

Citrus Cultivation in Punjab



**PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA**

CITRUS CULTIVATION IN PUNJAB

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INTRODUCTION

The importance of citrus fruits in world's economy is demonstrated by its wide scale cultivation under tropical and sub-tropical conditions. Citrus has a tremendous socio-economical and cultural impact on the whole society. The multifold nutritional and medicinal values make this fruit indispensable in several parts of the world. Citrus is primarily valued for the fruit, which is either eaten alone as fresh fruit, processed into juice or added to dishes and beverages. At the moment, citrus is being grown in Punjab over 52,836 hectares with annual production of 10,49,977 tonnes. Kinnow mandarin occupies an area of 49,356 hectare with annual production of 10,21,719 tonnes.

The agro-ecological conditions of Punjab are best suited for the production of Kinnow mandarin. Kinnow cultivation has proved a boon for the farmers due to its higher economic productivity as compared to other fruit crops. The inherited abiotic stress tolerance in Kinnow came from its mother parent King mandarin make this tropical fruit suitable for the sub-tropical region too. The introduction of Kinnow in Punjab is the glowing example for strengthening of the citrus industry in Punjab. Furthermore, farmers of Punjab are innovative and are practicing high-density plantation for higher income in lesser time.

Kinnow is a hybrid between King (*Citrus nobilis*) and Willow leaf (*Citrus deliciosa*) mandarins developed in 1915 by Dr. H.B. Frost at Citrus Research Centre, University of California, Riverside, USA. After a long evaluation period of 20 years, it was released in 1935 as a new variety for its commercial cultivation. Its characters range between

mandarin and sweet orange having neither loose nor tight skin. It was brought to the PAU, Regional Fruit Research Station, Abohar by Dr. J.C. Bakhshi from California (USA). Initially four plants were preserved in the citrus collection of Regional Fruit Research Station (RFRS), Abohar. After evaluating its consistent performance at the research station, Kinnow was recommended for commercial cultivation. Since then, it has emerged as number one fruit, both in area and production and has brought the “Golden evolution” in the Punjab state.

Besides introduction of new cultivars, the scope of citrus cultivation therefore exists for further expansion of citrus industry through release of early and late varieties. For resource conservation and higher returns per unit, farmers should adopt high quality planting material and judiciously use inputs such as fertilizers, insecticides, pesticides, machinery equipment, packing material, etc. There is an urgent need for the advanced citrus production systems for sustainable economic production of this crop and for improving disease and pest management efficiency in Punjab. The specific problems faced by citrus growers of Punjab are needed to be addressed properly. This e-book is written with an objective to improve citrus cultivation and to overcome the difficulties faced by the citrus growers.

SOIL AND CLIMATE

The selection of proper location and site has to be considered carefully to ensure maximum productivity. Moreover, the establishment of an orchard is a long term investment and deserves very careful planning. The soil requirements of citrus are very exacting and it is not necessary that soils ideal for growing field crops are suitable for growing citrus because of some unfavorable sub-soil conditions. Therefore, it is highly advised that before planting a citrus orchard, the soil should be tested for its suitability for cultivation. For this purpose, few prospective sites should be examined for both physical and chemical properties.

Citrus fruit trees are very sensitive to high salt concentration in the soil; the soil profile should be carefully examined for the presence of any hard pan, stone layer/lime concretion. Under these conditions, plant cannot absorb adequate water and nutrients from the soil and consequently, the plant growth remain stunted. The presence of high amount of calcium carbonate in soils induces the deficiency of essential nutrients like phosphorus, zinc, manganese, iron and copper. Moreover, soil reaction as a measure of its acidity or alkalinity is another important factor that needs to be considered. The availability of many nutrients essential to plant growth is closely related to pH of the soil. It has been observed that citrus plants thrive best in soils having a slightly acidic reaction with a pH range of 5.5 to 7.5. Under such conditions, most of the nutrients are readily available to the plants. As far as possible flat land should be selected and there should be no hard pan up to a depth

of 2m.

