Precision Farming

APPLE

With Jain Technology™

Jain Irrigation Systems Ltd.

Small Ideas. Big Revolutions.®

Jain Plastic Park, Jalgaon

Hon. Padmashri Bhavarlalji Jain (Bhau)
Founder Architect, Jain Irrigation Systems Ltd., Jalgaon

Founder's Conviction: As a son-of-the-soil and first generation entrepreneur, Bhavarlal Jain has hands-on farming experience. He genuinely believes that agriculture is backbone of the Indian economy. He feels that the transformation of India into an industrial society will take many decades. In the meantime, for sustainability, self-reliance, and all round growth, the country has no alternative but to adopt science and technology for progress in agriculture. He says, "*I have a dream to change the way the Indian farmers do agriculture".*

Advances in other sectors, however phenomenal, cannot substitute agricultural development. This is the conviction with which the founder commenced his journey in 1963.

CORPORATE PHILOSOPHY

Mission

Leave this world better than you found it.

Vision

Establish leadership in whatever we do at home and abroad.

Credo

Serve and strive through strain and stress;
Do our noblest, that's success.

Goal

Achieve continued growth through sustained innovation for total customer satisfaction and fair return to all other stakeholders. Meet this objective by producing quality products at optimum cost and marketing them at reasonable prices.

Guiding Principle

Toil and sweat to manage our resources of men, material and money in an integrated, efficient and economic manner. Earn profit, keeping in view our commitment to social responsibility and environmental concerns.

Quality Perspective

Make quality a way of life.

Work Culture

Experience : 'Work is life, life is work.'

OUR COMMITMENT

Customer and Market

- Commit to total customer satisfaction.
- Build and maintain market leadership.

Quality Excellence

- Strive continually to reach and maintain quality in every aspect.

Safety and Health

- Secure safety and health of associates and other assets.

Environment and Society

- Protect, improve and develop the environment
- Cherish the symbiosis and nurture the creative partnership between society and the environment.

Development of Other Stakeholders

- Adopt transparency and fair practices for continuous sustainable growth.

THE CORPORATION

Jain Irrigation Systems Ltd is a diversified entity with turnover in excess of 5000 crores. We have a Pan-India presence with 28 manufacturing bases spread over 4 continents. Our products are supplied to 110 countries with able assistance from 6700 Dealers and distributors worldwide.

We are the second largest Micro-Irrigation company in the world. The Micro-irrigation Division manufactures the full range of precision-irrigation products; provides services from soil survey, engineering design to agronomic support; nurtures a sprawling 2000 acre Hi-Tech Agri Institute; a Farm Resource R&D, Demo, Training and Extension Centre and undertakes turnkey projects for agricultural and irrigation development in totality. Over 1000 agri and irrigation scientists, Engineers, technologists and technicians are engaged in offering consultancy for a complete or partial project planning and implementation e.g Watershed Development through Wasteland Transformation, including crop selection and rotation.

Jain Irrigation is also the largest Plastic pipe manufacturer in India covering a wide range of pipes and fittings. We annually process over 300,000 MT of various polymers. We extrude and injection mold PVC, PE, PP along with other engineering polymers like Polycarbonate, Polyamide, PBT,ABS etc. We are a 'Total Solution Provider' for various thermoplastic Piping systems that are used in transportation / conveyance of fluids, semi-solids , gases and cables.

The Tissue Culture Division produces Grande Naine Banana plantlets at full capacity and has established a matching primary and secondary hardening facilities as well as independent R & D and virology labs. Similarly a modern Bio-tech lab equipped with PCR based and other molecular markers, HPLC, AAS and GC, has been established to meet the needs of continuous genetic improvement and validation programme in cultivation of onion, banana, mango and some of the energy crops.

We also processes tropical fruits into purees, concentrates, juices and IQF products. The Dehydration Facility dehydrates Onions and Vegetables. The Spray Drying Unit processes gooseberry and other fruit purees into powders.

Agricultural and Fruit Processing waste is converted into Organic Manure. Plant-based pesticides are also formulated. Both are critical inputs for organic farming, a system we profess and practice.

Jain Irrigation is the only company in India which is not only a Pioneer manufacturer of hi-tech agricultural inputs but also a Total Agri-Service provider , houses R&D, Demo,Training and Extension Institute,is a large farm cultivator and an Agricul rural Consultancy organization. It is through such multi-dimensional activity profile, that Jain Irrigation nurtures the complete agri value chain and has become a 'one-stop hi-tech agri shop'.The reward has been over a million satisfied farmers and scores of happy customers globally.

Our other businesses include PVC and Polycarbonate sheets,Solar Water Heaters, Solar Lighting etc where the emphasis is on the conservation of scarce

natural resources like forest and energy. PVC sheets can replace wood as a substitute for building material and save our forests. Similarly Solar Water Heaters and Photovoltaic Lighting systems uses the abundant Solar Energy available free and saves the natural sources of energy like coal which is used to produce electricity.

Our unflinching efforts in pursuit of excellence appropriately blended with ongoing Research and Development efforts have earned the company highest R & D awards of the country and numerous other awards and recognition for our performance in Exports, Fair Business Practices, Quality Excellence etc.

Our obsession with quality has enabled us to reach export turnover of 490 crores from our India operations.

A lifetime commitment to introduce modern yet affordable and viable technologies in all our product offerings have compelled us to be creative and innovative.

ONE STOP AGRI SHOP

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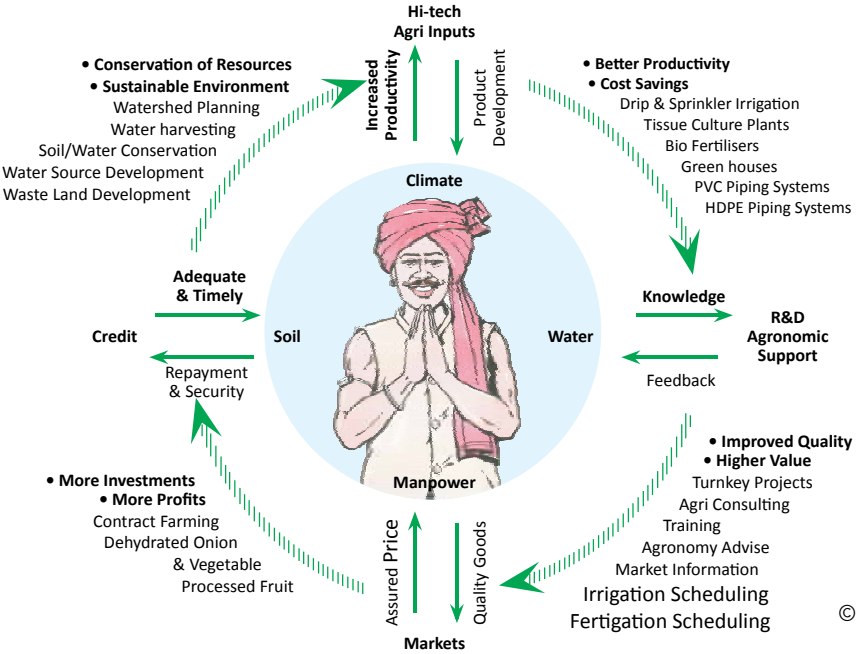
Note: Crop yields depend on climate, soil and management and therefore can't be guaranteed by the company.

Jain Self Sustaining Agri Development Cycle



The organization, at its inception in 1963, started with trading of agricultural inputs – an activity which continued till 1978.

In the next three decades, we embarked on manufacturing and supplying a wide range of quality agri-inputs to enhance farm productivity, which includes water piping systems, on-farm irrigation systems, and superior bio-tech products.

Along with the supply of agri inputs, we also provide a host of hi-tech agri-services from land preparation to post-harvest management etc.

Today, we undertake infrastructural development in agriculture, and provide total solutions for water, soil, and crop management, and insight into farm cultivation and operations. We take up such jobs on turnkey basis which involves executing, operating, and managing the projects; in other words, we offer everything from concept to commissioning.

We undertake research in laboratory and fields to develop hi-tech agricultural technology and carry out demonstration, training, and extension work in order to take these technologies to the farming community at the grassroots level.

We are engaged in corporate farming, and also sponsor contract farming for fruits and vegetables which are in turn used as raw material for processing and other value addition.

We have the largest pool of agricultural scientists, technicians, and engineers in the private sector. The company is led by a professional management team. Our professionals are committed to our corporate mission. Our core strength is our global experience with local knowledge and feel.

1. INTRODUCTION

Apple cultivation in India started during Eighteen century and now it is an important crop of temperate region. Apple ranks 6th among fruit production in India. China is largest apple producer in the world with 43% share, however, India has only 3% share.

Table 1 : Apple area production & productivity in various countries and in India.

Country	Area (lakh ha)	Production (lakh t)	Productivity (in t/ha)
China	20.00	298.5	14.90
USA	01.41	43.58	30.70
Polland	01.70	28.31	16.50
Iran	01.74	27.18	15.60
Italey	00.55	22.05	40.40
Turkey	01.29	25.04	19.30
France	00.22	19.40	37.20
India	02.80	17.78	06.30
World	47.96	698.19	14.60
Jammu & Kashmir	01.28	13.12	10.27
Himachal Pradesh	00.98	05.10	05.20
Uttrakhand	00.32	01.30	04.06

Source: FAO Database & State directorate of Horticulture.

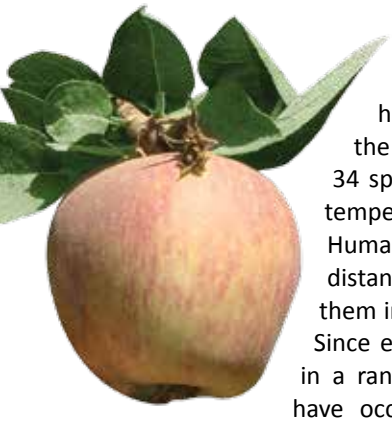
The table-1 indicates that apple productivity in India is much lower than other apple producing countries. Reason behind this, is that other countries have adopted new and improved methods of cultivation in recent years however, Indian growers are still using old techniques. Among Indian states productivity of J & K is higher than the other two states. It is mainly due to the best climate available in this state. In Jammu-Kashmir, there are regular

snowfalls and winter rains which provide sufficient moisture in the soil to protect the bloom from spring frosts, resulting in good fruit–set. Further, this zone being in inner Himalayas, the summers are cool and dry and there is plenty of sunlight available to the growing crop. If precise irrigation facilities are created, and a systematic approach to cultural practices is adhered-to, the yields and quality can be increased many fold.

The main handicaps are non-availability of 1)Irrigation, 2)Suitable cultivar which can produce sustainable yields under changing environment, 3) Nutrients for their efficient use during the growth stage when an apple tree demands, 4)Training and pruning, 5)Disease and pest management and 7) Protection of fruits from hailstorms.

1. During early days the snowfall in winters and rains during summers were regular, hence people did not realize need for irrigation. From last few decades neither snowfall nor rains occur at proper times – some years in excess, in other years, deficient. Looking to the topography of apple growing areas, water can be stored in tanks and can be used whenever neccessary through drip system for irrigation.
2. Cultivars have been developed which do well under fluctuating temperatures. These are to be popularized on priority basis.
3. Fertigation can be used for application of nutrients along with irrigation water. The nutrient can thus be made available to the trees when they require them most.
4. Although the system of training and pruning is recommended since long, however, it has not been used as an essential practice. Proper training and pruning gives strong framework to a tree and also enable the tree to yield a normal crop on a regular basis.
5. The first precaution to be taken up for management of diseases and pests is to maintain proper sanitary conditions in the orchard, provide conditions for aeration and sunlight upto the inner parts of the tree. Use of appropriate fungicides and insecticides at proper timings are very important for their control and to check their spread.
6. In some pockets, during summer, the hailstorms occur regularly which adversely affect the quality and production. Planting of apple orchards in these areas should be avoided and be put under temperate nuts like walnut, pecan nut etc.
7. Several orchards do not have sufficient number of pollenizer varieties.

2. ORIGIN AND DISTRIBUTION



Apple, *(Malus pumila L.)* belongs to the family Rosaceae and sub-family Pomoideae. It has originated in Asia in the regions of Asia Minor, the Caucasus and Soviet Central Asia. There are about 34 species in genus *Malus* known to occur all over the temperate and sub- temperate climates of the world. Humans have carried these several species to great distances from their centres of origin and has adapted them in new areas for their own horticultural production. Since evolution has been influenced by physical isolation in a range of environments, and further these isolations have occurred during comparatively recent evolutionary history, hybridization between species is still relatively easy. The 18 genera of sub-family Pomoideae have 17 pairs of chromosomes and are distinctly different from other genera of Rosaceae which have 7,8,or 9 pairs . Botanical and chemical observations suggest that the Pomoideae is of allopolyploid (amphidiploid) origin, produced by natural hybridization, possibly between Prunoideae (8 pair) and Spiraeodeae (9 pairs) followed by doubling.

