase and effectively result in more employment and business opportunities in horticulture. Currently, apples account for 75% of the total cultivation of temperate fruits.

Horticultural industry made rapid strides during the last few decades. Compared to 1954-55, the area under fruits increased by 16 times and the production has shot up to 60 times. Among the temperate fruits, apple ranks first covering 43.30 per cent area and 80.18 per cent production. Yield of apple has shown an increase from 3.72 to 10.05 MT/ha (1975-2024). Though it appears to be highest among the apple producing regions in the country, yet it is far below the level achieved by advanced countries where productivity is of 70-80 MT/ha.High-density apple plantation gives farmers a return on investments within a period of three years. Approximately 800 hectares of land have been converted to high-density apple farming in J&K UT, with plans to expand it to around 5,500 hectares in the coming years. The cultivation of high-density apples has transformed the scenario of apple production in the world and is also expected to give a boost to the apple economy in Jammu and Kashmir UT, as well. It can be considered as one of the most important changes in apple production practice as these orchards are capable of not only producing early but sustained quality fruit production.

I am pleased that the Division of Fruit Science in collaboration with Directorate of Extension, Division of Entomology and Division of Plant Pathology, SKUAST-Jammu has come up with **" Practices for High Density Apple Cultivation "** covering latest information on all the aspects of high density orcharding on scientific outline. I accolade the editors and contributors for bringing out this publication in simple and eloquent language. I hope the package would be of immense help to the fruit growers, functionaries of the state department of horticulture, scientists, students and those involved with horticulture development in the UT of Jammu and Kashmir.

(B.N. Tripathi)

PREFACE

Dr. Amrish Vaid
Director Extension
SKUAST-Jammu

Jammu and Kashmir, UT leads in the productivity of apple (10.0 Mt/ha) in the country, but when compared to other horticulturally advanced countries like USA, China, France, Italy, New Zealand etc. the figures are very low where in the productivity has gone up to 70-80 MT/Ha. The government interventions of the past decade have generated a paradigm shift in farmers approach from mere production to productivity (quantity/unit area) to recently profitability (productivity/time/man). Currently around 5-6 per cent area in J&K, UT is under high-density apple plantation with the growers showing willingness to adapt the change. As of now, more than 100 farmers have established high density orchards in different parts of the Jammu division. However, the lack of awareness about this new system of orcharding among the farmers of Jammu division is a major deterrent in the successful transition. Thus far, it is high time to be in orchard business and a time of great optimism when new varieties and non-traditional orchards have started making inroads and the growers are willing to make the change.

With stagnation in productivity, looming threat of imported fruits and land prices touching new peaks in Jammu & Kashmir, it becomes imperative to go for high-density plantation for which change in the system of cultivation is a pre-requisite. The problem of stagnant low productivity and sizeable fraction of production of high quality and also global competition are the challenges that the apple industry needs to overcome. SKUAST-Jammu always aims to confront these challenges. Introduction of high-density orchard system is also one of the means of overcoming the stagnant low productivity, quality problems and achieving maximum productivity, higher yield efficiency, reducing input cost, minimizing risks and maximizing returns.

I express my gratitude towards my team of editors and contributors who have been working tirelessly to compile this booklet. I also express my sincere thanks to the Division of Entomology and Division of Plant Pathology, SKUAST-Jammu for their contributions in compilation of this manuscript.

This booklet " Practices for High Density Apple Cultivation " provides the overall solution to some of the questions related to the establishment of high-density apple orchards. It provides an insight to various establishment problems and guides the growers through the various maintenance strategies to be taken care off so as to ensure maximum productivity and profitability. I am confident that information contained in the book would be very useful to students, teachers, scholars, field functionaries, extension workers and especially to growers who can effectively establish and manage their high-density apple orchard using this book as a guide

(Amrish Vaid)

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Jammu
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Prof. (Dr) Vikas Tandon
Dean CoH & F, SKUAST-J

MASSAGE

I am pleased to know that Division of Fruit Science in collaboration with Directorate of Extension SKUAST-Jammu has come up with " Practices for High Density Apple Cultivation" covering latest information on all the aspects of high density orcharding on scientific outline. High-Density Planting (HDP) is a modern orchard management system designed to maximize productivity and fruit quality per unit area. The underlying principle of HDP is to make the best use of vertical and horizontal space per unit time and to harness the maximum possible return per unit of output. Technology "HIGH-DENSITY" orchards can be laid on flat and fertile lands with assured irrigation are trained to modern methods of training systems, viz. espalier, vertical axis, slender spindle, tall spindle, etc. The technology is helpful in the best utilization of land resources, ease in orchard inter-culture operations, plant protection, harvesting and to obtain export quality of the produce. High density planting facilitates better utilization of available resources i.e. solar radiation, land, water, labour, dwarf rootstocks, spur cultivars, human skill etc.

Faculty of Horticulture and Forestry under Sher-E-Kashmir University of Agricultural Sciences and Technology is fully dedicated towards research and extension in the field of horticulture. New interventions in the field are being continuously tried such as strawberry and dragon fruit cultivation in plains, kiwifruit and nut fruit cultivation in mid hills and high density apple and pear cultivation in higher reaches of Jammu region to give maximum exposure to our growers in these belts. Best planting material is also being produced at our centres for both subtropical as well as temperate fruits including nut crops for benefitting the growers.

I accolade the editors and contributors for bringing out this publication in simple and eloquent language. I hope the package would be of enormous help to the farming community particularly the apple growers of Jammu division, functionaries of the state department of horticulture, scientists, students and those involved with horticulture development in the UT of Jammu and Kashmir

(Vikas Tandon)

1. INTRODUCTION

For horticulture, to thrive in the context of diminishing land, water, labour and energy resources while addressing the challenges of ensuring nutritional security, has given thrust to the concept of high-density planting (HDP) in fruit crops. Majority of the perennial fruit crops across vast tracts in the country are characterized by the prevalence of old and unproductive trees leading to reduced fruiting potential. HDP system is normally understood as a system in which a higher number of plants are accommodated per unit area in comparison to the conventional planting density. The exact limit of plant density however varies with growing region, species, variety, rootstock, agro-techniques adopted for a particular crop and return from the orchard. Normally, an orchard is said to be in high density when more than thousand plants are planted per hectare. Yield and quality of the fruit are dependent factor of the number of trees per hectare, ideal tree architecture (training system) and the annual essential cultural practices like pruning, fertilization and plant protection measures. Such results are expected from high density plantings through proper use of package of practices set for high density orcharding. The common orchard densities adopted are explained as under:

Medium Density Planting (MDP): It accommodates 1111 plants per hectare at spacing of 3m x 3m. It requires proper pruning, produces more yield and better-quality fruits and have long productive life. The rootstocks used are MM-106, MM-111, M-7 etc

High Density Planting (HDP): This system accommodates 2222 and 3333 fruit trees per hectare at spacing of 1.5m x 3m and 1.0m x 3.0m, respectively. The plants are raised on clonal dwarfing rootstocks. The trees bear fruits in the 2nd or 3rd year of planting and attain commercial production level in the 5th or 6th year. Proper training and pruning is needed to obtain higher production and fruit quality.

A generalized comparison between traditional system and high-density system of fruit growing is presented in the table:

Attribute	Traditional system (ha)	High density system (ha)
Tree number	Few large trees/ha (150-200 trees/ha)	Many small trees/ha (2222-3333 trees/ha).
Bearing	Late in bearing, usual time required 6-8 years or more.	Precocious in bearing, usual time required 2-3 years.
Production	Overall production per ha is low.	Increased Overall production per ha.
Management	Difficult to manage due to large size of trees.	Easy to manage due to small size of trees.
Establishment cost	Low Cost.	Higher Cost.
Harvesting	Difficult	Easy

Principles of High Density Orcharding

a. Obtaining maximum productivity through planting a greater number of fruit trees per unit area.

b. To make the best use of vertical and horizontal space per unit time.

c. Optimizing the exploitation of natural resources like land, air, solar energy and water. High density canopies intercept 70- 75 per cent light instead of conventional orchards that don't intercept more than 55 % of available light.

d. High early yield to pay back the initial investment to plant the orchard.

Advantages of HDP:

a. It facilitates better utilization of solar radiation, land as well as water resources.

b. HDP plants are precocious resulting in early returns. Trees are easily manageable and fetch higher returns per unit area.

c. Horticultural operations such as pruning, plant protection measures and harvesting can be easily done which in turn reduces the labour cost involved.

d. The use of dwarf trees and managing excess vegetative growth gives higher production, productivity as well as early economic returns.

e. HDP produces high quality fruits and increases marketable yield for a longer period of time.

f. High pesticide application efficiency.

Constraints of HDP

a. Higher initial establishment cost and requires more professional approach for management as compared to traditional system of planting.

b. Lack of availability of clonal rootstocks in sufficient numbers.

2. Apple production scenario in World and Jammu and Kashmir UT.

Apple (*Malus* × *domestica* Borkh.) is known as the king of temperate fruits. It is fourth among the most widely produced fruits in the world after banana, orange and grapes. It belongs to genus Malus of family Rosaceae and order Rosales. Around the world apple is grown over an area of 4.95 million hectares with an annual production of 88.24 million metric tonnes (2024). In India, it is predominantly grown in Jammu and Kashmir UT, Uttarakhand, Himachal Pradesh, Arunachal Pradesh and Nagaland and covers an area of 3.20 million hectares with an annual production of 2.40 million metric tonnes (2024). Nature has bestowed Kashmir valley with agro conducive for apple climatic conditions cultivation and a strong comparative advantage in its production and marketing. In Jammu and Kashmir, apple has lived up to its reputation for being one of the choicest fruits. Kashmir has for long been called the home of apples. The fruit industry is the backbone of economy in Jammu and Kashmir UT and provides livelihood to more than 7 lakh farm families. Jammu and Kashmir UT is leading

both area and production of apple with an area of 1.78 lakh hectares and production of 18.88 lakh MT (2023-24). Horticulture industry in the state made rapid strides during the last few decades. Compared to 1974-75, the area under the fruits in the UT increased by 3 times and the production has increased up to 10 times. Among the temperate fruits, apple ranks first covering 67.97 per cent area and 87.93 per cent production. Yield of apple has shown an increase from 2.62 to 18.88 MT/ha (1975-2024). With the introduction of high-density plantation, the productivity is expected to increase more than five times (11 MT to 60 MT per hectare). Moreover, the quantum of "A" grade apple is likely to increase from 35-85 percent.

Climate & soil

Climate Requirement

Most of the apple varieties require 1,000 - 1,500 hours of chilling below 7°C during winter to break the rest period. These conditions are available at an elevation of 1,500-2,700m above mean sea-level in the Himalayan ranges. By and large, the average summer temperature should be around 21-24°C during active growth period. The areas with frost free spring and adequate sunshine during the summer without wide fluctuation in temperature are most suitable for apple cultivation. Low temperature, rains and cloudy weather during flowering period hamper the bee activity, affecting cross pollination adversely. Areas exposed to high winds particularly hill tops are also not suitable for its cultivation. Dry winds during the summer desiccate flowers and hamper bee activity, resulting in poor fruit set. Inclement weather, particularly low temperature below 15°C during bloom restricts the bee activity which is completely inhibited below 4.4°C affecting fruit set. Fully opened blossoms may be killed at temperatures below -2.2°C, -2.2°C, the optimum temperature for pollen germination and fruit setting is 21.1-26.7°C. Colour development associated with anthocyanin production is largely affected at temperature above 25°C.