Water logged soils or soils having very high and fluctuating water table should not be selected for citrus cultivation. Such conditions lead to root injury and decay, ultimately resulting in the death of the plant. Similarly, the soils with inadequate surface drainage should be avoided. Citrus orchards should not be planted in areas where water stagnates for many days and in flood prone fields. Well-drained fertile sandy loam soil having pH up to 8.5, electrical conductivity up to 0.5 mmhos/cm, calcium carbonate up to 5%, lime concentration up to 10% and free from hard pan are best suited for citrus growing.

Extremely cold and hot periods are not contusive for the citrus cultivation. It has been seen that even temperature of -2 to 0 °C can cause injuries to citrus plants, if such low temperature prevail for long periods. Under extremely high temperatures, the foliage is killed and much of the fruit drops. This type of injury is more prominent if the preceding winter has been rather cool. Under high temperature conditions, the exposed fruit may become sunburned. However, temperature also plays an important role in the production of high quality citrus fruits. In areas where more total heat is available during the growing season, orange mature early with higher amount of total soluble solids than the oranges produced in places where the temperature is not so high. It is therefore, clear that the citrus plants thrive best under warm conditions. Citrus cultivation can be done in almost all over the Punjab state but the arid irrigated and sub-mountainous regions of Punjab are best suited for the production of excellent quality fruits.

VARIETIES

The major citrus fruits grown in Punjab are mandarin, sweet orange, grapefruit, lime and lemon. Mandarins are of major economic significance followed by oranges. Grapefruits, limes and lemons are of minor importance. Though large number of citrus varieties can be grown in Punjab, but the research has proved some of the varieties to be of outstanding merit.

MANDARIN

Mandarin, commonly known as Santra or Sangtra in Punjab, are a large and varied group. Mandarins are popular because most of the varieties are easy to peel. The segments are tender, juicy which can be separated with great ease. Besides, at maturity mandarin fruit have a hollow core. Its trees are small to medium in size with slender twigs and small branches. The peel of fruit is loose at maturity. Also, mandarins have a greater tendency for alternate bearing than other citrus fruits. Alternate bearing means that they will produce a larger than normal crop one year followed by a lighter than normal crop the next year.

Kinnow

It originated as hybrid between King and Willow Leaf mandarin (*Citrus nobilis* x *C. deliciosa*) at Riverside, California. This hybrid was developed by Dr H.B. Frost in 1915 and was released for cultivation in USA in 1935. Kinnow was introduced in Abohar. In Punjab and adjoining states it soon became a huge success and replaced most of sweet

orange varieties under cultivation at that time. Till date area is consistently increasing under this fruit. The factors which contributed to the success of this fruit are its beautiful golden yellow colour, which is a major asset of this fruit from marketing point, abundant juice, excellent aroma and taste according to Indian palate. Its trees are highly productive, it is not uncommon to find 1000 fruits per tree. By adopting proper method of cultivation, handsome returns, much higher than those obtained from most of other fruit crops, can be had from well looked-after Kinnow orchards. It matures in January – February, and have 12 to 25 seeds.

PAU Kinnow-1

PAU Kinnow was produced through mutation breeding of Kinnow. Its fruits are medium globose to oblate, skin golden orange when fully mature. It is mid-season variety and matures in January. The fruits are low-seeded as compared to Kinnow with 0-9 seeds per fruit. The flesh is orange-colored and juicy, with a rich and sweet flavour having TSS of 10-11 °Brix and 0.7-0.9 per cent acidity. Yield of five year old plant is 45 kg.

Daisy

Daisy is a cross between Fortune (Clementine x Ponkan mandarin) and Fremont (Clementin x Dancy mandarin) varieties of mandarin. Daisy fruits are medium to large and round with smooth skin. Skin colour is reddish orange and glossy in appearance. It peels and sections moderately well. Fruits have good flavour and high sugar/acid ratio. The tree produces a heavy crop with the fruit held in large clusters. Daisy is moderately seedy with 10-14 seed per fruit. It is an early variety and matures within first to third week of November. It's plants should be propagated on Carrizo rootstock.