The six most important apple producing countries are the Russia, USA, China, France, Italy and Turkey. These six combined produce more than half the world's crop. Apple contributes significantly to human nutrition and world food production. In USA apples are grown in about 34 States out of 48, but intensive cultivation is confined to few States which have suitable climate. In the United Kingdom where <1 per cent of the world's apples are produced, commercial apple production is carried out in few pockets and mainly in South eastern region where temperature is most favourable for regular production. Apple production in the UK is much greater in home orchards than it is in commercial orchards. It is estimated that about one– third of all nursery apple plants are sold to home gardeners.

3. SOIL

Deep loam soil is best for apples. Clay-loam soils having good drainage can also be used. In sandy-loam soils, apple trees are adversely affected by the stem diseases like Canker and Papery Bark and insects like stem and root borers. The soils rich in organic matter and, have a pH of around 6.5 and have good drainage are best for apple growing. The shallow soils with gravels can be made suitable by adding heavy quantities of farm yard manure/ compost or leaf moulds. On the whole , the soils on which natural forests of oak and deodar a flourish are ideal for apple orcharding.

4. SITE SELECTION

Apple being a temperate fruit, enters into dormancy from late autumn. It remains leaf less, in deep dormancy during winter months. Nevertheless, under the evolution process, this character has been provided by nature for the benefit of trees to save them from the chilling cold winters. Further, evolutionary processes have made low temperature a need of their life that we call as the "chilling requirement". Although during dormancy, there is no visible sign of growth, however, the processes of development remain active under low temperatures (at or < 7° C) i.e., chilling temperatures. The chilling requirement of apple buds varies between 1000-1500 hrs. Some varieties can be grown with low chilling hours up to 800hrs. The temperatures which are several degrees below zero degree are not effective to fulfill chilling requirement. These are, rather, dangerous to the shoots and buds. On completion of chilling requirement, in case there is a warm spell the buds put forth growth and because of being succulent they are liable to injury from the succeeding low temperature. Hence such areas are not suitable for apple growing. The best climate for apple is considered when there are at least 3-4 spells of good snowfalls and temperature, for most of the time, remains at or below 7° C between December and Feb-March. Depending upon the altitude and direction of slope, flowering occurs in April- May. The areas located > 2400 metre above msl (mean sea level) and facing North remain under snow for most of the period of the year hence at such altitudes , apple growing is possible on west, east or south facing slopes.

Constant chilling cold during winters, no frost during flowering, availability of sunlight for at least 8 hours daily and no hailstorms during summers and average minimum and maximum temperatures 10 and 30°C, respectively during the growing period are the ideal factors of climate for apple growing.

The hills of Noth-Eastern states and Nilgiri hills of South India, being warm, are not suitable for apple growing.

It is suggested to choose higher elevation sites close to the moderating effect of water flowing down in the perennial rivers. Large bodies of water take a long time to change in temperature both during summer and winter. The cooling effect of water in the spring delays the onset of bloom thereby reducing the risk of damage from spring frosts. In the autumn their effect reduces the on-set of cold temperatures and the damaging effect these can have on unharvested apples and on tree before they completely harden off. A higher elevation related to the valley is desirable because heavier cold air, in the spring will flow into the lower areas. This makes low areas frost prone resulting in poor tree performance with crop loss. A gentle slope is better than steep slope as the latter make orchard operations more difficult and is susceptible to soil erosion. Wind is another consideration and windy sites should be avoided. Strong winds can reduce the growth rate of trees, reduce bee activity during pollination, increase fruit drop and make spraying operation more difficult.

Considering all the parameters together, in India the best sites for apple orchards are the gentle slopes and wide valleys all along the perennial rivers in the states of Jammu-Kashmir, Himachal Pradesh and Uttarakhand.

Table 2: Comparative climate suitability for Apple cultivation in India

State	District	Areas based on climate		
		Most Suitable	Moderately suitable	Average
Jammu-Kashmir	Baramula	Rohana, Dangerpora, Sopore and Hajin.		
	Shopian	Sadipora, Pinjora, Kachidora, Jamnagar.		
	Kupwara, Kulgam, Srinagar, Pulwama, Budgam, Punch, Anantnag, Doda	Several places	-	-
	Rajauri, Bhadarwah	-	Several places	-
Himachal Pradesh	Shimla	Nankhadhi, Rohru	Kotgarh, Kotkhai, Thanadhar, Kumarsain, Chaupaal,	Mashobra, Kufri, Thiog, Shilaru
	Mandi		Nagwai, Sanaur, Sauri, Karsoag	Pandaar,
	Kullu	Rayson, Katrain, Naggar	Banjaar, Bhuntar, Parvati valley, Kullu, Fanjal valley, Sainj valley, Lag valley	Katola, Rajaun
	Kinnaur	Ribba, Purvani, Spillo, Nichaar, Kilba, Sangla and Ropa vallies, Telengi, Leo, Chango, Kalpa, Kothi	-	-
	Chamba		Tisa, Kilor- Kihaar, Bharmaur	Khajyar, Dalhousie, Salooni
	Sirmour			Nouhradhar, Habban, Deothi-Majhgoan, Dhamla, Haripur Dhar
	Lahaul	Chandra valley (from Khoksar to Tandi Bridge), All along Chenab river (from Tandi bridge to Udaipur)		
Uttara-khand	Uttarkashi	Harsil, Arakot, Bhutanu, Netwadh	Purola- Dharauli	Naugaon- Sauri
	Chamoli	Urgam Valley, Mallahari, Bampa, Gamshalli, Jumma	Auli- Barsari- Tapovan- Jelam upto Hemkund Sahib	Gualdam
	Rudraprayag		Tirjugi- Narayan	Gimtoli, Chirvatia
	Nainital		Ramgarh- Paharpani	Padampuri- Dhari
	Almora		Mornaula, Shaharphatak	Kausani
	Dehradun		Tuni-Koti-Kanasar-Chausal	Chakrata

5. SPECIES AND CULTIVARS

Altogether about 34 species have been reported in the genus *Malus*. The world's most important commercially produced apple cultivars belong to *M. pumila* . Though other species also have their own importance for example, almost all the scab- resistant cultivars have come from the crosses made between *M. pumila* X *M.floribunda*. Genes for disease resistance have also been obtained from *M. micromalus, M. baccata* and *M.sargentii.* Selections of *M.prunifolia* have been cultivated for their fruits in eastern Asia, and *M.micromalus* is grown commercially in China for processing and preservation in cans. A high level of resistance to powdery mildew is available in *M.sargentii* and *M.baccata* species. *M.prunifolia* is relatively more tolerant to calcareous soils than *M.baccata* but chlorosis due to iron deficiency associated with calcareous soils is common.

Few apple species are evergreen and grown only in sub-tropical regions, while at the other extreme, *M.baccata* survives readily in very cold regions but because of its low chilling requirement it breaks rest even when there is slight increase in temperature during spring season. The yielding capacity of *M.pumila* can further be improved by acquiring good cropping genes from *M.prunifolia, M.baccata, M.yunnanensis* or others.

Upto about 1960, the following cultivars were very common:

- Tydeman's Early Worcestor
- Lord Lambourne
- Early Shanburry
- Benoni
- Fanny
- Rome Beauty
- Winter Banana
- Jonathan

- King of the Pippin
- Cox's Orange Pippin
- King of the Tompkins County
- McIntosh
- Yellow Newton
- Baldwin
- Granny Smith
- Blenheim Orange
- Wagener
- Rymer (Maharaji)
- Ambri

Most of these are poor in colour and are either blended in taste or acidic.

Around 1970, cultivars of Delicious group came into existence which were preferred and planted in large scale because of their sweetness, red colour (except Golden Delicious) and attractive appearance. The Red Delicious, Royal Delicious and Rich-a-Red are still common but because of their sensitivity to changing environment, have now become poor performers and are showing un-sustainability in their production levels. There are now good prospects for cultivars like Vance Delicious, Star Crimson Delicious, Topred, Skyline Supreme Delicious and the spur cultivars like Red Spur, Gold Spur, Red Chief, Oregon Spur, Bright-N-Early, Silver Spur, Mac Spur, and Well Spur which on the whole have much better abilities to produce good yields under somewhat marginal climates. Moreover, their tree size is about two-thirds and fruits mature one to two weeks earlier than those of the Red and Royal Delicious. The cultivars Galla, Fuji and Red Fuji, recommended as pollenizers for most of the spur cultivars (unlike Golden Delicious and Jonathan- pollenizers for Red and Royal Delicious), produce much better quality fruits and hence can be planted in a proportionately greater number in the orchard for efficient pollination of the main cultivars.

There are cultivars such as Beacon, Sweet Sixteen, Heralson, State Fair and Keep Sake which can be grown in areas where the temperature during winter months remains as low as -20°C.

There are a group of cultivars which requires less hours of chilling for the normal flowering and fruit–set and hence, is suitable for cultivation in mild-temperate climate. Cultivars like Mollie's Delicious, Michal and Schlomith which produce good quality fruits as compared to their predecessors and have much better commercial value are recommended for growing in mild Climate.

The Scab disease is very common in many apple growing countries of the world, scab resistant cultivars like Prima, Priscilla, Sirprize, Florina, Macfree, Jonafree, Redfree and Freedom have been developed by transferring genes from the wild apple species.

Table 3 : Description of varieties and their suitability

Sr.	Variety	Main features	Suitable for
1	Tydeman's Early Worcestor	Fruits roundish, hard, red, blended taste, regular bearer, maturity 2nd fortnight July, good pollenizer for Delicious group.	H. P. and J &K
2	Lord Lambourne	Fruits roundish, green streaked, sweet, self-pollinated and a good pollenizer, maturity August 1st fortnight, regular bearer.	H.P. and J & K
3	Early Shanburry	Fruits small, red streaked, blended taste, maturity in July- August	Uttarakhand and J & K.
4	Fanny	Fruits medium, red blushed, blended taste, maturity in August	Uttarakhand
5	Red Delicious	Fruits conical, large, skin colour deep red streaks over yellow back ground, sweet, maturity in August-September	Uttarakhand, H.P. and J & K
6	Royal Delicious	Fruits large, conical, skin yellow covered with red streaks all over the surface, sweet, maturity in August-September	H.P. and J & K
7	Red Gold	Fruits round to slightly oblong, red blushed, waxy, glossy, heavy cropper, maturity in August-September	Uttarakhand, H. P and J & K
8	Golden Delicious	Fruits large, round, conical to oblong, golden yellow, sweet, maturity September-October	H.P and J and K
9	Rymer/ Maharaji	Fruits round, large, acidic, heavy cropper, long shelf-life, maturity in September- October.	Uttarakhand, H. P and J & K
10	Ambri	Fruits medium to large, yellow shining surface with red streaks, maturity in September- October	J & K
11	King of the Pippin	Fruits medium , skin yellow with light red streak, blended taste, maturity in September.	Uttarakhand and J & K
12	Oregon Spur II	Fruits medium, conical, skin colour deep red streaks over yellow background. Fruits mature about 10-15 days before Royal Delicious. It is suitable for mid hills and valley areas. Tree spur type.	H.P and Uttarakhand
13	Red Chief	Fruits medium, red streaked, maturity same as to Royal Delicious but colours 8-10 days earlier. Tree spur type.	H.P and Uttarakhand
14	Super Chief	Fruits medium, maturity slightly early than Royal Delicious. Tree spur type.	H.P and Uttarakhand
15	Gale Gala	Fruits medium, red over yellow background, maturity in August. Tree spur type.	H.P and Uttarakhand
16	Red Fuji	Fruits medium, round to conical, solid and aromatic, sweet, good shelf-life, maturity in September.	H.P, Uttarakhand and J & K

6. NURSERY MANAGEMENT

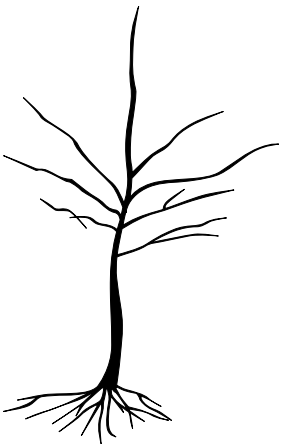
The seedlings of crab apple or of commercial cultivars and stooled plants of clonal varieties of year old are used as rootstock. Several types of clonal rootstocks are available which can be used for tree size control. The clonal rootstocks of Malling–Merton series are resistant to woolly aphid. Similarly, resistant rootstocks are also available for Collar Rot disease. In India, at present, the seedlings of crab apples or of commercial cultivars are used as rootstock for standard planting. Among the clonal rootstocks the M-106, M-111 and Merten-793 are recommended. The whip grafting is done in Feb-March about one month prior to bud break. These grafted plants are ready to be planted in the orchard during the next winter season. Budding is done in May-June and also in September-October.