Soil

Apple grows best in fertile loamy soils that are rich in organic matter with gentle to moderate slope, proper drainage and good aeration. The soil should be free from hard substrata and waterlogged conditions. Submergence of roots in water for long time (more than 24 hours) causes damage and death of large portions of roots due to lack of oxygen. Where cultivation is done on flat lands, proper drainage channels need to be developed to restrict the incidence of collar rot, root rot and other soil-borne diseases. The high-density planting cannot be adopted in very steep, unfertile, shallow and drought-prone areas.

The ideal pH of soil for fruit trees is 5.5-6.5. The pH has a great influence on the availability of some minerals that are very important for the health and growth of the trees. It is very difficult for the roots to absorb minerals such as iron,

manganese and boron when the pH is higher than 6.5. A soil with a pH lower than 5.5 cannot be used for growing fruit trees.

land preparation

The best way of soil preparation is to plough or spade before winter. During the winter, the ploughed-up soil will be frozen. This is good for the structure of the soil later on. Large clods will crumble into smaller pieces. Just before planting soil should be pulverized with a harrow.

The pits need to be of 1.5ft x 1.5 ft x1.5 ft. For better results incorporate 3-5Kgs of Vermicompost per pit. For areas having gradient of more than 10%, it is recommended to go for terraces. Wherever possible make terraces of at least 6m width so that minimum two rows can be accommodated per terrace to increase the efficiency and reduce orchard establishment cost.

PLANTING MATERIAL

Starting an orchard with high quality nursery plants is the first key to a successful planting. High quality plants will establish quickly, grow to the desired height, and fill their space. Such plants will be ready to produce fruit in the 2nd year and will reach full production a few years later. Planting the right tree means early cropping, which is the key to profitability of a new orchard. Trees of lesser quality can eventually fill their space and produce good are lost, so yields, but the early returns profitability over the life of the planting will be less.

Nursery Trees for High Density Orchard

The ideal nursery tree should possess following qualities.

- At least 1.7m (5 ft) tall, preferably 2-2.2 m (6-7ft)
- An abundance of healthy roots.
- A dominant straight leader
- 5-7 "feathers" that are 20-25 cm (8-10") long. The bottom feathers no lower than 24" (60 cm) above the ground level when the tree is planted in the orchard.
- Well distributed feathers along the leader at regular intervals
- Delivered unbroken, with moist roots and no disease.

A feather is a branch that is produced in the same year as the leader. Feathers are sometimes produced in strong growing first year budded trees (although usually not enough feathers), or by a “knip-boom” or “cut tree” technique (where the one- year nursery tree is cut at the 60 cm (242) height and re-grown in 2nd year, producing feathers on a strong-growing leader). For successful high-density orchards, a minimum of 3+ feathered plants is a pre-requisite and planting of whips would push back the orchard profitability by at least 2-3 years.

Rootstocks

The apple plantation in case of conventional planting systems is raised on seedling rootstocks. However, these seedling rootstocks lack uniformity in tree size and productivity but show better adaptability to sloppy and shallow soils under rainfed conditions. In case of high-density plantation ideal tree size can be obtained by use of proper rootstock scion combination. Clonal rootstocks besides being precocious help in production of trees with uniform and reduced tree size. The promising size-controlling clonal apple rootstocks include Malling (M) series, Malling- Merton (MM) series and Geneva series etc.

Name of rootstock	Salient feature
Dwarf rootstock	
M-9	It is a dwarfing rootstock ideal for raising high density plantation in apple. The trees on this rootstock are precocious and tolerant to a wide range of soil and climatic conditions. It produces a tree size approximately 25-30% of the full size with most of the cultivars. The rootstock has shallow root system and poor anchorage, hence requires assured irrigation and mechanical support to hold the tree. M-9 readily forms burr knots and is prone to suckering, susceptible to woolly aphid and fire blight.
M9-T339	Clonal rootstock of M9. Slightly vigorous than M9 T337.
M9-T337	Developed from Dutch research programs. It is an improved clone of M9 that can be easily propagated than M9 and produces less burr knots
G.65	This rootstock is from the Cornell University breeding program, New York state. It is a very dwarfing rootstock producing a tree smaller than M.9. It is precocious and productive. It is resistant to collar rot, almost immune to fire blight, but moderately susceptible to woolly aphid. It produces few suckers and burr-knots.
G. 11	Developed by Cornell University, M.26 x Robusta 5 cross. Similar in vigor to M.26. Similar or better yield efficiency than M.26, resistant to collar rot and fire blight.
G.16	A 1981 cross of 'Ottawa 3 x Malus floribunda', G.16 is a fully dwarfing rootstock with tree growth and vigour similar to vigorous clones of M.9 i.e. Nic-28 or Pajam2. Precocity and cumulative yield efficiency have been similar or slightly better than M.9. It is essential immune to fire blight. It has excellent performance in stool beds and produces a large tree in nursery. Tree growth in the first 2 years in the orchard is vigorous but with the onset of cropping tree vigor is moderated similar to M.9. G.16 has wide soil adaptability and some tolerance to replant disease.
Pajam 1	French apple rootstock, dwarfing and easy to propagate in comparison to M9
Semi- dwarf	
M-7	It is the most widely planted semi- dwarf rootstock. It exhibits an open spreading type growth. The trees are well anchored and hardy. The drawback is that it is susceptible to crown gall and crown rot. Moderately resistant to scab.

Semi-vigorous	
MM 106	It is semi dwarfing rootstock, roots easily in nursery. The rootstock is free from wooly aphid and susceptible to collar rot. It bears crop early ad heavily.
Vigorous	
MM 111	A vigorous semi-dwarf, produces trees larger than EMLA 106. Trees are well anchored, resistant to collar rot and woolly aphid. A good selection for heavy and poorly drained soils.
Merton 793	It is a vigorous rootstock and tolerant to high temperature and high soil moisture comparatively resistant to SARD (Specific Apple Replant Disease)

6. VARIETIES

6.1 Mid-season

Varietal information	**Gala Redlum**	**Gala Mitch**
Origin	New Zealand	New Zealand
Size	Medium	Medium
Taste	Sweet	Sweet, honeyed flavour
Colour	Intensive red with stripes	Orange-red stripe over a yellow background
Flowering date	Mid-season	Mid-season
Pollinizers	Breaburn, Granny Smith, Cox, Fuji, Golden Delicious	Braeburn, Elstar, Golden Delicious, Idared and Pinova
Picking time	Early to Mid-August	Mid to Late August
Storage (in cold store)	7-8 months	6-7 months

Varietal information	**Red Chief Camspur**	**Red Velox**
Origin	USA	Italy
Size	Medium to Large	Medium to Large
Taste	Sweet reduced acidity	Sweet
Colour	Bright red covering at least 80% of the surface. Glossy and smooth skin	Intensive red
Flowering date	Mid-season	Mid-season
Pollinizers	Golden Delicious, Gala, Fuji, Golden Hornet, Elstar	Braeburn, Idared, Granny Smith, Fuji, Golden Delicious
Picking time	Mid-September	Mid-September
Storage (in cold store)	6-7 months	6-7 months

6.2 Late Season

Varietal information	**Red Del. (Silver Spur)**	**Super Chief Sandidge**	**Fuji Zehn Aztec**
Origin	USA	USA	New Zealand
Size	Medium	Medium to Large	Medium
Taste	Juicy, Slightly Sweet	Sweet	Slightly acidic
Colour	Dark red	Dark red blushed with strips	Very attractive intense pink red, blushed with a few stripes
Flowering date	Early to Mid-season	Mid-season	Mid to late season
Pollinizers	Elstar, Gala, Golden Delicious and Granny Smith,	Braeburn, Elstar, Gala, Idared and Pinova	Gala, Elstar, Granny Smith, Golden Delicious
Picking time	Late September	Late September	Mid to Late October
Storage (in cold store)	6-7 months	6-7 months	7-8 month

Late season

Varietal information	**Golden Delicious Reinders**	**Granny Smith**
Origin	Netherland	Australia
Size	Medium to large	Medium to large
Taste	Sweet with slight acidic taste	Sour acidic taste
Colour	Yellow; smooth skin and very light lenticels	Green with white lenticels
Flowering date	**Mid-season**	Mid to late season
Pollinizers	Braeburn, Elstar, Gala, Pinova, and crab apples.	Gala, Red Delicious, Golden Delicious and Idared
Picking time	Early October	Early to Mid-October
Storage (in cold store)	6-7 months	6-7 months

Royal Gala

Redlum Gala

Red Velox

Dark Baron

Jeromine

Trex Gala

7. TRAINING SYSTEM

Trees in high density apple orchards usually require a different training system than those in standard orchard. Modern canopy management systems like tall spindle, super spindle, espalier, cordon etc. help accommodating more plants

per unit area and enhance yield and quality of fruits by providing more fruiting area and improving the penetration active and diffusion of photo-synthetically radiation. Proper tree training opens up the tree canopy to maximize light penetration which in turn is essential for strong flower bud development and optimum fruit set, flavor and quality. Open tree canopies also permit air movement through the tree, which promotes rapid drying to minimize disease infection and allowing thorough spray penetration. Thus, primary objective of training is to develop a strong framework that will support fruit production. Improperly trained fruit trees generally have very upright branch angles, which result in serious limb breakage under heavy fruit load. This significantly reduces the tree's productivity and may greatly reduce tree's life.

Training system for apple adopted under Jammu & Kashmir conditions:
Tall spindle:


It Maximizes profitability through early yield, improved fruit quality, reduced spraying, pruning and training costs. Proper selection of density for this system depends on consideration of the vigor of the variety, rootstock and the soil strength. The optimum spacing for an average vigorous variety is 1m by 3.3m. Fully dwarfing rootstocks should be selected for this system (M- 9 and B-9). Nursery stock ideally having 5-7 feathers per tree should be used. Significant pruning at planting is a common practice with most planting systems to provide balance between the scions and root to encourage growth to fill the allotted tree space. The important components of this system are: 1) high planting densities, 2) dwarfing rootstocks, 3) highly feathered nursery trees, 4) minimal pruning at planting, 5) bending feathers and branches below horizontal, 6) no permanent scaffold branches and 7) limb renewal pruning to remove and renew branches as they get too large. Salient features of this system include:

- Optimum Economic Tree Density: - 2222 to 3900 trees per hectare
- High early Production
- High mature yields

- High Fruit Quality:
- Improved labour efficiency

Benefit: The planting system achieves the goals of very high early yields, high sustained yields and excellent fruit quality, while moderating the initial investment compared to the super spindle system.