W. Murcott

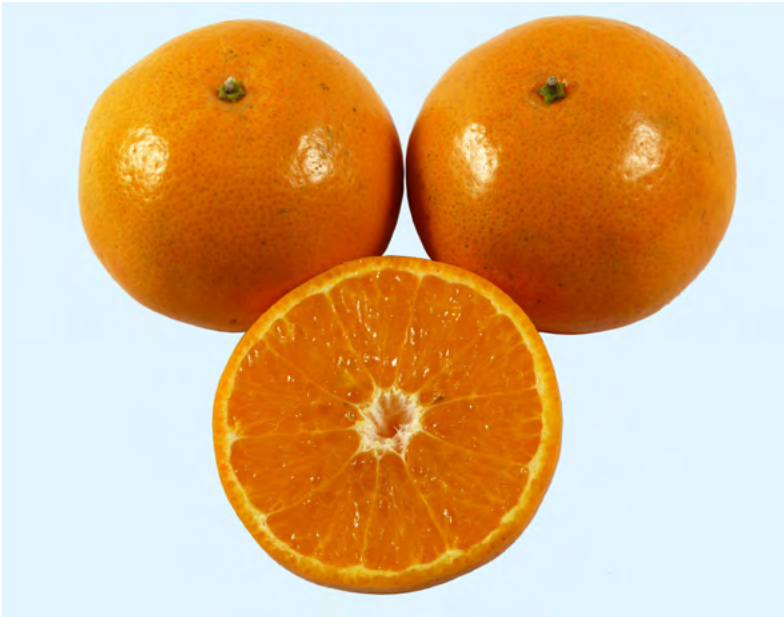
The tree is moderate in size and vigor. The fruit is mostly medium sized, sort of flat shaped with a thin, smooth, easy to peel skin, with a perfect balance of sugar and acid giving it a rich flavour. The flesh is orange-coloured and juicy, with a rich and sweet flavor. The fruit is low-



Kinnow



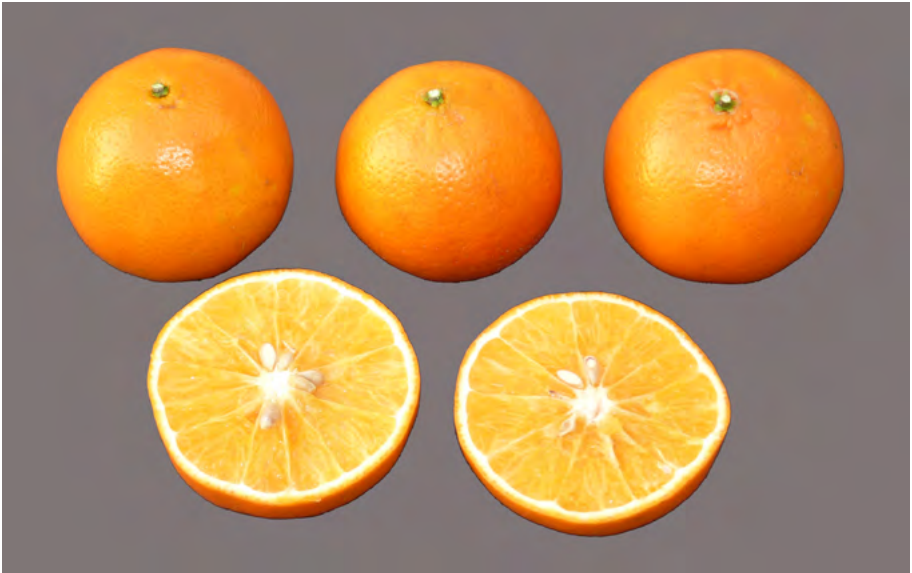
Kinnow



PAU Kinnow-1



Local



Daisy



W. Murcott

seeded in the absence of cross-pollination, but seedy when cross-pollinated. It is a mid season variety, maturing in January. It's plants should be propagated on Carrizo rootstock.

Local

Local mandarin is grown in some pockets of Gurdaspur, Hoshiarpur and Ropar districts of Punjab. This variety is known for its beautiful cadmium yellow colour and is identified by loose skin and the presence of small furrowed neck at the base. Juice is abundant with good flavour and slightly acidic. Only 3-7 seeds are present per fruit, making it suitable for out-of-hand eating. Fruits mature in December-January.