In the high density planting, the role of clonal rootstocks is immense. The dwarfing rootstocks that are commercially available to fit this niche are M.9, Bud.9 and M.26.No perfect rootstock exists, and the limitations and strengths of each rootstock must be evaluated to select the rootstock that performs best in a specific situation. These rootstocks develop dwarf statured stions and also make the scion precocious. Malling 9 produces stions 1/3rd to 1/4th of the size of standard stions. It is very precocious and very productive rootstock. It has, however, brittle roots which break easily, hence anchorage is poor. This rootstock is tolerant to collar rot and does well on heavier soils where drainage is adequate. Many virus free M.9 sub-clones have been developed by heat treatment. More vigorous strains of M.9 are the Pajam 2 and RN29. The rootstock M.26 is more vigorous than M.9 and, therefore, a popular choice for re-plant sites. M.26 does well on slightly heavier textured soils if drainage is adequate. While moderately resistant to Collar Rot, it ,however, does not perform well on poorly drained soils. M.26 may be more suitable for cultivars such as Fuji, where M.9 is too weak. Bud.9 is one of the hardy Budagovsky rootstock series. It displays dwarfing similar to M.9, but is more winter hardy. It has greater resistance to Collar Rot than M.9. The P.2 is a Polish rootstock with

similar precocity and yield potential of M.9. Its winter hardiness is similar to B.9. It is resistant to Collar Rot and does not produce root suckers. Rootstock like Bud-9, Pajam-2 and RN-29 are in use in other countries and need testing in India before they are recommended on commercial scale.

Apple seeds require stratification for germination. Stratification is done by keeping seeds in moist sand either in open or in refrigerator during December to February for 2-3 months at 2 to 5°C temperature. At higher elevations (at or > 2100 metre above msl), direct sowing of seeds in the field under mulch in November is practiced which germinate naturally in early summer.

The rootstock plants should be about 80-100 cm in length and 1 to 1.25 cm thickness of the basal 1/3 rd length of the plant. Plants having more thickness, if used for graftage, success is poor. The weak plants, on the other side, are allowed to grow further and can be used for budding in May-June or Sept.-Oct.



A well feathered apple plant in the nursery

The seedling plants initially are free from viruses while plants of clonal rootstocks may have viruses, hence to ensure that these have no viruses, these should pass through tests before using them as rootstock. Similarly, the mother plants to be used for scion-wood should be true to type, productive having no viruses.

Stooling or mound layering is used for multiplication of clonal rootstocks. The young vigorous mother plants are first established for at least one year. These are planted in 20-30 cm. deep trenches at a distance of 1 metre. During the first growing season these trenches are filled-in 2 to 3 splits with the soil mixture consisting of 2 parts soil, one part each of sand and well decomposed FYM . These mother plants, once established, with proper care regularly produce new shoots for about 15 years. Every year during winter or about a month prior to start of main flush of growth, mother plants are cut down to a stump only about 8-10 cm high. This stump sends out vigorous shoots which are gradually earthed up during the growing season with soil, starting when these are about 12-15cm high, working the soil well in among the shoots. Repeat this earthing up when the shoots have made another 12-15 cm or so of growth, completing the operation within 3 to 5 months duration. When the growth has ceased during winter, fork away the soil out off the rooted shoots as close as possible to the original stump which is left exposed for few month to sprout again, thus restarting the cycle . Every year, thus rooted shoots are obtained from the

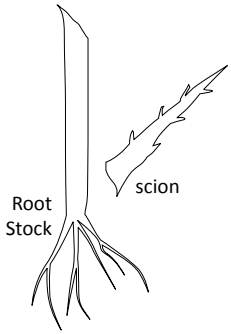
mother plants. These rooted shoots are either used immediately for grafting or planted in the nursery for budding purposes.

At high altitude (>2400 metre above msl) the growing period is short, hence establishment of nurseries in open is not economical as the desired growth needed is not available in one season both in rootstock and in stion. It is advised to have nurseries in polyhouses where the plants shall get longer growing period with optimum temperature for growth.

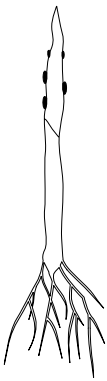
Tongue Grafting

Rootstock plant of one year age

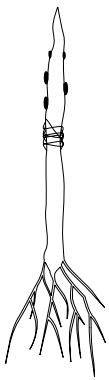
scion shoot from last year growth



Rootstock is cut, keeping 15-20 cm length. To the scion shoot similar type of slanting cut is given. On both the cut surfaces the tongue shaped cut are given



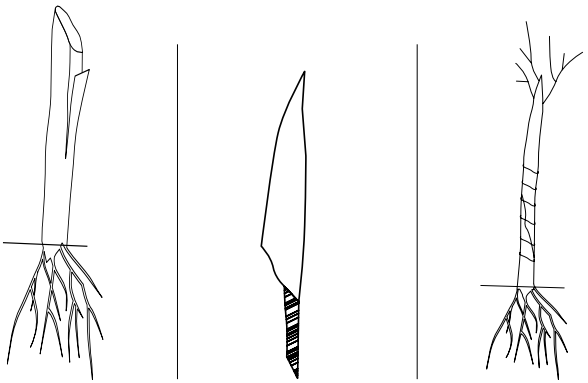
Joining of rootstock and scion shoot at cut surfaces through their tongues



Tying to Joining portions with polythene sheet for union to takes place.

The grafted plant after one year growth in nursery

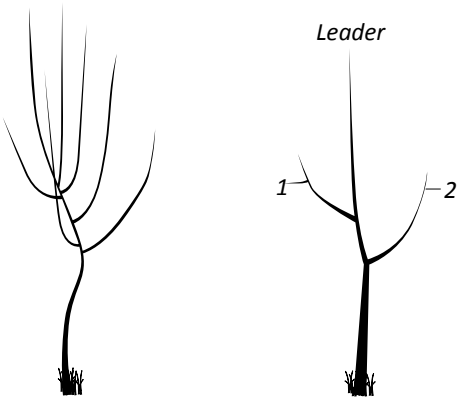
Cleft Grafting



Rootstock *Scion* *Stion*

Selection of quality grafts for planting

Special care must be taken while buying plant. Quality should be given first preference over cost of plant as success of all efforts will depend on them. Grafts should be procured from good nursery which gives guarantee of variety and rootstock authenticity. Well developed plants with 60-100cm height having 3-4 branches and main stem thickness about 17-25mm should be preferred.



Nursery Plant ready for sale

Nursery plant after pruning before planting

7. ORCHARD ESTABLISHMENT

In case the fields have < 45 degree slope, it is advisable to make terraces of about 2 to 3 metre width and of convenient length with inward slope to protect them from erosion. The contour planting is preferred in fields having > 45 degree slope.

The rectangular planting system is followed wherein the distance between rows is kept more than that between plants. When seedlings or vigorous clonal rootstocks are used as rootstock and the scion cultivars are spur types, a 6 x 6 metre distance is recommended under normal soil conditions. When soils are less fertile and shallow, it may be reduced to 5 x 5 m.

Pits are dug 1 m. diameter and 1 m. depth. While digging the pits, the soil of upper half is placed at one side and of the lower half on another side. The pits should remain open during rainy season. These are appropriately filled during Sept-Oct using top soil along with 40-50 Kg well decomposed farm yard manure and 3 kg superphosphate with insecticide to control grubs etc. During filling of the pits, proper compression of the mixture is required and about 25-30 cm top portion of the pit may preferably be filled with the surface soil. The filling should be done upto 15-20 cm above the ground level. Prior to pit digging and also prior to planting, use of planting board is recommended to have plants at the right distance.

High Density Planting of Apple

Now a days most of the apple growing countries are using high density planting (HDP) system. In HDP row to row distance is 3-5 metre and plants in a row are spaced 1.5 to 2.0 metre. Thus 1000 to 2222 trees are accommodated in a hectare. Initially trees are supported with poles and trees are trained in slender spindle or vertical axis or trellis. In high density plantation system orchard start giving commercial yield in 3-4 years after planting and commercial life of orchard is considered to be 20 - 25 years. Table below has some examples of spacing with production capacity.

Planting distance (m)	Number of Plants (ha)	Production Capacity (T/ha)
4.0 x 3.0	333	30 - 45
4.0 x 2.0	1250	35 - 45
3.0 x 2.0	1666	35 - 50
3.0 x 1.5	2222	40 - 60

Advantages of High Density

a. Early commercial yield from third or fourth year onwards.

b. High yield per unit area, 25-30t/ha as compared to 10-12 t/ha in conventional planting.

c. Less pruning requirement in bearing orchards due to heavy bearing and tree architecture.

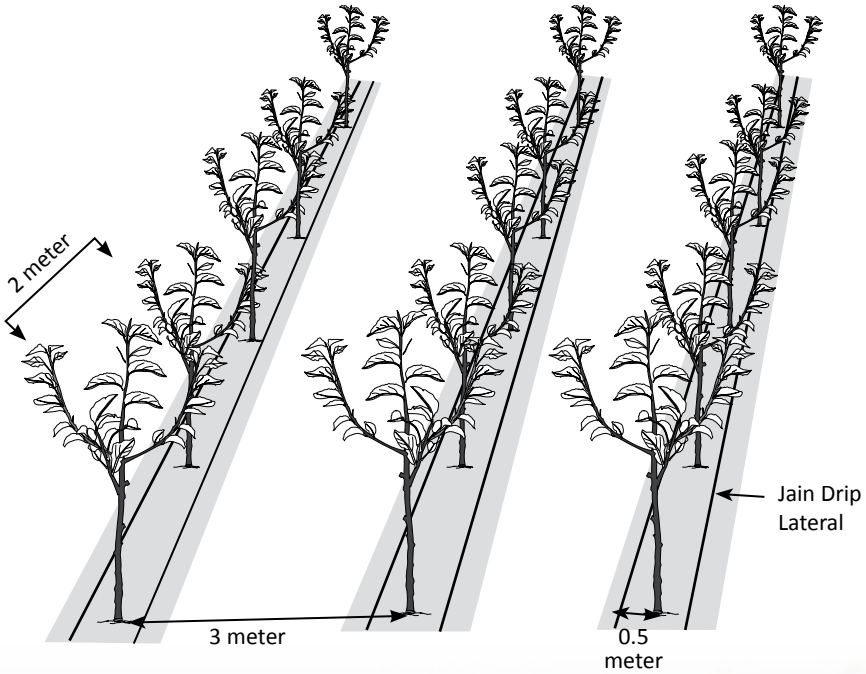
d. Easy pruning operation.

e. Uniform and high quality fruits.

f. Easy spraying, interculture and orchard management.

In high density plantings, trees are maintained 2.5 to 3 metre tall. The row to row distance is kept between 3 to 5 metre while trees within the row are planted at 1.5 to 2 metre distance . The root system , being very restricted, hence the pits are dug having 50-60 cm dimetria and 70-80 cm depth. The pits can be dug using big sized augers. The pits being small have almost half the quantities of FYM, super-phosphate, and chloropyriphos as that of the pits dug for widely spaced planting.

High Density Planting of Apple.
Plant to Plant Spacing 3 x 2 metre



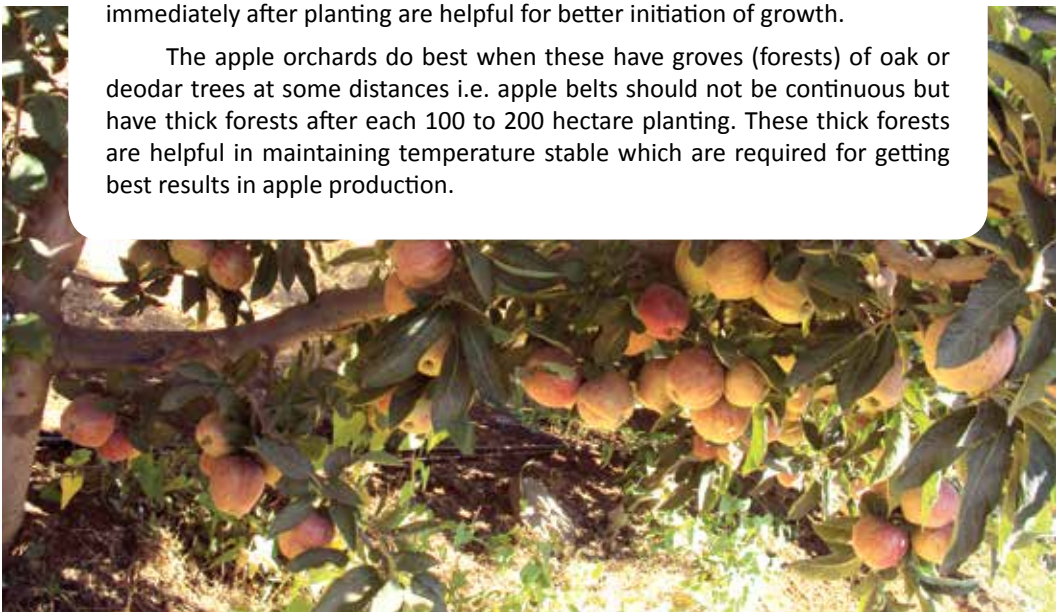
Well feathered two year old nursery plants are the ideal form that should be purchased where possible. These are better able to maximize canopy growth in the first two years of orchard establishment. The graft /bud union should be 8-10 cm above the ground after settling of soil occurs, and branches should not be closer than 60-70 cm to ground level. Branches should be well spaced up the main trunk, and the leader and side branches should be intact and not damaged. Ensure that there is sufficient root volume on each plant and these roots are healthy and free of root diseases.