Simplified training and pruning plan for the Tall Spindle system

First leaf	
At planting	Plant highly feathered trees (10-15 feathers) at a spacing of 3-4' x 11-12' (90cm-1.2m x 3.3m-3.6m). Adjust graft union to 6" (15 cm) above soil level. Remove all feathers below 24" (60 cm) using a flush cut. Do not head leader or feathers. Remove any feathers that are larger than 2/3 the diameter of the leader.
3-4" Growth	Rub off 2nd and 3rd shoots below the new leader shoot to eliminate competitors to the leader shoot.
May	Install a 3-4 wire tree support system that will allow tree to be supported to 3m. Attach trees to support system with a permanent tree tie above 1st tier of feathers leaving a 2-inch diameter loop to allow for trunk growth.
Early June	Tie down each feather that is longer than 10" (25 cm) to a pendant position below horizontal.
SECOND LEAF	
Dormant	Do not head leader or prune trees.
10-15cm growth	Pinch lateral shoots in top 1/4 of last year's leader growth removing about 5 cm of growth (the terminal bud and 4-5 young leaves).
Early June	Hand thin crop to single fruit four inches apart. (Target 15-20 fruits/tree)
Mid-June	Re-pinch all lateral shoots in top 1/4 of last year's growth. Tie developing leader to support system with permanent tie.
THIRD LEAF	
Dormant	Do not head leader. Remove overly vigorous limbs that are more than 2/3 the diameter of the leader using a bevel cut.
Late May	Chemically thin according to crop load, tree strength, and weather conditions, then with hand follow up with hand thinning to appropriate levels to ensure regular annual cropping and adequate fruit size. (Target 50-60 fruits/tree).
June	Tie developing leader to support system with a permanent tie.
August	Lightly summer prune to encourage good light penetration and fruit color.
FOURTH LEAF	
Dormant	Do not head leader. Remove overly vigorous limbs that are more than 2/3 the diameter of the leader using a bevel cut.
Late May	Chemically thin and follow up with hand thinning to appropriate levels to ensure

June	regular annual cropping and adequate fruit size. (Target 100 fruits/ tree).
August	Tie developing leader to support system with a permanent tie at the top of the pole. Lightly summer prune to encourage light penetration and fruit colour.
MATURE TREE PRUNING (fifth-twentieth leaf)	
Dormant	Limit tree height to 10' (3m) by cutting leader back to a fruitful side branch. Annually, remove at least 2 limbs including lower tier scaffolds that are more than 2/3 the diameter of the leader using a bevel cut. Remove any limbs larger than 1" diameter in the upper 2ft (60cm) of the tree
Late May	Chemically thin and follow up with hand thinning to appropriate levels to ensure regular annual cropping and adequate fruit size. (Target 100-120 fruits/tree).
August	Lightly summer prune to encourage light penetration and maintain pyramidal tree shape.

SUPPORT STRUCTURE:

Trellis system: Support systems provide anchorage for the trees, aid in controlling tree vigor, facilitate ease of management of the orchard, and help provide good light exposure to fruit and foliage. The support system must be designed to last the life of the orchard. The dwarf trees on M9 rootstock have poor anchorage and require a support system. The support system must be built to last because the support is an integral part of the planting. If the post, wire or anchors fail in a support system, the deteriorated or broken trellis can be difficult or impossible to repair. The support failure can lead to growth problems, reducing production and depreciating the entire investment. Various materials are available for establishing support system in an orchard which range from galvanized steel to pre-stressed concrete ports. In addition to poles, anchors play a pivotal role for a successful trellis. Anchor failure may be difficult to repair and may cause complications in the production system.

If properly constructed, the support system will outlast the trees it is supporting. These types of orchard systems and the results they produce are very attractive, but the approach is much different from free-standing conventional central leader/modified central leader training. Growers contemplating an intensive high-density planting must be prepared to adopt new training and crop management ideas, as well as accept the idea that these dwarf apple trees need proper support. For a successful high density orchards system on dwarfing rootstocks, tree support is not an option, but it is a requirement.

Fig: Trellis system (Supportive structure)

8. PRUNING

Once fruiting begins, only a minimum of pruning is necessary, as heavy pruning reduces or delays production and induces unnecessary shoot growth. Main aim of pruning is:

- To maintain a narrow, compact tree shape, small in size and easy to manage.
- To ensuring good light distribution for better fruit quality and spur formation.
- To balance vegetative growth with reproductive output for continuous high yields.

Pruning may be done in winter (dormant), summer or both. Winter pruning, if too heavy, stimulates excessive growth, which may cause tree crowding, shading out of lower fruitwood, and poor-coloured fruits. Conversely summer pruning reduces vigour and can be used to decrease excessive growth. All upright shoots should be removed from bearing, central leader trees. Excess shoot growth should be removed to allow light throughout the tree and to balance fruiting and tree growth. Where tree lack sufficient vigour, limbs should be headed (cut) into last season's growth each winter. In case of high-density plantation, for the first 4 years, pruning should be limited to the removal of unsuitable branches, such as those lateral branches that are as large as or larger than the leader.

The 3:1 pruning rule is suggested wherein the thickness of leader should be three times the diameter of any of the lateral branches in the upper part of the tree. Limbs that are larger than the 3:1 rule should be removed early on to preserve a hierarchy of branch and leader diameter. This allows moderate pruning each year and is a method to contain tree size. It also maintains good light distribution in the canopy without inducing excessive vigour. The most important method of inducing cropping and reducing induced juvenility is tying down of the scaffold branches to induce cropping. In most climates, if pruning of branches is

minimized, often crop load will bend branches down and a natural balance between vigour and cropping will be established without additional limb positioning. In vigorous and/or warmer climates where winter chilling is insufficient, limbs often become too large before they set sufficient crop loads to bend the branches down. In these climates, the tying down of all vigorous limbs must be done annually for the first 3-5 years until the tree settles down and begins to crop heavily.

Pruning concept for high density apple orchards:

Modern high-density orchard systems such as the Tall Spindle are based on simple pruning concepts that include minimal pruning in the early years to induce early production and limb renewal pruning at maturity to maintain the canopy narrow and with good light distribution. Pruning is always a matter of compromise since pruning has both positive and negative effects. The adverse effects of pruning may include:

I. Reduced yield.
II. Delayed cropping.
III. Increased vegetative vigor.

Benefits of proper pruning:

I. Better light dispersion into the canopy which improves spur fruitfulness and fruit quality.
II. Revitalization of bearing surface.
III. Restraint of tree size
IV. Improved spray penetration into the canopy ensuing in greater insect and disease control.
V. Modern pruning strategies attempt to maximize the benefits of pruning while reducing the negative effects

Pruning the mature tree

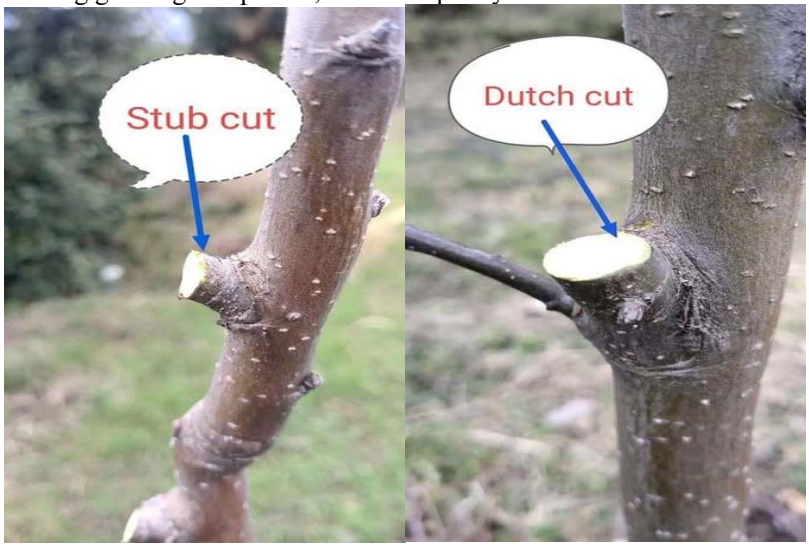
Tall Spindle trees as spanned five years, they are considered mature and a simple repetitive pruning process of limb renewal is implemented which is fast, has a minimal number of cuts, results in good light distribution. This simple pruning method is readily adjustable to partial mechanization using orchard platforms which can result in savings of 25- 35% in dormant pruning costs. One of the most significant differences between the Tall Spindle and the more traditional Vertical Axis and Slender Spindle is that the tall spindle tree has no perpetual lower tier of branches. The Tall Spindle is basically a 10 ft (3m) trunk associated with small fruiting branches enclosed all along its length. The basic tree structure can be developed in only 3 years since the central leader is not cut (headed) at planting. The pruning of the Tall Spindle tree can be simplified into 3 steps.

1. Limiting tree height.

The leader is not headed at planting or for the first 4-5 years until mature tree height has been achieved. Usually in year 6 after heavy cropping in the top has begun, the leader is cut annually to a small side branch at the optimum height where light interception is maximized without causing excessive shading of the lower canopy. Our experiments have shown this height to be about 90% of the between row distance.

2. Branch caliper management.

When a lateral branch in the tall spindle tree gets too long or too big in diameter it is removed allowing a smaller replacement branch to develop. To bound the negative effects of pruning on vegetative vigor, limit the number of branches to be removed each year to just two. However, if this is repeated annually the tree never develops any large branches and continues from an early to an old age to have only small fruitful branches which give the tree a narrow, slender shape. To assure the development of a replacement branch, the large branch should be removed with an angled or bevelled cut, so that a small stub of the lower portion of the branch remains. From this stub a flat weak replacement branch often grows. In the early after trees reach maturity, lower branches including some of the original feathers become too large and are systematically removed (2 per year). We usually target branches larger than ¾" diameter for removal in the Tall Spindle system. At the trees age, the top of the tree tends to overgrow the bottom. To prevent this problem and to maintain good light circulation and good fruit quality as trees age, the top of the tree must be kept narrower than the bottom of the tree. For the tall spindle system, maintaining a conic shape as the trees age is critical to maintaining good light exposure, and fruit quality in the bottom of the tree.



3. Simplifying or columnarizing the fruiting branches.

After the 1-2 largest branches are removed each year, the remaining branches in the tree should be columnarized or simplified (secondary side branches larger than ½ the diameter of the branch should be removed leaving each branch as a long fruiting column) to improve fruit colouring. A columnar branch shielded with spurs and fruit will cast less shade on the lower part of the tree than a complex branch which has secondary and tertiary laterals. Such complex branches create a "roof" of shade for the lower branches. When columarized branches become too long or too large in diameter they are removed through the annual removal of 1-2 large branches per tree. When this branch columnarizing strategy is teamed with limb renewal pruning, narrow, slender trees with good light distribution can be maintained over the life of the tree.

9. Anti-Hail Nets

Hail nets are used in regions where there is a chance of hail occurrence every year. Use of hail net reduces the wind speed and transmission of sunlight. The amount of light reduction depends on the size of mesh and colour of the net. In the morning there is more light reduction than during daytime and more reduction in autumn than in summer. To counter the effect of light under the nets, the trees must be pruned in winter to make it more "open". It has been established that hail nets don't interfere in the formation of flower buds, fruit production and the quality of the fruit. Under hail nets the performance of chemical thinning is a bit better. The colouring and the ripening of the fruit is delayed by a couple of days. Hail nets also reduce the damage from sun burn, wind and birds.