SWEET ORANGE

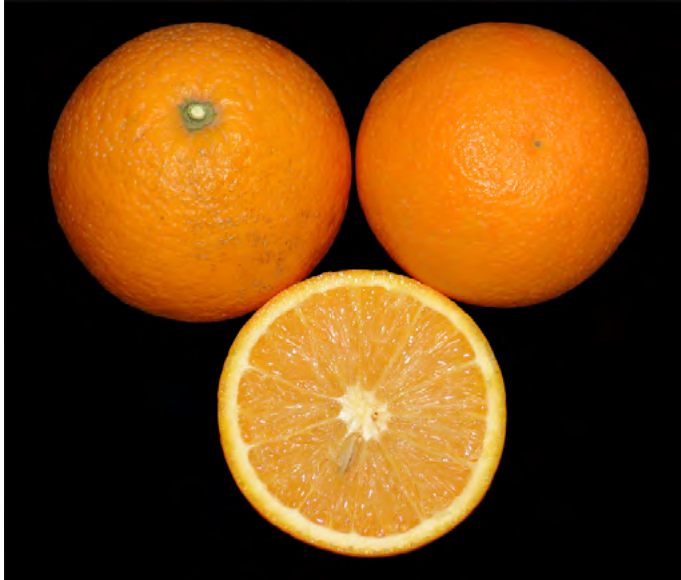
The sweet oranges are commonly known as Malta in Punjab. The sweet orange is dominant fruit in citrus industry of the world, but in Punjab it is the second important group after mandarin. The sweet oranges are primarily used as a fresh fruit for eating out-of-hand or serving as a dessert. The sweet oranges naturally fall into four kinds: the common oranges, acidless oranges, pigmented oranges and navel oranges. The common orange, is the most important of the four and contains a large number of varieties. In Punjab, Jaffa and Valencia varieties belong to this group. The fruits of acidless orange group have very low acidity and flavour. Mosambi variety of this group is recommended under Punjab conditions. In pigmented or blood oranges, fruits develop anthocyanin pigment in pulp, as a result pulp becomes red to deep red in colour. Blood Red variety belongs to this group. The navel orange, mainly represented by the Washington Navel variety, can be identified by the presence of navel at the apical part of the fruit. Varieties belonging to this group do not perform well under Punjab conditions.

Mosambi

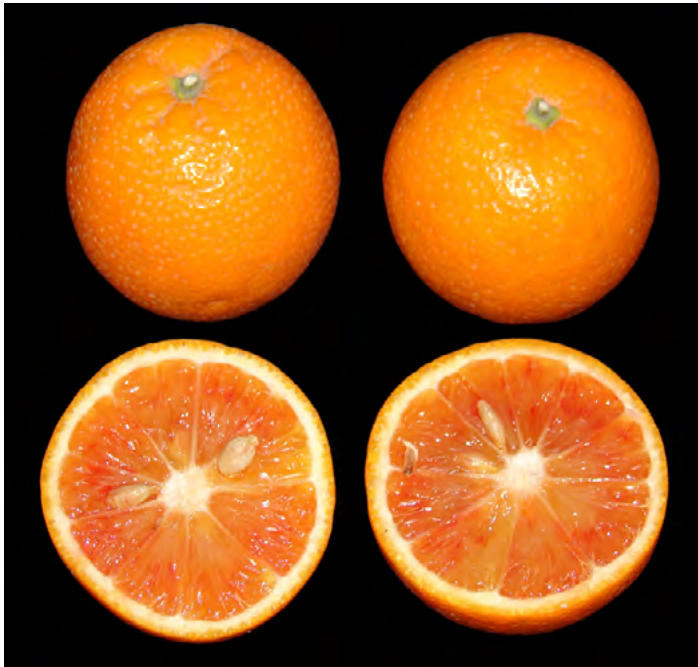
This is a very distinctive variety with its fruits being small to medium in size and broadly sub-globose. Its colour varies from light