In case the grafts are of one year age, the technique of bagging of the leader helps in the creation of laterals.

Planting is done from December to March. The roots are liable to injury from low temperatures; hence the plants are uprooted from the nursery as soon as possible after the leaf fall. The roots are covered with wet sphagnum moss and are further tightened with a sheet made up of jute. These are then sent to the desired destinations. On arrival at the respective places, these are put in shallow trenches and the roots are covered with soil where regular watering is practiced till their planting in the orchard.

In areas where the temperature during winter is around 0°C planting is completed by January. In winter the soil temperature remains few degrees above the air temperature, hence there will be growth of roots, though non-significant. This helps to nourish the plants on resumption of growth in the spring season. In areas where the temperature falls several degrees below 0°C, the best time for planting is March/ April. Watering and thick mulching immediately after planting are helpful for better initiation of growth.

The apple orchards do best when these have groves (forests) of oak or deodar trees at some distances i.e. apple belts should not be continuous but have thick forests after each 100 to 200 hectare planting. These thick forests are helpful in maintaining temperature stable which are required for getting best results in apple production.



8. SOIL MANAGEMENT

In standard planting where the trees are widely open, during early age when plants are young, there is plenty of vacant space available. This space can be used for growing of short duration crops particularly legumes and other vegetables. Hence there is regular cultivation of the orchard land initially for 5-6 years till the trees become large and the area is occupied by them. This regular cultivation facilitates the nitrification process hence better vegetative growth of trees is expected. In apple, fruits are borne on spurs which are formed on two year or older wood, therefore, once the trees have started fruiting, less vegetative growth is required which can be manipulated under semi-sod system of orchard soil management. In semi-sod system, the basin area of each tree is hoed and kept clean. Over rest of the area, natural grasses are allowed to grow but their growth is kept under control by mowing or cutting. Instead of natural grasses, cover crops can also be sown.

In high density planting, the trees are closely planted hence the area allotted is occupied within 3-4 year period and there is no scope for growing of short duration crops as intercrops. Cultivating to loosen soil around the base of the trees will promote growth. This cultivation should be at regular intervals before weed and grass competition gets well established. It should be shallow in depth so tree roots are not disturbed. It should be discontinued in July to avoid stimulating late tree growth that may be susceptible to winter injury. Weak weed growth under the trees by late summer can help trees harden off, and reduce soil erosion.

Soil fumigation, weed management & mulching

In many cases, tree growth of new orchards planted on old orchard land can be improved significantly with soil fumigation. Ideally, growers should conduct a bioassay before replanting an orchard site to assess the severity of replant problem and determine the value of soil fumigation. Growing a bio-fumigant crop such as *Brassicas* or mustard and ploughing in the soil to release

the active isothiocyanate compounds to fumigate the soil. Another method is to keep the site fallow for few years, adding organic matter either as composts or green manure crops or adding DAP fertilizers. Although these will improve the soil, they have not been proven to be as effective as fumigants or biofumigants in controlling replant disease pests and pathogens. Preferably apple orchard should not be established again on the same site from where the old apple orchard has been uprooted. It would be proper if other temperate fruits like plum or walnut be planted in cycles.

Weed competition can drastically reduce tree growth during the first few years and can cause a failure of the orchard to fill its allotted space which always results in diminished yield and profitability. Good weed control during the first 3-4 months of a growing season is the most critical period of the season. In later summer months if weed control is poorer it is not detrimental to the trees.

Placing a thick layer of dry grass or forest leaves on the soil basin of a tree is called mulching. For apple tree, the best time of putting mulch is from second fortnight of March to first fortnight of April after the snow has fully melted and the soil has become workable. After mixing of nitrogenous and potassic fertilizers into the soil, the area upto the tree spread is mulched with grasses/ leaves with 10-15 cm thick layer. It will help in conserving moisture significantly and also function as buffer for keeping the temperature of soil at normal levels. On rotting , it will add humus to the soil.

9. IRRIGATION AND FERTIGATION

Due to low frequency and uncertainty conditions of snowfalls and rains, the availability of water has become inadequate for normal growth and fruiting. Due to rainfed conditions or improper conventional irrigation practices, apple yield is affected greatly. Due to tough competition from imported apples in Indian market as well as competition and stringent quality expectation in export market, there is a great need of adoption of advanced irrigation and fertigation techniques.

What is drip irrigation ?

Drip Irrigation is the method of application of water and fertilizers directly near the root zone at frequent intervals and at low application rate so as to maintain proper air-water balance within the root zone of the crop. It is the pressurised irrigation system, water reaches to the farthest end under pressure and gives equal volume of water within the field area.

Characteristics of drip irrigation:

1. Water is applied at a low rate to maintain optimum air-water balance within the root zone.
2. Water is applied over a long period of time.
3. Water is applied to the plant and not to the land.
4. Water is applied at frequent intervals.
5. Water is applied via a low pressure delivery system

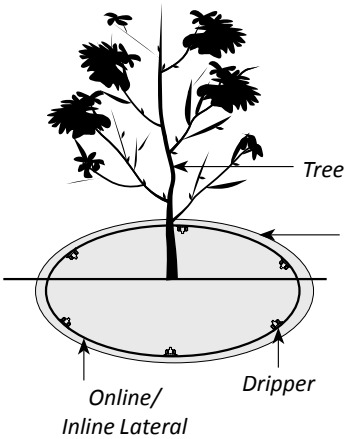
On resumption of growth after winter dormancy, apple trees should start getting irrigation. The flowering starts when the trees attain 4-5 years age. Drip Irrigation should commence two weeks after petal fall and continue till October. In case the water availability is limited, it should be used judiciously at critical stages of water requirement i.e., at (i) 20-25 days prior to flowering (ii) 1-2 weeks after petal fall (iii) 4-5 weeks after petal fall, and (iv) 3-4 weeks prior to fruit maturity. In such conditions drip irrigation plays vital role.

Advantages of drip irrigation system in apple

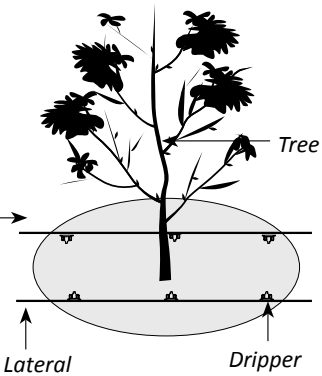
- With use of drip irrigation overall yield and quality of apple increases.
- During the prolonged gap of rainfall, drip irrigation is useful to avoid water stress, this timely survival irrigation also help to increase the yield.
- Drip irrigation promotes early maturity. Early harvest fetches higher price in the market and improves profitability.
- Drip irrigation increases the vegetative growth i.e., tree girth, tree height, shoot extension growth, tree spread, tree volume and leaf area.
- Drip irrigated apple exhibits higher flowering intensity and fruit set.
- With drip irrigation incidence of fruit drop reduces.
- Minimised fertilizer/nutrient loss due to localized application and reduced leaching.
- It is observed that use of drip irrigation accelerates assimilation and stimulates the formation of anthocyanin, which is responsible for red colour development.
- High water application efficiency. In hilly and undulating terrain, specially designed drippers can provide uniform discharge for change in static head.
- Reduction in manpower requirement. Operation of drip irrigation system involves least manpower.
- Energy saving. In hilly areas where sufficient elevation head is available, drip irrigation can be operated on gravity pressure without electricity.
- Control over weed growth, reduction in weedicide expenses and labour expenses.
- Improved disease control.
- Minimised soil erosion.

Layout of Drip Irrigation System

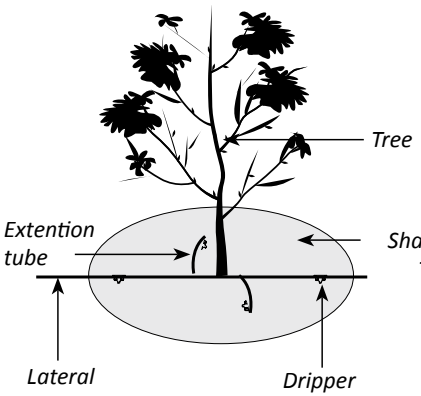
Loop Drip Irrigation



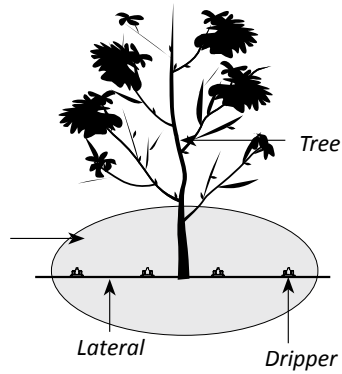
parallel Drip Irrigation



Online and Extenstion tube Drip Irrigation



For High Density Planting Drip Irrigation System



In water scarce areas for the purpose of drip irrigation, water can be stored in poly lined tanks from the water sources such as roof water harvesting, natural water springs, tube wells or by lifting water from rivers. If water is available near orchard from river, canals, etc., irrigation system can be directly connected from there. In cold regions, losses due to evaporation and transpiration are comparatively less as compared to warmer areas. The irrigation to plots can be designed accordingly during rainy season, if there is no rain for several days, irrigation has to be provided. On the basis of tree age, the approximate water requirement has been given in Table 4.

Table -4 (a): Approximate daily water requirement of apple trees under drip irrigation system. (Planting Distance 6x6 metre)

Age of tree (Year)	**Approximate daily water requirement in different months** (Litre/tree)*					
	April	May	June	July	August	September
1	1.0	1.5	3.0	4.0	4.0	3.0
2	2.5	5.0	10.0	13.0	14.5	11.0
3	3.0	6.0	12.5	17.0	19.0	14.0
4	6.5	13.0	26.0	35.0	38.0	29.0
5	10.0	20.0	40.0	55.0	60.0	45.0
6 and thereafter	14.5	29.0	58.0	79.0	86.0	65.0

Table 4 (b) : Approximate daily water requirement of apple trees under drip irrigation system. (Planting Distance 4 x 2.5 metre)

Age of tree (Year)	**Approximate daily water requirement in different months** (Litre/tree)*					
	April	May	June	July	August	September
1	1.0	1.5	3.0	4.0	4.0	3.0
2	2.5	5.0	10.0	13.0	14.5	11.0
3	3.0	6.0	12.5	17.0	19.0	14.0
4 & thereafter	6.5	13.0	26.0	35.0	38.0	29.0

- These values are for true temperate climate where winters are severe and are experiencing regular snowfalls. In summers, rains are scanty and precipitation is confined to few centimeters only.
- Area specific refinements are only possible through experiences or by using location specific climatic data and considering soil type. For intercrops like potato, french bean, tomato, cauliflower, cabbage etc., additional quantities of water will be required which can be estimated for each of these crops.

Online and inline system can be used for apple. It can be installed in loop type or using extension tubes.

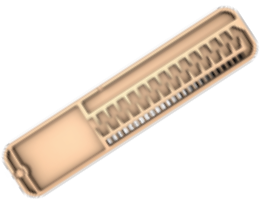
If the field is fairly flat (slope less than 2%), non pressure compensating dripper can be used. For slopes more than 2% or undulating terrain we have to use pressure compensating emitter. Following are the various options of drippers available,

Inline Emitter

There are several choices you have for selection of inline emitters,

1. Jain Turbo Excel®

- Available discharge rates - 0.85, 1.2, 1.6, 2.1, 4 lph @ 1kg/cm².
- 12, 16, 20, 25 mm nominal diameter.
- Dripper Spacing 15, 20, 30, 40, 50, 60, 75,90 cms.
- Suitable for surface as well as subsurface installations.
- Can be used for loop system



Jain Turbo Excel®

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2. Jain Turbo Line® Super

- Available discharge rates (at 1kg/cm²)

  12mm - 2.2, 4 lph

  16mm - 4, 8 lph

  20mm - 2.2, 4, 8 lph
- Availabe in 12, 16 & 20 mm nominal diameter.
- Suitable for surface as well as subsurface installations.
- Can be used for loop system

Jain Turbo Line® Super

3. Jain Turbo Top

- Available discharge rates – 1 & 1.6 lph
- Injection moulded silicone rubber compensates with pressure and discharge gives uniform performance.
- Anti Syphone feature (optional) prevents suction of sand and silt particles inside the dripper.
- Cascade labyrinth gives strong, self-cleaning turbulence.
- Available in 16 & 20mm nominal diametre.
- Suitable for surface as well as subsurface installations.
- Can be used for loop system

Jain Turbo Top

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4. Turboline PC

- Available discharge rates - 1.3, 1.6, 2.6, 4 & 4.5 lph at 1 kg/cm² Pressure.
- Injection moulded silicone rubber compensates with pressure and discharge gives uniform performance
- Application on the undulating land/ Terrains/ Steep slopes.
- Applicatiion where ever longer lateral length is necessary.
- Available in 16 & 20 mm nominal diametre.
- Suitable for surface as well as subsurface installation.
- Can be used for loop system

Turboline PC

Online Emiter

In online emitters, drippers are punched on to the tubing.