Construction:

Mostly concretes provided with steel wires (bracing wires) are used for supporting the hail nets. The total length of the concretes is 5 m with a size of 7 x7.5 cm. They are placed in every row, 100 cm deep and with a distance in the row of 6.5-7 m with special machines using the GPS system. At about 10 cm under ground-level so called anti sink plates are fixed to the concretes to prevent the concretes from sinking further into the soil because of the weight of the hail. The length of the concretes above the ground is 4 m. Length of more than 4 m makes the construction weaker. The first and the last concrete in every row are placed in a curve and connected with steel wire to the soil anchors. These anchors have a length of 1.5 m and are screwed into the soil, 2 m from the underside of the concrete. The anchor plate has a diameter of 24 cm. A soil anchor must have a attractive power of 3000 kg. On the tops of the concretes plastic hoods are placed to make it easier to place the nets. Also, steel wires are placed crossways.

Anti-Hail Nets for Ultra High-Density apple

Choice of Nets

Black nets are mostly used in regions with a lot of bright sun light. The lifetime of black nets is much longer than other coloured nets. Grey or crystal nets are used in regions with less sun light. Light reduction increases vegetative growth of the trees, but has no negative effect on flower bud initiation for next year

Net Colour	Light reduction (%)	Life time (years)
White	10-12	5-8
Grey	18	12-15
Black	25	15-20

10. Irrigation in High Density Apple Plantation

For high-density apple orchards, water relations are even more important. Irrigation is essential for ensuring optimum growth of newly planted and young apple orchards and also to obtain the desired fruit size. For high-density orchards, the economic success mainly depends on obtaining significant yields in the third, fourth, and fifth years to repay the establishment costs. To obtain the expected high yields requires excellent tree growth during the first three years after planting. However, one of the biggest problems we see with new high-density orchards is inadequate tree growth during the first three years. It is estimated that when poor tree growth in the early years delay cropping of a new orchard, peak investment is delayed by 20% and the total profits are reduced by 66% over the 20- year life of the orchard. Much of the problem of poor tree growth can be traced to inadequate water supply during the first three years. Therefore, it is very important to have precision irrigation system for high-density apple orchards.

A typical drip irrigation system includes a water source (e.g., well water, river water), pump, a pressure regulating system, valves, pipeline, emitters, and other accessories.

Irrigation Schedule

Determining irrigation schedule provides a simple explanation for determining how much water your trees need per week, how much water your soil can hold based on water holding capacity and determining your irrigation systems output. How much and how often that water is applied is also important to the overall health of the trees. These conditions make irrigation scheduling extremely important to ensure trees are not over or under watered

ET-based irrigation

Weather-based irrigation is also called evapo-transpiration (ET)-based irrigation. The ET rate equals the total loss of water by evaporation from the soil surface, plus the transpiration from plants, over a given area in 24 hours, in inches per day. With ET-based irrigation, the application rate of an irrigation system would be the total ET rate subtracted from the precipitation rate. ET-based irrigation requires a complete set of weather parameters from nearby weather station to calculate the ET rate along with crop coefficient of the crop for the season.

$$\mathbf{ETC = ETo \times Ke}$$

Where, ETC = Crop Evapo-transpiration
ETo = Pan Evapo-transpiration
Kc = Crop co-efficient
Various computer-based software like Crop Wat, PETv 3.0 can be used for calculation of irrigation water requirement using various weather parameters.

Plant-based irrigation

Canopy temperature has been shown to be an indicator of plant water stress. Plant-based thermal optimum approaches scheduling irrigation based on plant

infrared thermal response to water status. Crop water stress index (CWSI) can be used to indicate the status of the crop. The index is based on the difference between canopy temperature and air temperature normalized for the vapor pressure deficit of the air. The index can be used to determine when to irrigate based on the stress level of the plant. Meanwhile, the climate data will also be taken into consideration. Besides this, the kind of rootstock also imparts significant affect. A smaller root zone is more sensitive to water and nutrient stress because crop roots have no motivation to and will not grow into dry soil. Therefore, a larger root zone can be encouraged by running the drip system for longer amounts of time.

Soil moisture based:

Soil moisture measurements acquired in the field adjacent to the crops being irrigated are one of the best and simplest ways to support water management decisions. Soil water content and soil water potential are two indicators of plant-available water used by soil-based irrigation systems. There is a wide range of measuring instruments for measuring soil moisture, including neutron probes, time-domain reflectometry/transmissivity (TDR) sensors, capacitance sensors, tensiometers, and granular matrix sensors. These devices range from inexpensive gypsum blocks to costly TDR sensors. Variable soil texture and structure, as well as the difficulty of accurately locating the root zone, are two challenges for soil moisture- based irrigation technology. Despite these difficulties, soil sensors report conditions directly from the field and can be polled locally or remotely to control irrigation. Numerous sensors are commercially available using microelectronics.

Irrigation Requirement for High Density Apple Crop under Jammu & Kashmir Conditions*

Water requirement (litre per plant per day) under high density

Crop stage	Month**	E Pan (mm)	Range of Water requirement lit/plant/day*					
			Y1	Y2	Y3	Y4	Y5	Y6 and onwards
Bud break Flowering	April	3.0- 3.8	0.5-0.9	1.1-1.8	2.1-2.9	2.8-3.9	1.2-1.6	2.1-2.5
Veg. growth & Fruit set	May	4.3-4.8	0.9-1.2	1.7-2.5	3.4-4.2	4.6-5.6	2.9-3.1	3.3-3.8
Initial fruit growth	June	4.3-5.2	1.9-3.3	3.0-3.7	3.9-4.3	4.5-5.2	4.9-6.2	6.0-7.4
Rapid fruit growth	July	4.5-4.6	2.1-2.5	3.5-4.0	4.2-5.0	6.5-6.8	7.1-8.3	8.0-8.5
Harvest	Aug-Sept	4.0-4.4	1.4-1.7	2.8-2.9	3.0-3.5	3.7-4.1	4.9-5.8	6.5-7.8
Leaf Fall	October	3.6-3.9	0.3-0.5	0.5-0.6	0.8-0.9	1.0-1.1	1.0-1.1	1.3-1.5

Note: *Estimates are based on average pan evaporation data and few experiments; however, water requirement of specific orchard can be calculated by climatic condition of specific location.*

**The above-mentioned findings have been derived from research conducted on high density apple orchard at Shalimar campus.*

***Month corresponding to crop stage may vary depending on elevation/location*

11. Fertigation

When drip irrigation is used it is also possible to add fertilizers to the water and supply to the plants in the root zone. This method is called fertigation. Fertigation makes it possible to regulate the nutrition supply precisely and is easy to automate. In high density orchards with tall spindle system and highly feathered trees, lateral growth is not required. In these orchards fertigation during initial years is more essential both for water to avoid stress and nutrients which are rapidly moved towards root zone where they become readily available to plants. It results in higher N use efficiency in apples. Fertigation offers increased flexibility in managing orchard nutrition programs because of the potential for more closely synchronizing nutrient application with plant demand and thus makes it possible to reduce the quantity of nutrients applied and thus reducing environmental impact. Due to various reasons, in high density orchards priority is given to fertigation and foliar nutrition as these methods assist in increasing efficiency of applied fertilizers. Fertigation even allows to lessen nitrogen doses by half.

Fertigation with water soluble fertilizers like ammonium nitrate, calcium nitrate, urea, potassium chloride, potassium nitrate and potassium sulphate has become important as it saves lot of nutrients. Urea and ammonium nitrate are highly soluble and clogging is very less. Fertilizers which raise water pH (>7.5) are not desirable, as such this reduces micronutrient availability.

Fertigation doses:

Appropriate fertigation amounts can be calculated based on soil conditions, age of plant and other factors. The amount of N should be applied to start at rapid shoot growth, and divided over four to six week period, ending no later than mid-July. The P rates should be supplemented with a strong post-harvest and pre-bloom foliar nutrient program, including urea, and boron. Apply these amounts preferably in three separate doses or divide into daily doses and fertigate for one to two weeks. Fertigation with a soluble form of P like ammonium polyphosphate allows the phosphorus to be available as the root growth occurs. Soluble forms of potassium are moved relatively easily with irrigation water and leached as well but not as quick as nitrogen. Potassium requirements increase after the June drop; the amounts increase according to the crop load. Application of P in this manner, timed to coincide with a period of high shoot, fruit, and root growth around bloom, is highly efficient as specified by its mobility in applied water throughout the rooting zone and its capability to raise leaf P concentration throughout the growing season and fruit P concentration at harvest.

12. Foliar Nutrition

Elements as nitrogen, phosphate, potassium and magnesium will come into the tree by the roots i.e., applied to soil. In case of HDP, mostly we add some leaf

foliar when there is a shortage of one of the elements.
For example:

Nitrogen

Urea: CO (NH2)2 is considered the best choice for the foliar application of nitrogen. Urea contains 46% N. When the nitrogen reserve is experiencing bad weather (low or we temperature) during blossom time, then spray of urea a couple of times before and during blossom time @ 0.25-0.50 per cent mitigates nitrogen deficiency. After blossom time urea is applied @ 0.25-0.50 per cent. Urea spray after harvest time @ 2-3 per cent, results in storage of nitrogen in the tree and healthy flower buds.

Calcium

For foliar spray of calcium both calcium chloride and calcium nitrate can be used. Calcium chloride can cause burning of the leaves when the temperature is high. Low calcium levels increase the chances of Cork in the fruit, bitter pit, Internal brown and soft fruit, makes fruit sensitive to rot, lowers firmness, poor colour development besides reducing shelf life. Thus, spray from mid-June till picking time every two weeks with 0.3 per cent calcium nitrate/calcium chloride is recommended.

Calcium deficient plants show an upward cupping of the margins. In older leaves, the margins turn necrotic and they may fall. Also, there is death of growing points followed by die- back.

Boron

Boron has a beneficial influence on the flower bud formation, pollen germination and fructification. One or two sprays with 1-1.5 per cent boron before and during blossom improve pollination and fruit set. Boron deficiency symptoms normally appear on the fruits before vegetative parts are affected. Fruits become misshapen caused by depression usually under laid by hard corky tissues which rapidly turn brown while exposed surface colour is dark green. Leaves become dark green, thick and brittle, starting at shoot tip.

Manganese

Manganese influences chlorophyll synthesis and the process of photosynthesis. It is required during mitosis or cell division phase. To remove manganese deficiency foliar application of Manganese can be done. Manganese sprays are done starting at blossom (2 times @ 0.05-0.1 %.)

Zinc

Zinc is a component of enzymes and activates the enzyme reactions. It has a beneficial influence on the quality of the pollen. Therefore, it is useful to spray

zinc before and after blossom time. In case of zinc deficiency buds and shoots fail to develop. Leaves remain small and narrow (little leaf) tending to form rosettes at tips.

Fertilizer Schedule:

Age of tree	FYM	Vermi-compost	Nutrient / tree (gms)	Fertilizer/tree (gms)				
Years	**(kg)**	**(kgs)**	**N**	**P205**	**K2O**	**Urea**	**DAP**	**MOP**
0	3	2.0	-	-	-	-	-	-
1	4	2.5	50	25	60	108	54	100
2	5	3.0	95	50	120	206	108	200
3	6	3.5	140	75	180	303	162	300
4	7	4.0	185	100	240	401	217	400
5 and above	8	5.0	225	125	300	488	271	500

Note: -First dose of fertilizers comprising 1/3rd dose of Urea along with full dose of DAP and 1/2 dose of MOP should be applied about three weeks before expected bloom as a basal dose. Second dose comprising 1/3rd of urea and remaining MOP may be applied about 3 weeks after fruit set. 3rd dose of Urea may be applied during June-July.