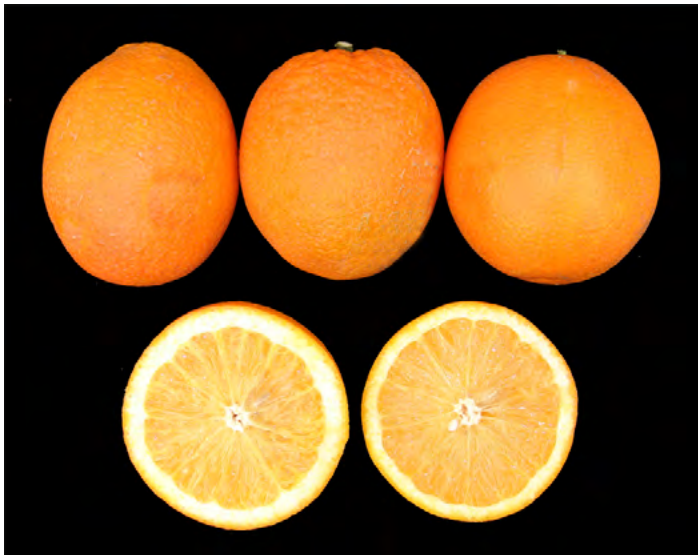
Mosambi



Jaffa



Blood Red



Valencia Late

yellow to pale orange at maturity, its surface is moderately to roughly pebbled with faint stripes, narrow longitudinal grooves and ridges. The variety is marked by the presence of shallow areolar ring at the apex. The juice has low acidity and no marked flavour. The flesh is pale yellow or whitish with 20-25 seeds. It is early in maturity and ripens in November. These plants budded on Pectinifera rootstock do much better than those budded on rough lemon rootstock.

Jaffa

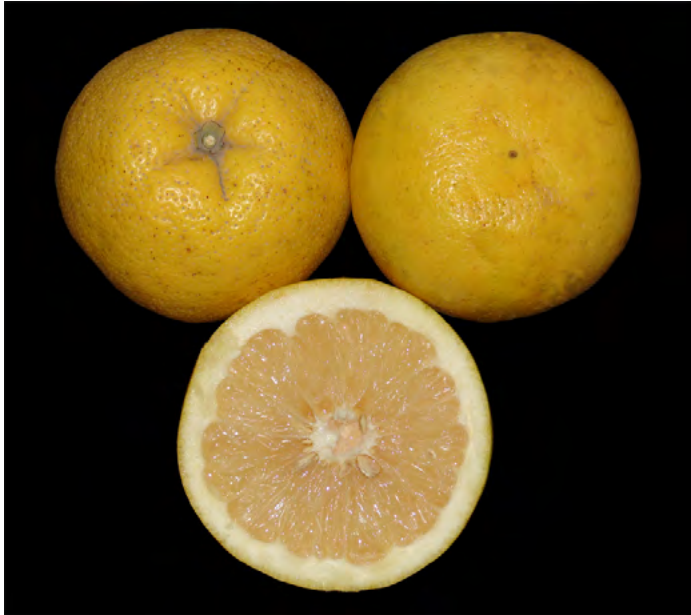
The colour of this fruit is orange red under favourable conditions. It's rind is medium-thick, finely pitted and moderately pebbled. The fruit medium to large sized, globose to slightly ellipsoid or obovate and seeds are comparatively few, around 8-10. Flesh colour is light orange, tender, juicy with a good flavour. It stores poorly on tree, but ships rather well. It is a mid-season variety with maturity in December. Trees of this variety are vigorous, upright with dense foliage and have alternate bearing tendency.