1. J-Turbo Key Plus

- Available discharge rates - 2,4, 8 and 14 lph at 1 kg/cm².
- Turbulent flow path with wide cross sectional area makes the dripper clog resistant.
- Narrow cross shaped inlet acts as a filter.
- Openable dripper - easy to clean.
- Extended outlet facilitates use of polyethylene extension tube, vinyl tube with multioutlet connector arrangement.

J-Turbo Key Plus

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2. J-SC PC Emitter

- Available discharge rates - 2,4 and 8 lph for the pressure compensating range of 0.8 to 3 kg/cm².
- Self cleaning design ensures flushing at start up, shut down & during operation.
- Hydraulically designed turbulent flow path emitter with wide cross sectional area and precision inlet filter that makes it a truly clog resistant'.
- Silicone rubber diaphragm ensures consistent performance for longer period.
- Application on the undulating land/ Terrains/ Steep slopes.
- Applicatiion where ever longer lateral length is necessary.
- Protected cross-shaped water inlet.
- Optional Anti-bug cap- prevents entrance of ants/bugs into the dripper.

J-SC PC Emitter

3. Click Tiff - HD

Click Tiff

- Available discharge rates - 2,3,4, 8 and 12 lph for the pressure compensating range of 0.5 to 4 kg/cm².
- Strong turbulent flow in labyrinth with continual cleaning and flushing makes emitter a truly clog resistant.
- Silicone rubber diaphragm ensures consistent performance for longer period.
- Application on the undulating land/ Terrains/ Steep slopes.
- Applicatiion whereever longer lateral length is necessary.
- Protected cross-shaped water inlet.
- Can also be in PC (Pressure Compensation) & PCNL (Pressure Compensating Non Leakage) arrangement.
- Optional Anti-bug cap- prevents entrance of ants/bugs into the dripper.

Apart from these drippers, micro sprinklers can also be used for irrigation of apple. Micro sprinklers can be installed above the tree as overhead micro sprinklers or underneath the tree. Where frost protection is necessary, micro sprinkler can be a better choice. It serves the purpose of irrigation, evaporative cooling and frost protection. Choices available with micro sprinklers are,

1. Aqua Master

Aqua Master

- Innovative structure for improved durability, performance and insect protection.
- Unique water spreader for optimum distribution, maximum range and fine droplets.
- Can be used for under tree irrigation system or overhead above the apple tree if to be used for frost protection and irrigation.
- Uniform precipitation rate between 2 to 8 mm/hr.
- Uniform coverage over a wide range of spacing, flow rates and pressures.
- Special arrangement for rod attachment.
- Wide flow range 100 to 260 lph at an operating pressure of 1.5 kg/cm².
- Radius of throw from 4 m to 6 m.

2. 501-U

- Special turbo hammer arrangement for uniform distribution.
- Can be used for under tree irrigation system or overhead above the apple tree if to be used for frost protection and irrigation.
- Uniform precipitation rate between 1.5 to 7 mm/hr.
- Wide flow range, 100 to 170 lph at an operating pressure of 1.5 kg/cm².
- Fine water droplets for delicate crops.

501-U

Apart from these Micro Sprinklers larger overhead Sprinkler like 233 B AF- Lal Topi can also be used for Irrigation and Frost protection purpose. For details please see Frost Protection Chapter.

In high density, all super dwarf and semi dwarf clonal rootstock have a limited root volume, most of the roots that feed are located in the top 30 cm of soil profile. The M.9 rootstock is much less tolerant to dry soils than the vigorous rootstocks like MM-111 or apple seedlings. Further, large highly feathered trees produce much more leaf area shortly after planting than un-feathered trees which creates a high water demand before the root system can re-grow sufficiently to support the trees. Frequent and early drip irrigation can help these trees produce good growth in the first year. Hence, it is recommended that growers should install drip irrigation system soon after planting to prevent water stress and maximize initial years tree growth.

Soil that have adequate moisture available throughout the growing season are likely to establish better trees, grow more fruit bearing shoots, initiate more and healthier fruit buds and produce larger, better keeping quality apples. Each mature apple tree on fully dwarfing rootstock may require 25-35 litres of water per day in May, June, July and August when applied with a drip irrigation system. Irrigation can influence the individual sizes of fruit in the orchard, and have a positive effect on the following year crop. A tree experiences stress of available moisture long before its leaves wilt. The ideal situation is to have a continual supply available all through the season so growth is not interrupted and the tree is not stressed. A level of 40-50 per cent

available soil moisture(A.S.M) is considered adequate for all soil types. With drip irrigation system the A.S.M under the emitters is maintained at 85-90 per cent. The A.S.M. can be determined by feel. Fine textured soils (silt and clay loams), which can be cupped in the hand and gently squeezed and moulded into the ball that holds together, probably contains upto 50 per cent A.S.M. A ball which is somewhat crumbly, although holds together with pressure, may contain only 30 to 40 per cent A.S.M. or less.

Frequent low doses of nitrogenous fertilizer delivered at least twice weekly through the drip system for the first 12 weeks of resuming growth will greatly improve tree growth during the first 2 years to speed development of the canopy. With high tree densities as with the Slender Spindle system and highly feathered trees, almost no lateral tree growth is required and only vertical extension growth is needed. Adoption of immediate fertigation of highly feathered trees will considerably improve tree growth and vastly improve yield potential during the initial years of orchard establishment. For moderate densities, trees must be grown vigorously for several years to fill the allotted space with canopy and relatively high nitrogen fertilization is desirable for 2-3 years after planting. However, excessive N fertilization can cause too much growth which results into delayed flowering, reduced yields, poor fruit quality and greater pruning.

After the development of canopy, the mature trees should be fed with low nitrogen fertilization to keep the trees “calm” with a balance between vegetative growth and fruiting. The soils which are rich in organic matter or have complex proteinacious substances in them produce 30 to 60 kg/ hectare of nitrogen annually through nitrification. This is almost half of the total amount needed by mature high density orchards. The 1/3rd of N requirement is given in April as active root growth starts before any obvious bud development in the tree canopy. The remaining 2/3rd of the N requirement is applied in equal amounts with subsequent irrigation in May and June, but not thereafter. Termination of N application in June is required to slow vegetative growth and promote hardening off for winter. Calcium nitrate is the preferred N source for fertigation of fruit trees because soil acidification occurs more slowly. The K is injected in equal amounts with each irrigation in July and August. The delayed application of K relative to N is to enhance fruit colour, winter hardiness , tree growth and disease resistance during the latter half of the growing season The drip lines must be flushed immediately after each fertigation to prevent plugging of the emitters.

Jain Fertigation Equipment

There are various equipment which can be used for fertilizer injection through drip irrigation system.

1. Fertilizer Tank

- Metalic powder coated tank operates on differential pressure.
- Operates even at low differential pressure.
- Available 30,60,90, 120 & 160 liters capacity.

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2. Venturi Injector

- Simple easy to use device.
- Available in ¾, 1, 1¼, 1½ & 2" BSP connection.
- Suction rate 40 lph to 1400 lph.
- Excellent chemical resistance to most of the chemical.

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3. Injector Pump

- Hydraulically operated pump, no electricity required.
- Can be used a precision injection of fertilizer.
- Low pressure loss.
- Suction rate from 50 lph to 150 lph.

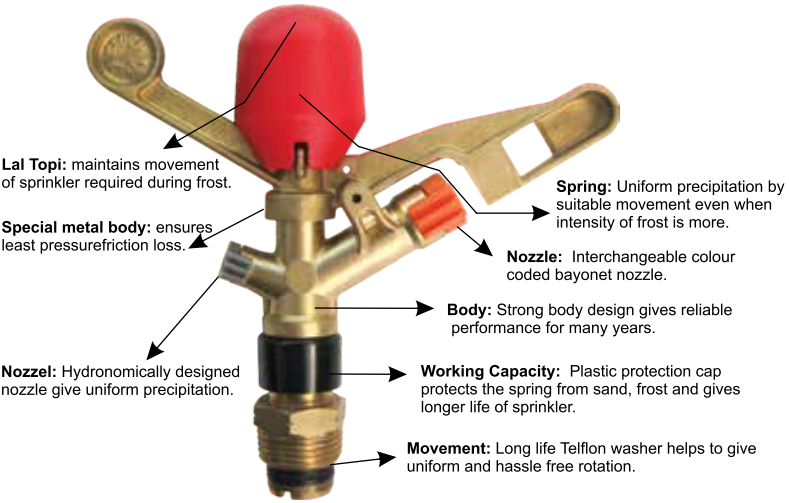
Jain Integrated Automation Systems

Automation of an irrigation system refers to operation of the system with no or minium manual intervention. The introduction of automation in irrigation system has increased application efficiency and drastically reduced labour requirment.

Advantages of Aumation Systems

- Conservation of Water and labour : Since the systems are automatic, they do not require operator.
- Systems & Operational flexibility : As desired, any valve can be controlled along with the pump.
- Increased efficiency of water and fertilizer use.
- Systems can be operated at night.
- Saving in energy, cost and water.

233 B AF - Lal Topi Sprinkler
Irrigation as also Frost Protection



Lal Topi Sprinkler - 233-B AF

- Superior technology from the world leader in sprinklers – NandanJain Irrigation.
- Sprinklers body manufactured with special metal ensures smooth inner surface. This reduce pressure friction loss compared to traditional sprinklers.
- Specially designed for frost protection. The top lal topi completely seals and protects the sprinkler from frost damage.
- In case of heavy frost fast, moving of sprinkled water removes frozen snow from the surface of plants.
- Does not allow temperature near plants to go below 0°C due to which frost does not settle on the crops and this way these are saved from frost damage.
- This is installed for irrigation and frost protection in apple, pear, walnut, cherry, litchi, almond, peach, plum, mango, kinnow mandarin and other fruits also.
- Lal topi sprinkler is capable for irrigation and frost protection in vegetable, medicinal and other crops.

Necessary for frost protection

- Suitable, movable speed of sprinkler
- Water distribution in suitable quantity
- Uniform precipitation rate

Jain Sprinklers More Crop Per Drop | NAANDANJAIN Irrigation

Principles of frost protection by Red Cap Sprinkler

- If snow and water is mixed below freezing point, temperature does not go below 0° C. until and unless whole water is freezed.
- Crops are not affected adversely from frost if temperature is lower than freezing point because for freezing of plant protoplasm the temperature should be below 0 degree c.