14. Crop Load Management

In high density apple orchards management of cropping during initial four years is important in order to prevent biennial bearing and to maintain a balance between vegetative and reproductive growth. Apple trees on dwarfing rootstocks set fruit second or third year after planting which results in alternate bearing. Moreover, it results in increase in vigour in the fourth year. Biennial bearing tendency of each variety varies and it should be incorporated into crop loads allowed on young trees. Recommended crop load of 6 fruits/ cm2 TCA (25-40 apples/ tree in the second year, 40-60 apples/tree in third year and 100-200 apples in fourth year) for varieties like Gala and 4 fruits/ cm2 TCA (15-20 fruits/ tree in second year, 25-40 apples/ tree in third year and 50-70 apples/ tree in fourth year) for slow growing and biennial bearing varieties like Honey Crisp.

Thinning

For obtaining optimum yield of high quality and super grade fruit and breaking the rhythm of alternate bearing, thinning is done, either by hand or by using chemicals. Thinning by hand is almost necessary (even after chemical thinning) so as to obtain good size of fruits, better quality (removing damaged fruits) and colour. In a cluster with 5 or more apples, 2 or 3 must be removed by hand thinning. During hand thinning first the damaged fruits should be removed, then the small ones and the fruits that grow on the underside of the branches (as these develop no colour). Hand thinning should be done after the June drop i.e. towards the end of June till the beginning of the July. NAA (Naphthalene acetic acid) @ 10-15 mg/litre can be used 7-10 days after petal fall for thinning.

15. Weed Control

Under just planted trees mostly a lot of weeds are growing because there is a lot of (sun) light and the trees are irrigated regularly. Weed control in the first year is very important. Weeds can be managed by applying Ammonium Glufosinate 71% SG @ 2gm/litre of water. Other pre and post emergent herbicides such as simazine, atrazine, pendimethalin, oxyfluorfen, glyphosate etc. can also be used for managing weeds. Try to avoid spraying the stems of the trees. Spray on a bright day (for a better working), but don't spray in the afternoon when there is a lot of sunshine. In fully grown plants critical time period of weed control in apple is first 3-4 months of growing season. Weed competition can reduce the tree growth during early years and in severe cases can even cause a failure of orchard. There are several kinds of machines available for mechanical weed control. If such machines are used then the soil must be touched just a few centimetres (very shallow), because fruit trees make roots close to the surface and thus, we need to ensure that roots may not be damaged. Weed control can also be achieved by mulching with suitable material.

16. Insect, Pest and Diseases Management

SCAB:

Causal organism: Venturia inaequalis (Wint.)

Symptoms: The most conspicuous symptoms appear on leaves and fruit. Scab lesions first develop on lower leaf surface after green tip stage. These lesions are olivaceous velvety which turn brown to black with age and do not have a definite margin. On young foliage, lesions have radiating appearance with feathery edge. On older leaves, lesions are more definite in outline. Convex surface with the lesions may form a corresponding concave area on the opposite side.

Fig 1, Scab on leaves

Fig. 2, Scab on Fruit

In case of heavy infection, the leaf blades may become curled, dwarf and distorted. On the young fruit, the lesions are small and olivaceous green which soon turns almost black. On mature fruit, the centre of the lesion turns brown and becomes corky. Distorted growth and cracking of fruit surface is seen when infection occur early. The lesions on the fruit stem (pedicel) are much the same in appearance as those on the leaf stem, but are somewhat broader.

Scab lesions also occur on twigs but are not as common as on the leaves and fruits. Under favourable conditions the infections may be so numerous as to cover the entire surface of the terminal growth. The individual lesion remains small and usually disappears with the growth of the twig. However, on susceptible varieties few lesions persist throughout the season, occasionally giving the twig twig a blistered appearance.

Control measures

- Use resistant cultivars.
- Prune to ensure good air circulation, this decreases the duration of leaf wetness.
- Spray fallen leaves with urea.
- Primary infection of apple scab is mainly caused by ascospores released from infected leaves that overwinter on the orchard floor. The higher the density of ascospore inoculum, the faster and more intense the resultant scab epidemic.
- Shred fallen leaves in autumn/winter.
- Sanitation practices can reduce the risk of scab build up in spring and improve the efficiency of scab control programs.
- Protectant sprays of suitable fungicides are needed at green tip, pink bud and at regular intervals afterwards. This is to make sure that rapidly developing leaves and fruits are covered with a fungicide residue that will prevent spores from germinating.

Leaf Blotch Miner:

Causal organism: *Leucoptera malifoliella,*

Symptoms: The apple leaf blotch miner, is a pest that affects apple trees by creating mines within the leaves. These mines, which are visible as silvery or translucent areas, can lead to defoliation and reduced fruit production if the infestation is severe. The pest goes through four life stages: egg, larva, pupa, and adult, with the larvae feeding on leaf tissue and creating the characteristic mines.

- **Damage:** Mines caused by the larvae can be seen as silvery or translucent areas on the leaves. Severe infestations can lead to leaf drop, reducing the tree's ability to photosynthesize and potentially affecting fruit size and quality.

Management and Control:

I. **Monitoring:** Regularly inspect leaves for signs of mining activity.
II. **Cultural Practices:** Collect and destroy fallen leaves, which may contain pupae.
III. **Insecticides:** Certain insecticides, like Betacyfluthrin 9% w/v + Imidacloprid 21% w/v.
IV. **Pheromone Traps**: These traps attract and capture male moths, reducing the number of eggs laid.
V. **Non-chemical methods:** Removing loose bark can expose and destroy pupae.
VI. **Timing:** Insecticide applications should be timed to coincide with specific life stages of the miner.

ALTERNARIA LEAF BLOTCH

Causal organism: ***Alternaria mali***

Symptoms: The disease affects the leaves, which under severe infection cause pre-mature defoliation. Initial symptoms appear about one month after petal fall, as small circular, light brown, non-sporulating lesion with purplish margins, measuring 0.5 mm in size. As lesions age, they often turn greyish brown. Some spots may exhibit secondary expansion becoming irregular and darker in colour. Coalescing of lesions under severe infection results in the formation of large irregular necrotic patches which later turn silvery grey with black tiny mass of spores. Leaves with infected petioles often turn yellow and fall early in the season.

Strains of "Delicious" have been observed to be more susceptible to Altenaria blotch. Mites predispose the leaf to infection by A. mali.

Fig. *Circular, light brown, non-sporulating alternaria lesions on apple leaf*

Control Measures

I. Preventative control measures are vital for controlling ALB. Foliar and ground applications of urea well after harvest can assist in the rapid breakdown of leaves helping to reduce levels of overwintering spores.
II. Removal of winter pruning's and fallen leaves also help minimise spread.
III. Providing adequate nutrition, water and maintaining overall tree health may help reduce the severity of infections and leaves should be regularly monitored for the presence of disease.
IV. When required, spray fungicides early in the season just after petal fall.

POWDERY MILDEW

Causal organism: ***Podosphaerea leucotricha***

Symptoms: The disease appears on buds, leaves, young shoots, flowers and rarely on fruits. The symptoms are first noticed on leaves in spring as small, irregular, white or greyish felt like powdery patches on the under surface. Soon the entire leaf becomes covered with white mycelium and powdery masses of spores. Young leaves tend to increase in length, but not in width and become longitudinally folded. Severely infected leaves become in rolled, hard, and brittle and give scorched appearance. Young shoots also start showing the typical disease symptoms. Heavily infected twigs remain covered with powdery mat of greyish-white mycelium. Diseased twigs either remain stunted with short internodes or show die- back symptoms with silvery appearance. Infected flower buds either fail

to open or open later than healthy buds which rarely set fruit. Infected areas of fruit become russeted as a very closely interwoven network of fine lines.

Fig. Whitish powdery mass on apple leaf surface.

Disease cycle

The fungus overwinters in fruit and leaf buds, and the first powdery mildew symptoms occur on flower trusses and shoots that emerge from infected buds in spring. Spores from these infected leaves give rise to secondary mildew infections on the leaves of shoots, which are rapidly extending throughout spring and early summer.

Spores from all sources infect newly formed buds in leaf axils. Fruit buds on spurs are susceptible to infection by powdery mildew for about 1 month, between pink bud and petal fall. Leaf buds are susceptible to infection for about 1 month after they appear in the axils of leaves on extending laterals. But the terminal buds on laterals can be infected throughout the period of lateral growth. Infected buds are generally not killed but provide the main source of primary infection in the following season.

Control measures.

1. **Removing infected buds:** The terminal bud is most commonly infected with powdery mildew, so can be a source of spores that infect new leaves and buds. Remove infected terminal buds when pruning where possible.

2. **Modifying the environment so that it's less favourable to infection:**

I. The humidity at the surfaces of leaves is an important factor influencing germination of spores.
II. Maximum germination occurs at high relative humidity, but not in free water. High relative humidity occurs at leaf surfaces when the air is calm, but it's reduced by air turbulence.
III. Trees with open canopies have more air turbulence and less powdery mildew than trees with dense foliage.
IV. Similarly, manage wind breaks in such a way that turbulence is reduced enough to prevent fruit damage, but not so much as to result in completely calm conditions that favour mildew development.

3. **Spraying to protect buds from infection:** To protect fruit, leaf and terminal buds, you need to spray frequently from pink bud until the end of lateral extension.

MARSSONINA LEAF BLOTCH

Causal organism:***Marssonina coronaria***

Symptoms: The disease appears as dark green areas interspersed with lighter or yellow portions mosaic like on the mature leaves giving a appearance, followed by brown to dark brown lesions of varying size ranging from 5 to 10 mm in diameter. As the disease advances, the infected leaves turn yellow and fall early in the season. In excessively humid conditions, the lower portion of the tree is defoliated within few weeks and only fruits are seen hanging on the naked branches. Repeated pre-mature defoliation results in failure of crop in the following season. Dark coloured pin-point specks (acervuli) are visible in and around the diseased leaf area. Fruit symptoms are characterized by the appearance of 4-5 mm circular to oval brown spots which later become depressed and turn dark brown to black in colour.

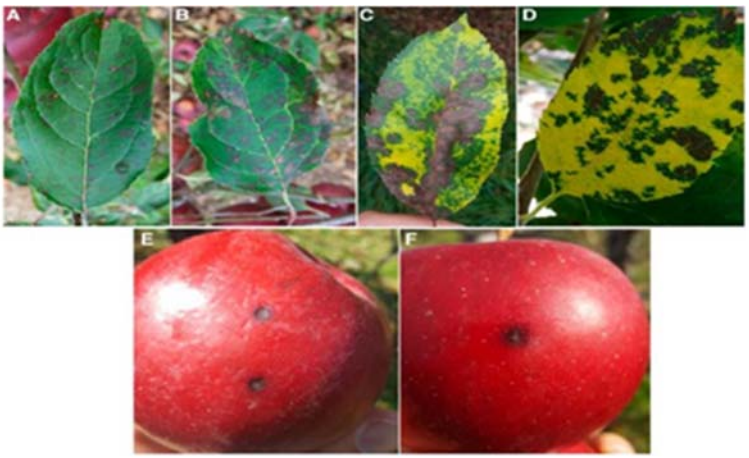


Fig: Marssonia leaf blotch

Disease Cycle

Like apple scab, primary infections are initiated by ascospores produced on overwintered leaves. Mature ascospores have been found just before the bloom stage of bud development. Ascospore discharge usually lasts for 3–4 weeks. Rain is required for spore release. Primary symptoms appear in the middle of June, usually on mature leaves. However, we have observed the first symptoms as late as August and September. Infection of leaves by conidia takes place most frequently at 68–77°F, and symptoms are present within 8 days of inoculation. Defoliation begins about 2 weeks after the symptoms appear.