Blood Red

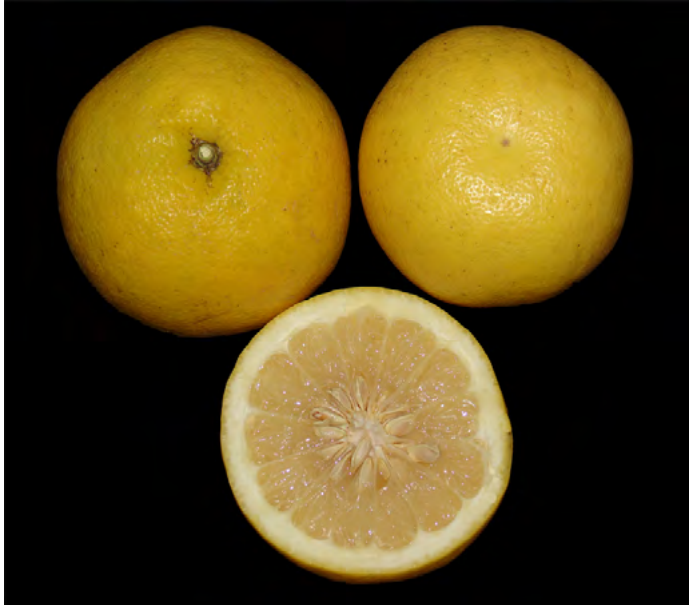
It is a prized variety of Punjab, distinguished by the development of red pigmentation in the pulp with deeply coloured cadmium-yellow glossy rind. The flesh is streaked red early in the season, but develops full red colour when ripe. Fruits develop excellent flavour and a pleasing blend of sweetness and acidity. Eight to ten seeded fruits ripen in December-January. The development of blood colouration is variable and is best in the sub-montane districts. This is a shy bearing variety.

Valencia Late

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



Marsh Seedless



Duncan



Star Ruby



Red Blush

GRAPEFRUIT

Grapefruit derived its name from the fact that the fruits commonly occur in small clusters rather than individually. The grapefruit tree is vigorous and under favourable conditions is one of the largest citrus trees. Grapefruit can withstand neglect to a considerable extent, moreover, its tolerance to both high and low temperature is high. These properties make this fruit well adapted to hot desert and humid semi-tropical or tropical climates. The grapefruit falls into two natural groups—the common and pigmented grapefruits. There is a common misconception that the red grapefruit is sweeter than the white, however, this is not true. Although the demand is greater for red grapefruit, the white grapefruit are just as sweet if allowed to fully ripen.

Marsh Seedless

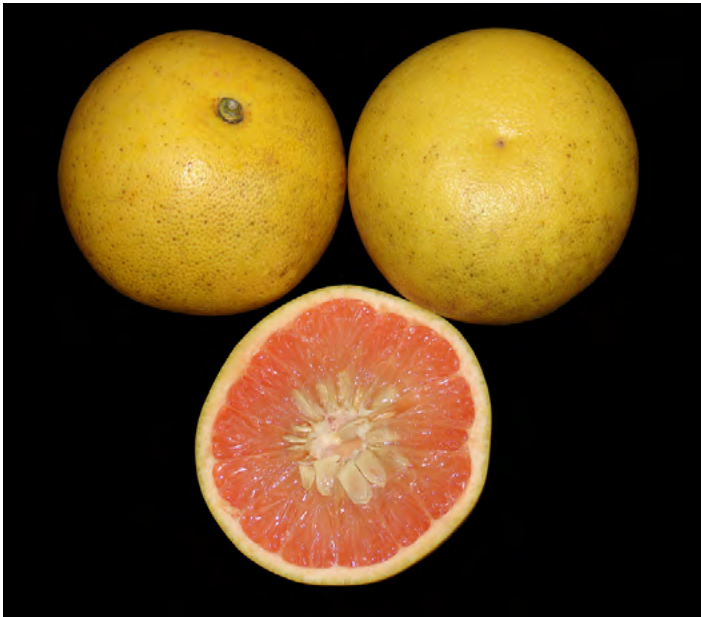
As name indicate this variety is known for its almost absence of seeds, if present these are few (0-6) and usually rudimentary. Fruit is medium in size, oblate to spherical in shape having smooth skin. The colour is pale to light yellow at maturity. The rind is medium to thin, tough and the surface is very smooth and even. The flesh is tender with abundant juice which is highly flavoured. Fruits ripen in December-January. Trees of this variety are vigorous, spreading and large.

Duncan

It's fruits are large, oblate to globose or broadly obovate with about 30- 50 seeds per fruit. The colour of the peed is pale to light yellow, the rind is medium-thick and the surface is smooth. The flesh is tender, acidic and the sweetness is medium, very juicy with pronounced and excellent flavour. Fruits ripen in December-January.