Nutrient requirement and fertigation schedule for standard planting

Age (in Yrs)	Nutrient Requirement / Plant								Fertigation schedule and quantities of chemicals /plant/dose								
	Period	N (g)	P (g)	K (g)	Ca (mg)	Mg (mg)	Zn,Fe, Cu,Mn (each) (mg)	B, Mo, each (mg)	No.of doses (1 in a week)	Urea (g)	Phosphoric Acid(ml)	Murate of Potash (g)	CaNO3 (mg)	MgSO4 (mg)	Zn, Fe, Cu,Mn (Sulph). (mg)	Boric Acid (mg)	Ammonium molybdate (mg)
1	March-August	60	60	60	300	250	200	200	24	5.4	2.7	4.2	62	52	42	50	16
2	March-August	120	120	120	300	250	500	200	24	10.9	5.4	8.3	62	52	105	50	16
3	March-August	180	180	180	500	500	500	500	24	16.3	8.1	12.5	104	104	105	125	40
4	March-August	240	240	240	2000	2000	1000	1000	24	21.7	10.8	16.7	416	416	210	250	80
5	March-August	300	300	300	4000	4000	2500	2500	24	27.2	13.5	20.8	832	832	525	625	200
6	April	120	216	0	0	2000	1700	800	4	65.2	60	0	0	2500	2125	1176	385
	May-June	240	144	120	0	0	0	0	8	65.2	20	25	0	0	0	0	0
	July-August	0	0	240	6000	4000	3300	1700	8	0	0	50	3750	2500	2063	1250	408
7	April	140	252	0	0	3330	1700	800	4	76.1	70	0	0	4162	2125	1176	385
	May-June	280	168	140	0	0	0	0	8	76.1	23	29.2	0	0	0	0	0
	July-August	0	0	280	10000	6670	3300	1700	8	0	0	58.3	6250	4168	2063	1250	408
8th and on-wards	April	160	288	0	0	3330	1700	800	4	87	80	0	0	4162	2125	1176	385
	May-June	320	192	160	0	0	0	0	8	87	27	33.3	0	0	0	0	0
	July-August	0	0	320	10000	6670	3300	1700	8	0	0	66.7	6250	4168	2063	1250	408

Note: 1. *Fertilizer schedule needs to be adjusted as per crop growth stages as months may vary with locations. April refers to before flowering and leafing stage, May-June refers to fruit growth and July-Aug. refers to fruit enlargement stage.*

2. *In place of Phosphoric acid, the mono-ammonium phosphate (MAP) can be used. Alternatively SSP or DAP can be applied in soil during Dec -Jan.*

Nutrient requirement and fertigation schedule for high density planting

Age (in Yrs)	Nutrient Requirement / Plant								Fertigation schedule and quantities of chemicals /plant/dose								
	Period	N (g)	P (g)	K (g)	Ca (mg)	Mg (mg)	Zn,Fe, Cu,Mn (each) (mg)	B, Mo, each (mg)	No.of doses (1 in a week)	Urea (g)	Phosphoric Acid(ml)	Murate of Potash (g)	CaNO3 (mg)	$MgSO_4$ (mg)	Zn, Fe, Cu Mn (Sulph). (mg)	Boric Acid (mg)	Ammonium molybdate (mg)
1	March-August	30	30	30	200	200	100	100	24	2.7	1.4	2.1	42	42	21	25	8
2	March-August	60	60	60	200	200	300	100	24	5.4	2.8	4.2	42	42	63	25	8
3	March-August	90	90	90	300	300	300	300	24	8.2	4.2	6.3	63	63	63	75	24
4	April	40	72	0	0	330	200	200	4	21.7	20	0	0	413	250	294	96
	May-June	80	48	40	0	0	0	0	8	21.7	6.6	8.3	0	0	0	0	0
	July-August	0	0	80	1000	670	300	300	8	0	0	16.7	625	419	180	220	72
5	April	50	90	0	0	670	400	400	4	27.2	25	0	0	838	500	588	192
	May-June	100	60	50	0	0	0	0	8	27.2	8.3	10.4	0	0	0	0	0
	July-August	0	0	100	2000	1330	800	800	8	0	0	20.8	1250	831	500	588	192
6	April	60	108	0	0	1000	800	400	4	32.6	30	0	0	1250	1000	588	192
	May-June	120	72	60	0	0	0	0	8	32.6	10	12.5	0	0	0	0	0
	July-August	0	0	120	3000	2000	1700	800	8	0	0	25	1875	1250	1063	588	192
7th & on-wards	April	70	126	0	0	1670	800	400	4	38	35	0	0	2088	1000	588	192
	May-June	140	84	70	0	0	0	0	8	38	11.6	14.6	0	0	0	0	0
	July-August	0	0	140	5000	3330	1700	800	8	0	0	29.2	3125	2080	1063	588	192

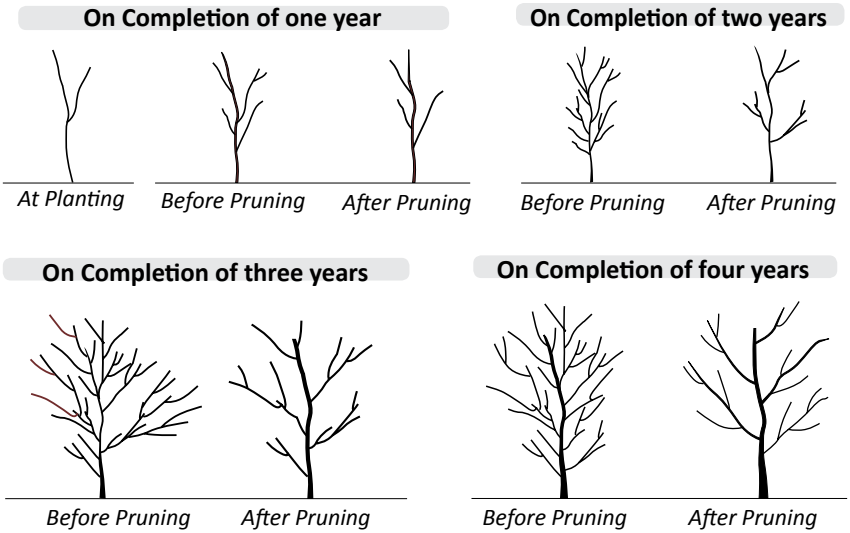
1. Fertilizer schedule needs to be adjusted as per crop growth stages as months may vary with locations. April refers to before flowering and leafing stage, May-June refers to fruit growth and July-Aug. refers to fruit enlargement stage.

2. In place of Phosphoric acid, the mono-ammonium phosphate (MAP) can be used. The alternatively SSP or DAP can be applied in soil during Dec -Jan.

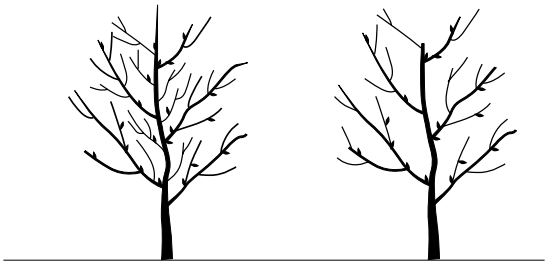
10. TRAINING AND PRUNING

Standard Planting

The widely spaced apple trees are trained to modified leader system. The shoot growing centrally is chosen as leader. The side shoots which are about 5-7 in number are selected over a period of 4-5 year. The first side shoot is retained at a height of 50-60 cm from the ground level, and thereafter, the difference between two adjoining branches should be in the range of 30-40 cm. The selected branches must have 45 to 60 degree angle to the leader shoot; secondly, these branches must have less vigorous growth than the leader branch; thirdly, these should be in different directions. On completion of selection of side branches, the growth of leader shoot is directed at 45° angle so as to modify it as a final and terminal side shoot. Over the years, the leader branch becomes trunk and side branches become scaffolds or limbs.



On Completion of five years



Before Pruning After Pruning

Pruning in bearing apple tree

Before Pruning *After Pruning*

Apple trees on vigorous rootstock start bearing fruit on attainment of about 4-5 years age. The objective of pruning of a bearing tree is to provide sunlight in the inner parts of a tree and lower the speed of vegetative growth. First of all, dried and diseased branches/portions are removed. Secondly, heading back of scaffold branches is performed upto strong laterals. Generally the heading back cuts on scaffold branches are made by removing top 2–4 side branches below upto a strong lateral. As one goes down, it invigorates to sprout the dormant buds further down on the scaffold. Hence, the severity of heading back cut is dependent on the requirement of vegetative growth during the following year. In this context the practical experience of the pruner is helpful to decide as to how deep should be the heading back. During pruning, the branches bearing old spurs and the branches which are weak and crowding are removed.

High Density Planting

Without putting if and buts, the ideal tree shape for close (high density) planting is a narrow cone. The tree will have a single trunk with fruiting units arranged evenly from 60-80 cm height to the top. There are three most common training systems as : (1) Slender Spindle (2) Vertical Axis and (3) Trellis.

1) Slender Spindle

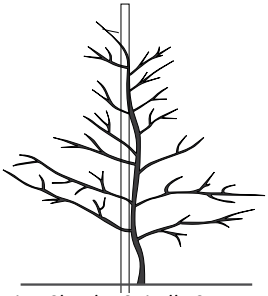


Fig.: Slender Spindle System

It consists of an individual support post at every tree . The post should be 2.5 to 3 metre in length and of pressure treated wood, concrete or metal to ensure it lasts the life of the orchard(Approx. 20-25 years) . A diameter of 5 to 6 cm is preferred. The depth of the post in the ground should be 60 to 90 cm for stability leaving rest of the portion above ground. The leader must be manipulated in some manner to ensure continuous branching. The main characteristics of this system are :

i) Height controlled at about 2.5 metre .

ii) Maximum width of tree spread is 2 metre.

iii) Lateral branches continuously along the central leader

iv) One or two permanent whorls of laterals can be established in the lower portion of the tree .

v) Leader management for profuse lateral branching is important to generate fruiting wood production and to increase the number of growing point to control vigour.

vi) Lateral shoot positioning is important to control vigour and encourage fruiting. This positioning is also necessary to stimulate secondary branching.

vii) Trees must have a permanent support system for the total height of the trees to attach the leader to every 40- 45 cm. This support holds trees stable in soil and supports the fruit load.

2) Vertical Axis

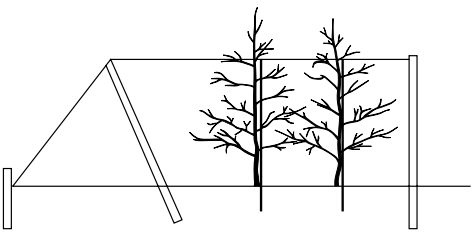


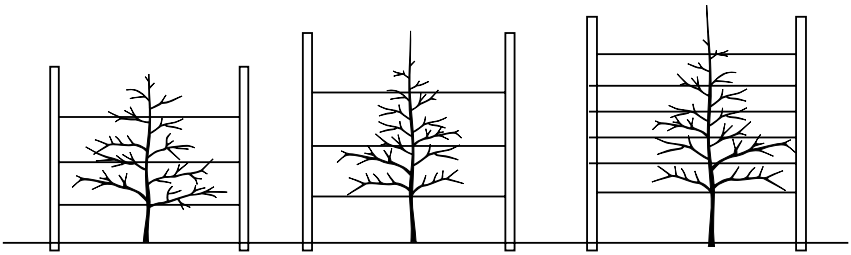
Fig.: Vertical Axis System

A strong un-headed leader is encouraged to grow until it reaches to about 3.5 to 4 metre from the ground i.e., the trees are taller than Slender Spindle system . This is the main feature that distinguishes it from Slender Spindle system. This central axis forms a short shaft around which lateral branches radiate to form a narrow cylinder of fruit bearing wood. The diameter of the branches should gradually decrease to the top of the tree, and these should always be smaller than the trunk where located. There should be lessening in the length of the laterals from the bottom to the top, this result in a slender conical shaped trees. The distance between

the branches should be less towards the top of the tree in order to allow for maximum light penetration.

This system basically consists of one or more high tensile steel wire (s) drawn tight and supported 2-3 metre above the ground by a series of in - line posts spaced 9 to 15 metre apart. The closer the spacing for the inline posts, the higher the degree of stability of the support system under strong wind or high crop load conditions. Individual trees in the row are supported by vertical leader supports that reach up to the top support wire.

3. Trellis



2 metre trellis *2.5 metre trellis* *3 metre trellis*

Fig : Trellis System

There is positioning of laterals along the supporting wires. The trees at planting are normally headed 15 cm above the bottom wire. Shoot growth is allowed to proceed un-manipulated until mid July. Upright shoots and water sprouts are removed during August to minimize re-growth and vigour. Completion of every layer is important in a Trellis system. Do not allow a strong leader to reach the top of the trellis too fast. Unlike the Vertical Axis there is no support alongside each individual tree. Instead, branches are trained horizontally along the wires.

The lowest two wires should be installed when trees are planted, to allow them to be supported immediately. Usually the first wire is 50-100 cm from the ground. From this point upwards the wires are required at 0.5 to 1 metre distance. Wires should be added as the trees grow. Placing wires on alternate sides of the tree trunks provide additional support. Tree trunks are attached to the wires either by flexible ties or staples.

In India, the apple orchards are planted/ being planted on slopy fields hence, Slender Spindle system is better suited over other two systems. In case of gentle slopes the Vertical Axis or Trellis can also be considered.

Under high density system pruning requirement is much lower once orchard comes under production than the conventional planting. Only light pruning is required to thin out water sprouts and some time renewal pruning for damaged branches to develop new ones.

Pruning

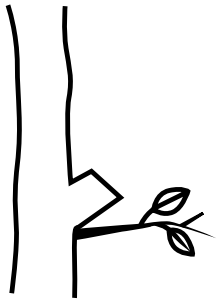


Fig : Renewal Pruning Cut (Angled or sloped cut)

The appropriate pruning approach is to annually remove 1-2 large upper branches completely during winter and develop younger replacement branches. The removal of entire branches in the upper portion of high density apple trees helps to open channels for light penetration which maintains fruit production and quality in the bottom of the canopy. This renewal pruning is the single most important pruning concept for mature high density orchards to contain the canopy and maintain a concrete shape. To assure the development of a replacement branch, the large branch should be removed with an angled or shaped cut so that a small stub of the lower portion of the branch remains. From this stub a flat weak replacement branch often grows. This type of pruning does not stimulate vigorous re-growth.