Control Measures

I. Disease control is managed through orchard sanitation, pruning, and the use of fungicides.
II. Removal of overwintered leaves on the ground may reduce the inoculum level.
III. Spray of Fluopyram 200 + Tebuconazole 200 SC is a promising fungicide against the Marssonina blotch diseases in apple.

SOOTY BLOTCH AND FLYSPECK

Causal organism:
Sooty blotch-*Gloeodes pomigena*
Fly speck-*Zygophiala jamaicensis*

Symptoms: These two superficial diseases appear simultaneously on fruit surface and can be easily mistaken as single disease. These diseases become severe in late summer with the on-set of rains. Sooty blotch is characterized by dull black to grey spots with indefinite outline.

Flyspecks are definite, circular, black and often glistening spots resembling flyspecks in size and colour. These diseases are common on the fruit hanging on shady portions and crowded branches of trees. Losses by these diseases are caused primarily through lowered fruit quality.

Fig: Sooty blotch

Control Measures

I. Trim hedgerows to limit inoculum.
II. Prune apple trees to ensure good light penetration and air circulation so that fruit dries rapidly.
III. Maintain good weed control to ensure good air circulation.
IV. As disease symptoms do not appear until 3-6 weeks after initial colonisation, orchard monitoring as a basis for decision makers is not practical. However, identifying the problem in one year can be used as an alert for treatment in later years.
V. Where the disease has been a problem the previous season, apply sprays of an effective fungicide to fruit in early summer (mid-late June) and in July and August. Mancozeb is the most effective fungicide.
VI. Some disease warning systems have been developed such as *RIMpro*, which include a model based on leaf wetness, rain and temperature. This allows sprays to be more targeted.

COLLAR ROT

Causal organism:***Phytopthora cactorum***

Symptoms: The affected trees exhibit poor terminal growth and may remain stunted. Foliage is sparse, chlorotic or bronze in colour. Fruits are small and tend to colour prematurely. The disease symptoms are not visible unless outer layers of the bark are removed to expose inner phloem tissues which instead of healthy and white appear necrotic, orange to red brown in colour and eventually become dark brown on decaying. Active collor rot cankers may also be formed in the phloem near the ground line and may extend to outer bark surface. Rapid extension of the cankered areas both in the lateral and vertical direction results in tree girdling. Symptomatic trees usually decline seasons over several and progressively eventually die.

Control Measures

I. Apply hygiene measures, like cleaning machinery and tools, destroy waste heaps, remove remaining roots, infested leaves
II. Choose less susceptible or resistant cultivars when available
III. Prevent over-irrigating and be careful with overhead irrigation since both a high-water content of the soil and water splash promote disease.
IV. Ensure fast drying and wound healing, by allowing air circulation
V. Disinfect recirculating nutrient solutions
VI. Prevent plant diseases by optimizing plant potential and crop resilience.
VII. Treatment with a combination of Metalaxyl + Mancozeb around the base of the tree can also prevent the growth of P. cactorum in the trunk.

ROOT ROT

Causal organism: *Dematophora necatrix*

Symptoms: The disease symptoms appear on the underground parts of the tree but the effects are also manifested on the above ground parts. The earliest above ground manifestation of the disease is bronzing of the leaves, diminution in their size and a stunted tree growth resulting in the progressive decline of the tree vigour. Root rot affected trees are usually associated with a heavy blossom and fruiting in next year, however in succeeding years, fewer leaves emerge and much of the immature fruits induce early coloration and fail to reach maturity. The lateral roots turn dark brown and are covered with greenish grey or white mycelial mat causing rotting of small roots which then invade larger roots. Fibrous root system almost disappears and tree cortical and phloem cells are ruptured which disrupt the translocatory system. Infected trees often persist for 2-3 years depending upon the infection severity.

Fig: Root rot

CANKER

Causal organism*:* *Botryosphaeria obtusa*

Symptoms: Cankers usually develop in summer months and appear as small, sunken, reddish brown well demarcated areas which later enlarge, become elliptical, develop series of concentric rings, turn smoky and completely girdle the trunk and limbs. Some cankers remain superficial and cause roughening of the bark. On branches and twigs no conspicuous cankerous symptoms are produced. However, browning of the bark with simultaneous yellowing of leaves are the initial symptoms which ultimately result in cracking of the bark exposing reddish brown stained wood underneath it. Numerous black pimples like protuberances which are the reproductive structures usually develop on the cankered surfaces which serve as source of inoculums for infection.

Disease monitoring and forecasting.

Inspection of orchards for cankers during winter pruning and for shoot die back in spring/summer due to canker will give an indication of the problem in orchards. In addition, assessment of Nectria rot incidence during fruit grading from store will also give an indication of canker incidence in the orchard. -

Management

In problem orchards routine treatments are required every year. Effective control of canker requires an integrated approach with both cultural and chemical treatments.

I. In winter, prune out cankers where possible or cut back cankers on scaffold branches to healthy tissue. Treat with a suitable canker paint immediately after pruning.

II. If possible, remove prunings from orchard and burn. Otherwise pulverise or macerate pruning debris taking care that pieces do not remain beneath the trees on the herbicide strip.

III. In summer prune out shoot dieback as soon as possible to reduce inoculum for fruit rot. On young trees ensure that wounds are painted.

IV. In orchards with low canker incidence at autumn leaf fall, apply a spray of a copper fungicide at 10% leaf fall and repeat at 50% leaf fall.

V. In orchards with moderate to high canker incidence apply a spray of tebuconazole before the end of leaf fall, followed by a spray of a copper fungicide at 10% leaf fall, then a spray of tebuconazole or thiophanate-methyl at 50%leaf fall with a second copper spray at 90%leaf fall.

VI. At bud burst spray dodine or dithianon to protect bud scale scars against infection. Repeat at mouse ear.

VII. Use dithianon or captan as part of the scab control programme. These products will give some protection against canker. Dithianon +

pyraclostrobin or pyraclostrobin + boscalid or cyprodonil +fludioxonil will also give some control.

VIII. These will give fruit some protection against Neonectria rot and in orchards with a high canker incidence, are essential if fruit is to be stored without significant losses.

IX. The same treatments can be applied pre-harvest in late July and August.

APPLE MOSAIC

Causal organism: *Virus*

Symptoms: Infected apple trees plants show variable symptoms infield. Usually creamy white to yellow patches appear on the lamina. The spots may be so numerous that a part or whole leaf may turn yellow. The leaves become necrotic and finally wither away. Gradually plant looses vigour, and yield is reduced considerably. The virus is transmitted through bud-wood, by natural root grafting and budding.

Management of Fungal Fruit and Foliar Diseases

Presently various foliar and fruit diseases of apple caused by different fungi are managed in an integrated manner as follows:

I. Cultural:

- Ensure collection and destruction of fallen leaves, mummified fruits pruned snag, and dead wood.
- Remove crowded branches for proper aeration and sunlight to avoid high humid conditions in microclimate of the fruit trees.
- Remove the disease twigs/branches at least 10 cm below the point of visible infection and apply wound dressers like Chaubattia or Bordeaux paste at the cut ends.
- Keep orchard area clean from weeds, bushes and wild plants to avoid excessive humid condition in the rainy season. Ensure proper irrigation during hot, dry periods to avoid trees tress.

- Remove dormant shoot tip and silvered area to reduce source of primary infection in powdery mildew.
- Fruits in clusters provide favourable microclimate for sooty blotch and flyspeck spread. Thinning of such fruits is important in reducing the disease incidence.
- Maintain low mite population particularly in spring to early summer in apple orchards for avoiding Alternaria leaf blotch (A.mali) outbreaks.

II. Chemical

The dosage, time of application and type of fungicides to be used against the disease play a significant role in the success of chemical management of various fungal foliar and fruit diseases of apple. A protective spray programme comprising of 8-9 sprays of both protectant and systemic fungicides during the growing season, is being adopted in apple orchards of the valley. The division of Plant Pathology SKUAST-K has been constantly evaluating different fungicides year after year against major fungal diseases of apple viz. scab, powdery mildew, sooty blotch and flyspeck, Alternaria and Marssonina leaf blotch. These diseases can be simultaneously managed by adopting SKUAST-Jammu recommended spray schedule.

Management of Viral Mosaic Disease

1. To ensure infection free graft and bud wood, mother plants should be indexed for the virus.
2. Pruning of virus infected plants, properly marked should be carried out at last followed by proper sterilization of pruning equipments with ethanol.
3. Roughing and destruction of infected plants if possible. 4. Do not use graft/bud wood from virus infected plants for propagation.

Management of Canker diseases

1. Cultural control

i. Regular inspection of tree trunks/ branches for canker symptoms.
ii. Removal and proper destruction of dead wood, mummified fruits and pruned branches.
iii. Application of balanced dose of fertilizers, irrigation during hot dry periods to avoid tree stress.
iv. Protect plant trunks from high temperature injury by applying white washing.
v. Judicious training and pruning of trees to protect branches from sun burn.
vi. Avoid mechanical injuries to make trees less vulnerable to canker causing pathogens.

2. Chemical control

i. Pruning wounds or other mechanical injuries should be dressed immediately with fungicidal paint/ paste (Chaubatia or Bordeaux paste).

ii. Prune the girdled/ die back branches along with apparently healthy area (6" below the diseased area) and apply fungicidal paint.

iii. Scarify the cankerous portion and expose the healthy surface in and around the canker by removing all the scales, dead wood, bark and pimples.

iv. Apply/ dress the wound with any one of the following fungicidal paints (1:2:5 parts)

a) Carbendazim 50 WP + Mancozeb 75 WP + linseed oil
b) Carbendazim 50 WP + Captan 50 WP+ linseed oil
c) Carbendazim 50 WP + Copper-oxychloride 50 WP + linseed oil
d) Carbendazim 50 WP + Dodine 65 WP+ linseed oil
e) Carbendazim 50 WP + Ziram 80 WP+ linseed oil

v. Repeat the paint after 3 months

vi. Follow regular fungicidal spray schedule.

Management of Collar Rot

1. Clean the infected collar area with a sharp edgedknife and apply Chaubattia (copper carbonate + red lead + linseed oil in a ratio of 1: 1: 1.25 parts) or Bordeaux paste (copper sulphate + lime + linseed oil in ratio of 1: 2: 3 parts).
2. Improve drainage around the tree basin and remove crop refuse from orchard.
3. Drench the soil under tree canopy with metalaxyl MZ 72 WP (0.5%) or mancozeb 75 WP (0.6%) or copper oxy-chloride 50 WP (0.6%). Repeat drenching after 15-20 days of the first drenching.
4. Keep the graft union above the soil surface.
5. Keep 60cm of soil around tree trunks undisturbed.