Once branches have become horizontal or hanging under the weight of crop, these can be shortened by heading back cuts without adverse effects since the terminal bud no longer exerts significant control over the branch, However, if the overall vigour of the mature tree remains high, leaving the hanging branches long will help increase cropping and reduce the vigour of the tree. After a number of years, if the hanging branches begin to shade the bottom half of the tree these should be removed with a renewal cut and a replacement branch developed.

Time of Pruning

Pruning can be started few days after the tree enters into dormancy and is completed at least one month prior to resumption of growth in Spring. In areas where the winter season is moderate, the pruning operations should be completed early in the season. It gives sufficient time for healing of wounds made during pruning. Contrary to this, in areas where the minimum temperatures remain several degrees below freezing point, the pruning should be delayed until the danger from severe cold is over because there are chances of drying of succulent branches due to severe cold. In other words, early pruning under extremely cold conditions can lead to severe losses to branches and fruiting wood. Late pruning under similar climatic conditions removes winter injured shoots before any further pruning is done. For example, in the areas like Kullu-Manali of Himachal Pradesh and Ramgarh-Mornaulla areas of Uttarakhand, pruning should be done in December-January while in areas like Lahaul-Spiti and Harsil, it may be delayed and preferably be done during March.

11. PROVISION OF POLLENIZERS AND POLLINATORS

Apple, because of being self- incompatible, needs cross pollination. To provide pollen to the main cultivar, a provision is made of the pollen donor cultivars i.e., pollenizers. These pollenizers must be compatible and should also have synchronization in flowering. For Delicious group of cultivars, Golden Delicious, Red Gold, Lord Lambourne and Tydeman's Early Worcester; and for spur cultivars, the Gala and Fuji are the good pollenizers, respectively. The number of these pollenizer plants may be 10-20 per cent of the main cultivars and should be well scattered over the orchard. In areas where the climate is not static during flowering, the number of pollenizers may be increased to 30 per cent. It will also be a good practice to have apple seedling plants on the boundaries of the orchard. These will serve dual purpose, one as wind break and another as pollenizer.

New research shows that Bumble Bees are more effective pollinator than honey bees as they are able to work under lower temperature (up to 10^0C) when honey bees don't work. Bumble bees are now available commercially.

The apple pollen being heavy are carried by honey bees from one flower to another flower. The foraging nature of honey bees is very peculiar. When these are placed in the orchard when there are no flowers, they will go to near by trees or forest area for foraging and shall continue to do so even when flowering in apple orchard has occurred. Looking to this nature of honey bees, it is recommended to place/ transfer honey bee hives in the orchard only when at least 25 per cent flowering has occurred in the orchard. They will remain inside the orchard for their food as it will be a new area for them. Three strong colonies of honey bees are required for the effective pollination of one hectare of an apple orchard.

In square or hexagonal systems of planting, the honeybee flights are zigzag and in one flight, a honey bee generally visits three adjoining trees. Hence, the planting plan should be made in such a way that out of three trees, there should at least be one tree of the pollenizer cultivar. In case of rectangular system, the honey bee flights are straight hence, after about 18-20 metre distance there should be a tree of pollenizer cultivar. Honey bees prefer the fragrance of flowers therefore, sprays of any chemical should be avoided during flowering.

12. USE OF GROWTH REGULATORS

To Control fruit drop: The fruit drops may occur as; (1)early drop due to unpollinated or unfertilized blossoms, (2) June drop due to either moisture stress or over load of fruits, and (3) pre-harvest drop.

The problem of fruit drops is more common in early maturing cultivars. Spraying of Naphthalene Acetic Acid (NAA) @ 10 mg/litre (Planofix is the commercial formulation of NAA of which 1 ml is dissolved in 4.5 litre water to achieve the required concentration) is most effective. The spray is done about a week before the expected drop.

To improve fruit set: There is a problem of normal fruit setting in climatically marginal areas. Formulations like Miraculan (0.75 ml/litre) or Paras or other similar compounds (0.6 ml/litre) or other similar compound or Biozyme/ Protozyme (2 ml/litre) can be sprayed twice at (a) pink bud stage, and (b) immediately after petal fall.

To improve surface colour and enhancement of maturity: Apple surface colour development is greatly hampered in areas where temperatures during summers are high. Similarly, at high altitudes, the maturity is comparatively late. Application of ethrel @ 2.5 ml/l if sprayed about 10-12 days prior to harvesting date greatly improves colour and also enhances maturity. The application of ethrel is recommended at the stage when maximum fruit size has been attained and about 30 % red colouration has developed. Planofix (1ml in 4.5 litres) should be added to ethrel to arrest the excessive fruit drop caused by ethrel. Further, ethrel treated fruits are not suitable for storage as they have poor shelf life.

In old orchards of standard planting system use of paclobutrazol is also helpful in improving fruiting and reducing alternate bearing.

13. FROST PROTECTION

When the temperature during night drops below 4°C the water particles in the air are crystallized and are deposited on plant parts and also on all the exposed surfaces. It is called White frost. When there is very low humidity in the air and temperature drops to below 4°C during night, the frost occurs without deposition of any ice particles. It is called Black frost.

The occurrence of frost is a common phenomenon in subtropical and temperate zones of the earth. The temperate zone fruit trees remain in deep dormancy from December to February or upto March (>2400 metre above msl in Himalayas). The temperate fruit trees are benefited from these frosts by getting chilling temperature and completing their chilling requirement. The harm from frosts to apple starts after their chilling requirement is met and when they are able to resume growth. In case the frosts occur during the period of bud swelling to petal fall, it is very harmful, and many a times crop failures occur significantly.

Several devices have been developed to protect the bloom from frost such as giving irrigation to the orchard few days before bud swell, mixing of warm air settled above at about 100 metre height from ground, putting electric / solar heater during mid night for few hours and putting of caps on individual plants of small stature. Giving irrigation prior to bud swell stage is helpful as the water on freezing releases latent heat which raises temperature up to few degrees of the microclimate.

The small stature plants can be protected from frost by putting caps over them in the evening and removing with the sunrise. The science here involve during day time plant body gets warm and in the night gets cool. In case it is covered with caps (inorganic or organic) in the evening the heat released by the plant body remains all around the plant which is capable to protect it from frost.

Easy and convenient method to protect plants from frost damage is to sprinkle water above the canopy during frost hours.

Principle of Overhead Sprinkler Frost Protection

The principle of this method based on three factors,

1. When water freezes its latent heat is released. This latent heat keeps the temperature of the plant from dropping below freezing point.
2. A mixture of ice and water exposed to below freezing point remains at 0 degree Celsius until all the water is frozen.
3. Plants do not suffer frost damage until the temperature drops slightly below 0° C because the freezing point of plants liquid is below that of water.

Continuous sprinkling of water above the canopy during the frost allows plant tissue to take specific heat from water to protect them self from falling temperature below critical limit and prevent nucleation of plant cell fluids.

Key considerations

Successful protection of crops from frost damage using sprinklers depends on two crucial factors:

A. The rotation speed of the sprinkler.

B. Rate and uniformity of water application.

A. The rotation speed of the sprinkler

Effective protection from frost damage relies on the continuous release of latent heat as the water freezes. If the rotational speed of the sprinkler is too low there will be enough time for complete freezing to take place before the sprinkler has a chance to apply more water to allow the heat release process to start again.

B. Rate of uniformity of water application

The volume of water in relation to area has been found to be one of the most important considerations when designing for frost protection. The application rate is calculated after considering factor such as air temperature, wind conditions, humidity levels and critical temperature of crop. Table refers required minimum precipitation rates.

Approx. Minimum temperature ^{0} C	-3.3 to -3.9	-4.4 to -5.0	-5.3 to -5.8	-5.8 to -6.7	-6.9 to -7.8
Min. precipitation Rate, mm/hr	2.5	3.0	3.8	4.6	6.4

Extreme care shall be taken while selecting the sprinkler and sprinkler spacing for frost protection application. Frost protection system can not be

operated section by section. Entire system has to be started at the same time. Sufficient water availability in the reservoir is a must. As temperature plays very important role in frost protection system, it is recommended to have automatically operated system based on temperature sensor. Ensure that the electricity shall be available continuously throughout the freezing period when sprinklers are operated. It is recommended to have sufficient electrical back up for this system.

Jain's "LAL TOPI" sprinklers are specially designed for this purpose. These sprinklers can be installed above the canopy and operated during frost hours.

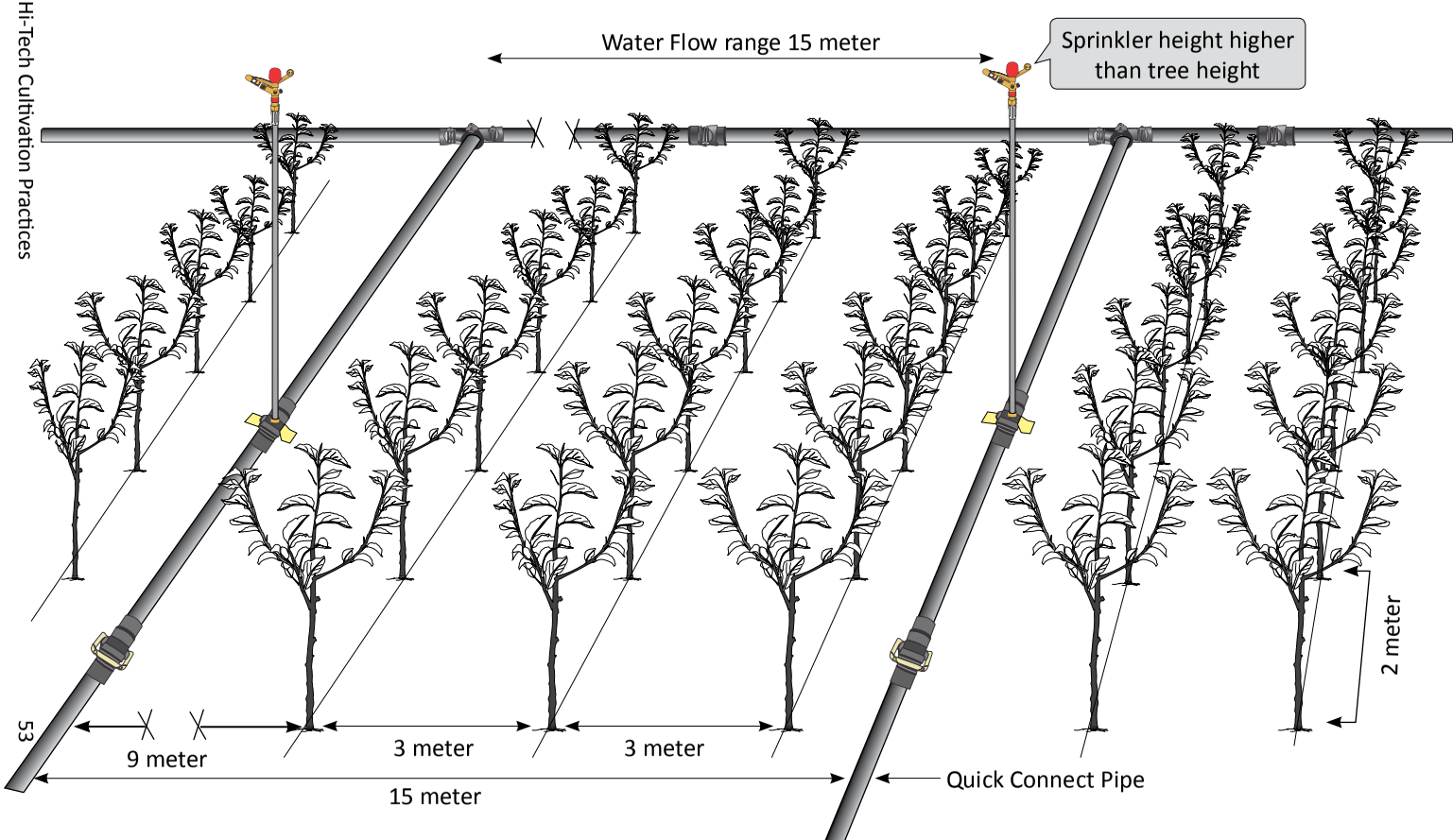
Jain Lal Topi - 233 B AF - Anti Frost Sprinkler

Apart from "Lal Topi - 233 B AF " sprinklers, we can also use micro sprinklers for frost protection system.