Management of Root Rot

1. The known infested pits should be treated with 3% formaldehyde three weeks before new plantation.
2. Rotten roots should be cut and cut ends painted with a disinfectant paste (Bordeaux or Chaubatia).
3. Infected soil of the basin should either be replaced or treated separately with 3% formaldehyde during dormancy.
4. Drench the soil under tree canopy with carbendazim50 WP (0.1%) or carbendazim + mancozeb 75 WP (0.5%). Fungicide suspension should be applied in 15-20 cm deep holes made with crowbar at a distance of 30 cm

throughout the tree basin

5. The affected tree should be approach grafted with seedlings.
6. Texture of clayey soils should be amended by adding more organic matter.
7. Central drainage system should be followed.
8. Channels 60 cm deep and 90 cm wide be prepared in between the infected and healthy trees.

17 INSECT PESTS

SANJOSE SCALE *(Quadraspidiotus perniciosus)*

San Jose scale is an extremely important indirect pest of apples, pears, peaches, and plums. It is a sucking insect that injects a toxin into the plant as it feeds causing localized discolorations. The presence of reddish blemishes on fruit at harvest indicates potentially damaging numbers on the trees. If left uncontrolled, San Jose scale can kill the entire tree in a couple years. If such damage is noted, inspect trees for scale, especially one year-old wood. Purplish-red halos on young bark are indications of scale infestation. Often this very small insect goes unnoticed until large populations have developed. San Jose scale overwinters as immature scales. In the spring, the tiny winged males emerge and mate with the wingless females, and about one month after the emergence of the male flight, the first crawlers can be seen. Eggs are not seen because females give birth to live crawlers. These tiny yellow insects move around randomly on bark and foliage before settling down permanently. A few days after settling down, crawlers will secrete a waxy covering over their body that will protect them from pesticides. From this point on female scales will not move. Males will remain in one location until maturity, at which time the winged males will seek out females and the cycle will begin again.

Damage:-If heavy scale infestations are left unchecked, trees may be seriously damaged, resulting in reduced vigor, thin foliage, cracked or dying branches, and the eventual death of the tree. Young trees may be killed before fruiting. Infested fruit develop a reddish purple ring surrounding each spot where a scale settles for feeding.

San José scale damage on apple fruit (left). San José scale black cap stage (center), female (upper right) and male (lower right). [Photos courtesy of Greg Krawczyk (Penn State University), E. Beers (Washington State University) and S. Schoof (North Carolina State University).]

Management

A. Cultural/Mechanical control

i. Infested nursery plantation, buds, graft materials should be avoided.

ii. Shade trees especially willow, poplar etc. should not be planted in and around fruit orchards.

iii. Pruning of heavily infested branches during dormant period and their burning helps in preventing the buildup of the pest.

iv. Scrap off the SJS from infested branches with gunny bags particularly in nursery plantation without causing any injury.

B. Delayed dormant spray

To ensure the suppression of scale spray the orchard during late dormant stage (before green tip stage) with any HMO's recommended by SKUAST @ 2% (i.e. 2 lit in 100 lit. of water). The spray should be applied thoroughly to all parts of the tree. In case, rain washes the spray within 24 hours, spray should be repeated. The light infestations of San Jose scale may be controlled by the normal orchard practice of delayed dormant spraying but heavy encrustations often require additional applications of insecticides.

C. Biological control

Two parasitoids namely *Encarsia perniciosi* and *Aphytis proclia* and a predatory Coccinellid beetle, *Chilocorous infernalis* are found actively associated with San Jose scale in the orchards of Kashmir. For their safety, it is essential to avoid indiscriminate use of insecticides.

D. Chemical control

i. Pink bud stage: Where spraying of HMO during delayed dormancy has

been missed, then spray the fruit trees with Dimethoate 30EC @ 100 ml/100 lit. of water.

ii. **Petal Fall (Need based):** At 80 % petal fall if 6-12 SJS crawlers/cm2 are observed on twigs, sprays the trees with any of the insecticides i.e. Dimethoate 30 EC or Quinalphos 25 EC @ 100 ml in 100 lit. of water.

iii. **Fruit let (Pea size) (Essential):** Spray SJS infested trees with Chlorpyriphos 20 EC or Dimethoate 30 EC @ 100 ml/100 lit. of water.

iv. **Fruit development-II (Essential):** Spray Dimethoate 30 EC @ 100 ml/100 lit. of water at this stage.

v. **Fruit development-III (Need Based):** If more than 13 crawlers/cm2 of SJS are observed on twigs, spray Dimethoate 30 EC (100 ml) or summer spray oil (750 ml) per 100 lit. of water.

17.2 WOOLLY APPLE APHID *(Eriosoma lanigerum)*

Woolly apple aphids infest roots, trunks, limbs, shoots, and occasionally fruit of apple trees. The bodies of these bark-feeding aphids are completely covered by masses of white, wool-like, waxy materials. This aphid is found in colonies on the aerial portions of the tree and on roots during winter. The nymphs migrate up or down the trunk of infested trees during fall and feed on roots. Galls are formed on roots where aphids feed and hamper in the uptake of nutrients. During summer, the nymphs migrate to the aerial parts of the tree and form colonies covered with cottony mass.

Fig: Wooly Apple Aphid

Damage: - WAA feeding causes development of black sooty mold due to honey dew secretion which hampers photosynthesis. Infested plants become stunted in growth and under severe infestation fruit size is reduced.

Management

a) Mechanical control: Removal of excessive water sprouts and covering of cracks, crevices and wounds caused by pruning should be covered with *Chaubatia paste.*

b) Delayed dormant oils (HMO): Some control of Woolly apple aphid is obtained by the spraying delayed dormant oils (HMO) @ 2% recommended by SKUAST-K.

c) Resistant root stocks: The root stocks of Malling Merton (MM) series show resistance to WAA.

d) Biological control: An aphelinid endoparasitoid, *Aphelinus mali* is well established against WAA in the orchards of valley. So as to prevent their damage from insecticides, it is essential to use the insecticides in a judicious manner.

e. Chemical control

i. Fruit let (Pea size) (Essential): Spray the trees with Chlorpyriphos 20 EC (100 ml) or Dimethoate 30 EC (100 ml) /100 lit of water for the management of WAA.

ii. Fruit development-II (Essential): Spraying with Dimethoate 30 EC (100 ml) per 100 lit. of water will take care of WAA.

iii. Fruit development-III (Need based): If colonies of WAA are observed on terminal shoots, spray with Dimethoate 30 EC (100 ml) or summer spray oil (750 ml) /100 lit. of water.

f. For Subterranean infestation (Roots): In order to check the subterranean infestation of WAA, drench the tree canopy area with Chlorpyriphos 20 EC (3ml/lit. of water) during December or March.

or

Roots damage due to WAA can be managed by application of Carbofuran 3% CG @70-100 gm per tree in the canopy by hoeing the 5 cm soil in depth around the tree trunk. **EUROPEAN RED MITE** *(Panonychus ulmi)*

Biology

Egg:

The European red mite overwintersasfertilized eggs. The environmental factors triggering winter egg production are diminishing food supply, temperature and photoperiod. The bulk of winter egg deposition occurs from mid to late August, but may continue until late September. Overwintering eggs are deposited in on roughened bark areas, especially groups around the base of buds and fruit spurs. These eggs may be so numerous that the infested areas take on a reddish

cast. Egg hatch is closely correlated with bud development and first occurs when buds are in the tight cluster stage; hatch is better than 50% complete at the pink stage, and virtually 100% complete by the end of bloom. The first summer eggs as a rule can be found at petal fall or at latest by fruit set.

The summer eggs are globular and somewhat flattened (onion shaped). They are bright red to dark orange and average 0.13 mm in diameter. The overwintering egg is deeper red and slightly larger, averaging 0.14 mm. The egg surface is ridged with the grooves running toward the top centre from which a slender tapering stalk (0.1 mm) arises. The average incubation period of the summer eggs for each generation varies from 6.7 to 14.4 days, the shortest period being in mid-summer.

Nymph:

The European red mite passes through 3 stages between egg hatch and adulthood. They are called the larva, protonymph and deutonymph. A quiescent or resting period precedes each molt to the following stage. The hatching larva is about 0.2 mm in length, light orange in color and 6 legged. All subsequent stages have 8 legs. With the exceptions of an increase in size and the ability to differentiate sexes in the deutonymphal stage, there are no conspicuous changes in structure or color between the nymphal instars. The average developmental time from eclosion to adulthood ranges from 5.5-15 days, depending on the generation.

Adult:

There are 4-9 generations of the European red mite a year, depending on the locality and the length of the growing season. The sexes of the adults are readily differentiated. The female has a globular body which ranges in length from 0.38 to 0.40 mm, is velvety brown to brick red, and has 4 rows of dorsal setae or spines borne on raised white tubercles. The body color and setal pattern distinguish this species from all other plant feeding mites. The male is smaller, 0.26- 0.28 mm in length, lighter in colour and has a pointed abdomen and proportionately longer

legs.

The rate of development is temperature dependent, being slower in the spring and fall and more rapid during the hot summer months. The first generation generally requires about 3 weeks developing, while summer generationsmay develop in 10 to 14 days. Reproduction can be both sexual and parthenogenetic. Unfertilized eggs give rise to males only, while as mated females produce both sexes. The average preoviposition period of females is about 21/2 days and the average life span is 18 days. The oviposition period averages 12.5 days with 18 eggs produced per female.

Damage symptoms

Both immature and adult stages puncture the tissues of the leaves and feed on plant sap. If the infestation is high, the foliage becomes speckled. Heavily infested leaves become dull green, brownish yellow or bronzed giving burnt appearance to orchards. Due to foliar damage, the fruit size is reduced and there is premature fruit drop. The damaged leaves are exposed secondary infection of fungal diseases like *Alternaria leaf blotch.*

Management strategies:

a. Cultural/Mechanical control

i. Up keep of the vigour of plant by applying balanced dose of fertilizers and proper irrigation.

ii. Pruning and destruction of infested twigs/ branches during dormancy.

b. Delayed dormant spray:

Delayed dormant spray oils @ 2% (21it/ 100 lit. of water) will provide adequate control of mites.

c. Biological control

i. A lady bird beetle, Stethorus punctum and predatory mite, Amblyseius fallacis are usually the most important and frequent predator of mites in fruit orchards.

d. Chemical control

i. Petal fall (Need based): Apply acaricide Hexathiazox 5.45 ECor Spiromesifen 22.9 SC or Fenazaquin 10 EC @ 40 m1/100 litre of water when 4-5 mites/ leaf are observed.

ii. Fruit let (Pea size) (Need based)

Apply acaricide Hexythiazox 5.45 EC or Spiromesifen 22.9 SC @ 40 ml/100 lit. of water when more than 5 mites/leaf are observed.

iii. Fruit development-I (Need based)

Spray Hexythiazox 5.45 EC or Spiromesifen 22.9SC @ 40 ml/100 litre of water when mite population is more than 10 mites/leaf.

iv. Fruit development-II (Essential)

Spray Hexythiazox 5.45 EC or Fenazaquin 10 EC or Spiromesifen 22.9 SC

@ 40 ml/100 litre of water or summer spray oil @ 750ml/100 lit. of water

v. Fruit development-III (Need based)

If population is more than 15 mites per leaf, spray Fenzaquin 10 EC or Spiromesifen 22.9 SC @ 40 ml/100 lit. of water or Spray Cyenopyrafen 30 SC @ 30 ml/100 litre of water.