- Superior technology from the world leader in sprinklers – NandanJain Irrigation.
- Nozzles manufactured with high quality special plastic materials provide resistance to corrosion, chemical and UV radiation as well as uniform water distribution for many years. .
- Sprinklers body manufactured with special metal ensures smooth inner surface. This reduces pressure friction loss compared to traditional sprinklers.
- Specially designed for frost protection. The top lal topi completely seals and protects the sprinkler from frost damage.
- Facility for changing different control nozzles in the same sprinkler available according to crops and intensity of frost.
- Suitable flow rate for effective irrigation along with protection from frost available.
- Irrigation in a circle up to 26.5 to 37.5 metres distance.
- Conforming to Indian Standard IS : 12232 approved by BIS.

Apart from Lal Topi - 233 B AF Sprinkler other sprinkler products which can be used for frost protection purpose are : Aqua Master 2005 and 501 U.

Jain Lal Topi - 233 B AF - Anti Frost Sprinkler Layout



14. DISEASES

Canker and Papery Bark

Canker and Papery Bark are the two diseases prevalent in all the three apple growing states. These are stem diseases which appear on shoots, scaffolds and also on trunk. In case of Canker, there are depressions which have pink coloured pustules. In Papery Bark, the bark becomes papery. There is death of cells in the affected portions. Initially phloem is affected and later on incidence may be upto wood. The affected shoots are removed, the affected bark and even the wood on scaffolds and on the trunk are scrapped, and the cut and scrapped portions are pasted with Chaubatia paste (Copper Carbonate:lead Oxide:Linseed Oil 1:1:1.25) during pruning in winters for their control. The whole orchard is sprayed with copper fungicide during dormancy and also in the rainy season.

Root Rot

The Root Rot is more common in poorly drained soils, hence, water stagnation either above or in subsoil is to be avoided. The drenching of soil either with copper oxychloride or mancozeb is helpful in controlling the disease. Keeping the soil pH near to neutral level is also a measure to check the spread of the disease.

Apple Scab

The Apple Scab is found in some pockets of the apple growing areas. Typical Scab symptoms appear on foliage and fruits. Light brown or olive green spots which soon turn musty black appear on either or both sides of the young leaves. Severe spotting leads to premature leaf-fall. Severe early infection results in the formation of illshaped knotty fruits. Fruits which get affected in late summer develop small, rough black circular lesions on the skin. Following spray schedule is recommended:

i) In dormancy at silver tip to green tip stage.
ii) At pink bud stage.
iii) At petal fall stage.
iv) When Fruits attain pea and walnut size.
v) When fruits have attained full size.
vi) 20-25 days before harvest.

In these sprays, the fungicides like Mancozeb, Fenarilmol, Bitertanol, Captan, Sulphur, Chlorothalonil and Carbendazim are used interchangeably but following precautions are taken: (a) Carbendazim should not be sprayed in two consecutive sprays. (b) Chlorothalonil should be applied only at silver tip or green tip stage and not after wards as it causes rusting on fruits.

Table 5 : List of fungicides recommended for Apple

Sr.	Name of Fungicide	Recommended Concentration	Waiting Period
1	Aureofungin	2g/lit	-
2	Carbendazim	0.25g/lit	40 days
3	Captan	1.2g/lit	8 days
4	Chlorothalonil	2g/lit	45 days
5	Dinocab	0.3g/lit	21 days
6	Diathion	0.75g/lit	21 days
7	Hexaconazol & Penconazol	0.5 g/lit	30 days
8	Ziram	2 g / lit	21 days
9	Wettable Sulphur	2.5-5 g / lit	

15. INSECTS

Among the insect pests, the most common ones are woolly aphis, stem and root borers, tent caterpillar and san jose scale.

Woolly aphid

The woolly aphid live in groups and suck on succulent shoots and buds. In winter, they feed on roots. During sucking, they secrete some poisonous substance and nods are formed at the portions sucked. Affected trees remain stunted with greatly reduced fruit bearing capacity. This insect can easily be controlled by spraying any of the insecticides like Dimethoate, Methyl-Oxydemeton, Monocrotophos or Imidachloprid during the months of April-May and September-October. During winters, drenching of soil with any of the above insecticides is recommended.

Stem and root borers

The grubs of stem borer feed on wood inside the stem. It's excreta comes out from a hole. For control, a cotton wick soaked in any of the fumigating insecticides like Dichlorovos, is inserted inside the hole and is immediately sealed with wet clay soil. Similarly the grubs of root borer feed inside the roots. Any systemic insecticide like Phorate or Carbofuran is applied during March-April in the root zone and is well mixed with the soil. Pheromone traps placed in the orchards can trap the adults of these insects which can then be killed thus minimizing the population of grubs (damaging stage).

Hairy Tent Caterpillar

This caterpillar has hairs on its body and fond of living in groups inside tent like structure. These caterpillars feed on the foliage and keep on shifting to the other shoots of a tree. This insect is very common in neglected orchards. Under severe infestation a tree becomes leafless. For control of hairy tent caterpillar, insecticides like Monocrotophos or Endosulfan is sprayed during September-October.

San Jose scale

San Jose scale insects live on the surface of the bark of stems. Initially trees show small, greyish specks on the bark surface but severely infected trees have the bark covered with a grey layer of overlapping scale appearing as if these have been sprayed with wood ash. For control, one to two sprays of any of the tree spray oils (Esso Tree oil, Survo Orchard spray, Agro Spray orchard) are done during winter at green tip bud stage.

Table 6 : List of insecticides allowed for application in Apple

Sr.	Name of insecticide	Targeted Pest	Recommended Concentration	Waiting Period
1	Carbofuran	Woolly Aphid	5-50g/tree (based on size of a tree)	
2	Chloropyriphos		0.5ml/lit	
3	Dimethoate	Stem Borer	0.3ml / lit	
4	Fenazaquin	Mite	0.1ml/lit	7 days
5	Methyl O Demeton	Sanjose scale & Woolly Aphis	0.25-0.75 ml/ lit	
6	Phorate	Woolly Aphis	10-15g/plant	
7	Propargite	Mites	0.75-1ml/ lit	9 days
8	Quinolphos	Woolly Aphis / tent caterpillar	0.5ml / lit	
9	Spiromegifen	Mites	0.3ml / lit	30 days

16. INTERCROPPING

In widely spaced plantations, initially when the apple orchard is young and adolscent stage, sufficient area remains unoccupied by the tree Table-7.

Table 7: Availability of space for intercropping during initial years of orchard life

Tree Age	Area Occupied by single plant (m^2)	Area Occupied by plants (%)	Area available for intercropping (ha)
First Year	1.00	2.28	0.97
Second Year	2.25	6.30	0.94
Third Year	4.00	11.2	0.88
Fourth Year	6.25	17.5	0.82
Fifth Year	16.00	44.8	0.55
Sixth Year	25.00	70.0	0.30

It is clear from Table (7) that for the initial three year period, on an average, 90% area is available for growing of short season crops on the orchard land. In areas of high elevations (>2400 metre above msl) the tree growth is slow hence the vacant area for raising of inter crops may be available for few more years.

The trees grow over the years occupying the land allotted to them and growing of intercrops will not be profitable once the orchard trees have covered about 70% area. Potato is a good inter-crop for areas having climates like that of Lahaul-Spiti of H.P. and Harsil of Uttarakhand. Potato crop is planted in April-May and is dug in September-October. The other equally suitable crop is french bean which can be used as vegetable, and two crops are possible from April to October. Using drip system of irrigation, one hectare can easily produce 30 tonnes potatoes (27 tonnes as only 90% area is available) which at the present selling price would be of Rs. 2.7 lacs. After deducting Rs. 0.90 lacs as cost of production, the net income from intercropping from one hectare will be to the tune of Rs. 1.80 lacs. Under assured irrigation facilities, other suitable intercrops which can be grown are cauliflower, cabbage, pea and tomato.

In high density plantations intercropping is not recommended except during first year with low growing legume.

17.FRUIT PICKING, PACKAGING, YIELD & STORAGE

Yield : A standard apple tree on vigorous rootstock starts fruiting at the age of 4-5 years and the commercial yields are obtained on attainment of 9-10 /8 year age. The productive life of an apple tree is about 50 years. Under proper management, average production of about 12 tonnes/hectare under the climates of Himachal Pradesh and Uttarakhand and about 15 tonnes/hectare under the climate of Jammu-Kashmir, can be obtained every year.

The closely planted trees on dwarfing rootstocks can yield fruits 25 to 30 tonnes per hectare starting from 4th or 5th year upto 20-25 years age. With precocious dwarfing rootstocks, young apple trees can often overset in the 2nd and 3rd year resulting in biennial bearing as early as the 4th year. This results in increased vigour in the 4th year just when the trees have filled their allotted space and when reduced vigour is needed. Having the density of 1500 trees/ hectare for annual cropping cultivars like Gala, the recommendation for crop loads are as: 15-20 fruits/ tree in the second year, 25-40 fruits/ tree in the 3rd year, and 80-100 fruits/ tree in the 4th year. For slow growing and biennial bearing cultivars this number of fruits should be halved to two-third that of the regular bearing cultivars.

Maturity indices : Each cultivar takes certain number of days from petal fall to maturity. A variation of 8-10 days may occur between different climatic zones. For example, the same cultivar may take few more days when planted in colder regions. In general, the fruits of early, mid and late maturing cultivars ripen in August, September and October, respectively. There are several indices which are used, to know the maturity of fruits.

- Days after petal fall.
- Heat units since petal fall
- Fruit Colour
- Fruit T.S.S. (Total Soluble Solids)
- Fruit firmness
- Starch Index (Disappearance of starch from fruit)
- Ethylene content of fruits

Among the above methods T.S.S., fruit firmness and starch index are more robust and easy to measure in field.

Fruit T.S.S. can be measured by Hand Refrectometer available in market, it is a simple instrument and easy to use by following instruction given in leaflet along with instrument. Indicative T.S.S. of major varieties at various elevation is given in table below

Variety	TSS	
	Elevation (1500-2000m)	Elevation (2250-2750m)
Red Delicious	13.28	14.10
Royal Delicious	15.01	14.35
Rech-a-Red	14.03	15.00
Golden Delicious	12.10	11.50

Fruit firmness can be measured by an instrument "Penetrometer" having 2.5cm² plunger. This equipment can be purchased from scientific instrument shops. Depending target market, fruit firmness and starch Index are given below

Type of Market	Fruit Firmness (Pounds/2.5cm²)	Starch Index
Local fresh fruit market	13.0 - 15.5	4.5 - 5.0
Distant fresh fruit market	18.5 - 20.0	2.0 - 3.0
Export & Cold storage	18.0 - 22.0	2.0 - 3.5

Method to measure starch Index

Materials required - Knife, Potassium Iodide (KI), Iodine cristals, hand sprayer(500ml capacity).

Desolve 3.3 g potassium Iodide in 30 ml hot water. After desolving KI add 2.2g Iodine crystals and shake well. After desolving, make the volume to one litre.

Iodine Test - Cut fruit vertically into two halves and spray Iodine solution. After one minute observe colour change and identity index as given in picture below.

Determination of fruit maturity should be done by collecting 15-20 fruits from various parts of the orchard and any of the described method or combination of methods can be used to determine maturity. Fruit having sun

scald, injury, insect or disease attack should not be used for determination of maturity index. Testing of maturity index should be started two week before expected date of harvest and should be repeated at five days interval. Fruits must be fresh for maturity index and Iodine solution should be also fresh. In case refractometer or penetrometer are to be used, check them and these must be functional.

Fruit harvest

During picking the fruits should be plucked individually with pedicel attached and are placed in the basket. Fruits should be handled carefully to save them from mechanical injury.

Precooling

Shelf life, storage and transportability remains good if fruits are pre-cooled to 7°C immediately after harvest, it can be done by keeping them in pre cooling chambers or spraying of water having temperature of 7°C.

Grading and Packing

Fruits must be graded before sending them to market. Grading can be done manually or by machine. Damaged, blemished and diseased fruits must be separated. Fruits can be packed in telescopic corrugated fibre boxes with apple trays. Generally corrugated fiber boxes are of 504x300x282 mm (outer) and 500x300x282 mm (inner) size. Depending upon fruit size they should be filled in 4-5 layers. If more layers are filled advantage of using corrugated fibre boxes is lost and fruits are damaged. Table below give information about number of fruits and layers per box depending upon fruit grade.

Fruit Grade	Fruits/ Box	Fruits layers	No. of layers	Weight per box (kg)
Super Large	72	18	4	16
Extra Large	80	20	4	16
Large	100	20	5	18
Medium	125	25	5	20
Small	150	30	5	22
Extra small	175	35	5	24

Fruit Storage

Cold storages or modified atmosphere cold storages are suitable for long term storage. For short term storage evaporative or zero energy cool chambers can also be used. In cold storages recommended temperature is 0 - 2°C.

In modified atmosphere cold storages 3.3°C temperature with 2 - 5% CO_2 and 3% O_2 is recommend. Fruits can be stored upto 12 month in cold storage.

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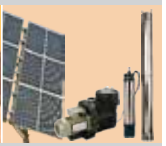
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