Two spotted mite *(Tetranychus urticae)*

Biology

Egg: The egg is spherical and about 0.14 mm in diameter. When first deposited, the egg is translucent, taking on the greenish tinge of the leaf where it is laid. It becomes more opaque as it matures, finally turning a pale yellow. The red eyespots of the embryo are visible just prior to hatch.

Immature: The larva is round, about the same size as the egg, and has three pairs of legs. Initially it also is translucent (except the red eyespots), but once it begins feeding, it turns pale green to straw color, and the characteristic two black spots begin to form on the dorsum (back). The protonymph is larger and more oval, and has four pairs of legs, as do all succeeding stages. The two dorsal spots are more pronounced, and the green color is slightly deeper. The deutonymph is slightly larger than the preceding stage, and males can be distinguished from females at this stage by the smaller size and more pointed abdomen. Each immature stage goes through three phases: active feeding, a quiescent period, and a molt. The integument (the outer covering of the body) may take on a silvery appearance in the quiescent stage as it separates from the skin. below in preparation for the molt.

Fig. 17.4: Two spotted spider mite adult females

Adult:

The adult male is smaller than the female and is characterized by its distinctly pointed abdomen. It sometimes has an orange or brown tinge and is more

active than the female. The female is about 0.42 mm and more robust than the male and is more oval in shape. Color of the female can also vary. Typically, it is a pale leaf- green, but it can be tinged with yellow, brown and orange. As the name implies, there are generally two distinct spots on the front half of the dorsum behind the eyes. These spots are caused by pigments in the digestive tract which is why the size, distinctness, and pattern of spots can vary considerably among individuals or at different times during the life span of a single individual. Overwintering females are usually a distinct solid orange, and the spots disappear.

Damage:-

Mites feed by inserting their mouth parts into leaf cells to suck out the contents, including the green pigment chlorophyll. The individual spots initially look white, giving the leaves a stippled appearance. As the damage progress, the infested leaves take on a brown hue, commonly called bronzing. Tree species, and cultivars within species, differ substantially in their reaction termite feeding. Although Red Delicious trees tend to build higher populations of mites, Golden Delicious is more susceptible to damage by mites. Apples, in general, are more tolerant than pears. Damage to apple foliage will cause bronzing and eventually some premature leaf abscission in August.

Management:-

All stages of anthocorid bug, Blaptostethus pallescens feed on the eggs of two spotted spider mites (Fig. 15). Preferably 8-10 days' old nymphs are being released weekly @ 200/ tree from May suppresses the population of the two spotted spider mites on apple. However, no chemicals are recommended to be applied during a week of the release of the bio-agent. Rest management is same as in European Red Mite

SHOT HOLE BORER/PIN HOLE BORER *(Scolytus nitidus)*

Nature of damage:

Adult and grubs tunnel into the sapwood and hardwood of the plant making galleries and pin holes surface of infested branches get perforated followed by yellowing and wilting of leaves. A serious infestation may kill the whole tree.Holes are sometimes indicated by borings on the bark.

Management strategies:

a) Cultural/Mechanical control

i. Pruning and destruction of borer infested branches during autumn.

ii. Application of balanced dose of fertilizers shall help to reduce the attack of borers.

b) Chemical control

i. The holes may be plastered with mixture of Chlorphriphos 1.5% WP and soil in the ratio of 1:1 part.

ii. Apply Dimethoate 30 EC during 1st week of May and 1st week of July at the time of adult emergence of 1st and 2nd generation of the pest, respectively.

GREEN APPLE APHID *(Aphis pomi)*

Nature of damage:

Feeding on plants by aphids results in severe distortion of leaves which may turn yellow or brown resulting in premature leaf fall. Infested trees appear sickly and show stunted growth. Young nursery plantations at terminal shoots are mostly attacked.

Management strategies:

a. Delayed dormant spraying: Delayed dormant spraying with HMO's @ 2% (2lit./ 100 lit. of water) will give adequate aphid control

b. Chemical control: Spray with Dimethoate 30 EC @ 100 ml/100 lit. of water or Imidacloprid 17.8 SL @ 28 ml/100 litre of water during late May or early June.

17.7 GYPSY MOTH/HAIRY CATERPILLAR (Lymantria obfuscata)

Biology

Egg: The egg mass is approximately 1.5 inches long and 0.75 inches wide. Eggs are attached to trees, houses, or any outdoor objects. The eggs hatch in spring (April) into caterpillars.

Larva: They have five pairs of blue dots followed by six pairs of red dots lining the back. In addition, they are dark colored and covered with hairs. Young caterpillars primarily feed during the day whereas the older caterpillars feed at night. When present in large numbers, the older caterpillars feed day and night. Older caterpillars are approximately 1.5 to 2.0 inches long. Larva period is 66-100 days.

Pupa: In early summer (June to early July), Gypsy moth caterpillars enter a pupal or transitional stage. The pupae are dark brown, shell-like cases approximately two inches long and covered with hairs. They are primarily located in sheltered areas such as tree bark crevices or leaf litter.

Adult: Adult Gypsy moths emerge from the pupae in 10 to 14 days. Females have white to cream- colored wings, a tan body, and a two-inch wingspan. Female Gypsy moths cannot fly. Females lay 500 to 1000 eggs in sheltered areas such as underneath the bark of trees. Both the adult female and male can be identified by the inverted V-shape that points to a dot on the wings. Gypsy moth has only one generation per year.

Damage symptoms

Caterpillars are gregarious but voracious feeder. They eat voraciously on leaves at night time. Under heavy infestation entire leaf is eaten sparing only hard vein. Defoliation of host completely results in failure of fruit formation.

Management

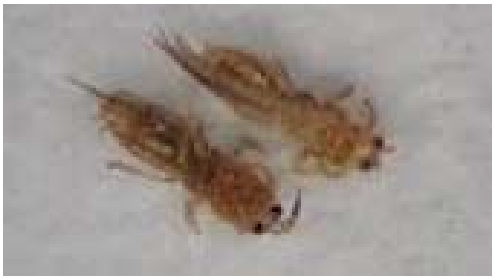
a. Cultural/Mechanical control

i. Collection and destruction of egg masses which are available around 9 months (July to March) on the tree trunk/scaffold branches of willow, poplar plants and hidden places (walls, stones, clod of soil etc.).

ii. Upkeep the vigour of plants by applying balanced dose of fertilizers and proper irrigation.

iii. Since the larvae hide during the day on main trunk in loose bark, crevices, therefore putting gunny burlap (dipped in Cholrpyriphos 20 EC@ 1ml/litre of water) around the tree trunk attracts the larvae for hiding. The larvae trapped in burlap from April to June be collected and killed.

b. Chemical control



Spray the hairy caterpillar infested trees with Cholrpyriphos 20 EC or Dimethoate 30 EC @ 100 ml/100 lit of water at fruit let stage.

APPLE BLOSSOM THRIPS (Thrips Sp.)

Biology

Egg: The eggs of thrips are deposited within plant tissues singly.

Larva and pupa: Larvae have two stages, which feed on plant tissues. The second instar larvae, when mature, fall to ground, where they molt to prepupae and pupae in the soil.

Adult:

After emergence, the adults move to the growing parts of the plants such as young leaves, flowers, or young fruits, where they feed and lay eggs (about 200 eggs per female). Adults are usually found on young leaves, while larvae are found on lower or older leaves. At 25°C, the life cycle is completed in approximately 17 days. Adults are winged sucking rasping insects ranging from 5-14 mm in length. Their slender bodies are shiny pale or black with silver stripes. Life cycle completed in 11-43 days. Thrips produce many generations in a year highest damage occur in spring. In colder region, life cycle is longer with fewer generations.

Nature of damage:-

Both nymphs and adults lacerate floral parts. Thrips feeding within the buds may cause oozing of sap from injured areas. Later brownish patches are produced at the base of stamens, styles and petals on infested blossom. Injury may lead to distortion of petals and reduction of fruit set.

Management strategies:

I. Mechanical control

Thrips are often attracted to weeds blooming on the orchard floor. To prevent thrips driving into the trees, do not disc the cover crop whentrees are in bloom. Open weedy land adjacent to orchards should be diced as early as possible to prevent thrips development and migration of adults into orchards.

II. **Chemical control (Need based)**

If there are 2 or more thrips/flower, then spray the trees at pink bud stage with Thiacloprid 21.7 SC @ 40 ml/100 lit of water.

CHAFER BEETLES *(Adoretus simplex and Holotrichia spp.)*

Nature of damage:

Adult beetles or cock chafers feed on leaves, buds, blossom and fruit lets during the night hours. They are voracious feeder and lives in gregarious fashion. Eaten leaves are perforated. The immature stage (white grub) feed on the roots and cause wilting of the plant and may dry up.

Management Strategies:

Cultural/Mechanical

i. Install light traps from March-July so as to collect the beetles and destroy them by dipping in water mixed with insecticides.

ii. Apply well rotten farm yard manure in the orchards.

Chemical

For adults: Spray Chlorpyriphos 20 EC @ or Quinalphos 25 EC @ 100 ml/100 lit. of water during mass beetle emergence period to host plants preferably in the evening hours.

For grubs: If 2-3 grubs/m2 is observed then drench the soil with Chlorpyriphos 20 EC @ 300ml/ 100 lit. of water or apply Carbofuran 3 CG @10-15 gm per tree in the canopy followed by hoeing the soil up to 5 cm in depth around the tree canopy.

8. COST OF ESTABLISHMENT

(As per Scheme formulated by Department of Horticulture, Govt. of J&K, UT for promotion of High-Density Plantation)

18.1 High Density Orcharding-3333 trees per hectare

(Rs. in lakhs)

S. No.	Components	Estimated cost per ha	Govt. share	Beneficiary share
1.	Cost of plant material (3 feathered) @ Rs.500/plant for3333 trees (1x 3m)	16.67	15.00	1.67
2.	Cost of 4-wire trellis system (with installation)	12.00	6.00	6.00
3.	Cost of anti-hail net (with installation) or fencing	4.50	-	4.50
4.	Cost of micro-irrigation system	2.40	1.20	1.20
5.	Land development	1.50	0	1.50
6.	Pit digging, plantation@Rs.70/pit	2.33	0	2.33
7.	Cost of vermi-compost unit	0.80	0	0.80
8.	Pesticides	0.40	0	0.40
9.	Plant protection machinery	0.20	0.10	0.10
Total		**40.80**	**22.30**	**18.50**
Approximate		**41.00**	**22.00**	**19.00**

18.2 Medium Density Orcharding-2222 trees per hectare (Rs. In lakhs)

S.No.	Components	Estimated cost per ha	Govt. share	Beneficiary share
1.	Cost of plant material (3 feathered) @Rs.500/plant for 3333 trees (1x 3m)	11.00	9.90	1.10
2.	Cost of 4-wire trellis system (with installation)	10.00	5.00	5.00
3.	Cost of anti-hailnet(with installation) or fencing	4.50	-	4.50
4.	Cost of micro-irrigation system	2.00	1.00	1.00
5.	Land development	1.50	0	1.50
6.	Pit digging, plantation@Rs.70/pit	1.60	0	1.60
7.	Cost of vermi-compost unit	0.80	0	0.80
8.	Pesticides	0.40	0	0.40
9.	Plant protection machinery	0.20	0.10	0.10
Total		**32.00**	**16.00**	**16.00**

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