Star Ruby

Trees are medium in size, fruit size is small to medium and the shape is oblate-roundish. The peel smooth, glossy yellow having distinctly bright red blush. The flesh colour is deep red, fruits seedless (1-2 seeds), juicy, rich in vitamin-C and have high TSS well blended with



Foster



Punjab Baramasi Lemon



PAU Baramasi Lemon -1



Eureka



Punjab Galgal



Kagzi

acidity. It is an early variety which ripens during last week of November and has yield of 53 kg/tree.

Red Blush

This variety is liked for the attractive appearance provided by the pigmentation of the rind and its deep flesh colouration. Fruits are small to medium in size, oblate to spherical, with seeds 0 to 8, mostly aborted. Peel is smooth, glossy, deep yellow having crimson blush on the rind, especially at points of contact between fruits. Flesh is pigmented with deep bright crimson blush in juice vesicles. Fruits are mildly acidic and ripen during the last week of November. Trees of this variety are large, vigorous and productive.

Foster

Its fruits are medium to large, oblate to spherical, having large number of seeds with 40-50 seeds per fruit. Primary colour is pale to light yellow, but sometimes rind blushed with pink, extending into the albedo. Rind medium-thick and surface smooth. Primary flesh colour is light with grey tinge and pink colouration, flesh texture tender and juicy with good flavour. Fruit ripens in November-December.

LIME AND LEMONS

The most distinctive fruit characteristics of the lime and lemons from other citrus fruits is high acidity, though their low acidic forms do exist. The fruits have an oval to elliptical shape with areolar mammilla or nipple.

Punjab Baramasi Lemon

Fruits are medium to large in size with a smooth rind. Fruit is very juicy and seedless. Average yield is 84 kg per tree and the juice has 5.6 per cent acidity. Plants are vigorous and spreading.

PAU Baramasi Lemon -1

The fruit is lemon yellow, round, tapering towards the base with round apex. The skin is smooth and thin, fruit very juicy, seedless and contains about 7 per cent acidity.

Eureka

The fruits are medium in size, oblong, sometimes with long apical mammilla or nipple. Seed content is variable but usually few to none. Skin colour is lemon yellow at maturity. The rind is medium-thick, tightly adherent and the surface is finely pitted with sunken oil glands. Segments are about 10 with small and usually solid axis. Flesh colour is greenish-yellow, fine-grained, tender and juicy. The fruits ripen in August-September. Tree is medium in vigour, spread and size and open in growth habit and virtually thornless.

Punjab Galgal

Its trees are vigorous. Fruit is medium in size, oval in shape, peel is smooth, glossy, medium thick and yellow at maturity. Its juice has 5.2 per cent acidity and 5-8 seeds per fruit. It matures in last week of November and gives 80-100 kg fruit per tree.

Kagzi

Tree is medium sized, hardy and semi-vigorous, and upright with an irregular and loose crown. Foliage is not dense, light green and there are numerous thorns. The fruit is small, round and thin skinned, pulp greenish white and the juice is strongly acidic.

Local

The fruit is medium, globose to ellipsoid, the rind is smooth with distinctive aroma. The juice is abundant, lacking in acidity, insipid, seeds 5-6 and ripens in the beginning of September.

CITRUS NURSERY PRODUCTION

Modern citrus nursery production involves mainly two methods i.e. field nursery production and container nursery production. In Punjab, conventional method of field nursery production is commonly followed, as this method is less capital intensive, less labour intensive and requires no specialized technique. In this method, plants are raised in field and plants for sale are taken out with earth ball or bare rooted. Disadvantages of this method is a higher percentage of plant loss due to mortality and longer establishment periods after transplanting. Container nursery production is gaining popularity as it ensures high profitability even from small nurseries besides, ensuring better phyto-sanitary conditions. In this method, plants are produced in polyethylene bags or pots. The advantages of containerized production include:

- High plant densities
- Less chance of disease spread from one plant to another plant
- Use of land unsuited for field production
- Planting times independent of the weather
- Elimination of some operations (like hoeing, weeding)
- Lower transportation costs because of lightweight media
- Less root loss and a greater chance of survival than with field-grown trees

Now a day's most of nurseries use both these methods side by side, with container grown plants give high transplanting success as compared to field grown plants.

Rootstock Raising

Citrus varieties are usually not propagated on their own roots. Usually citrus plants are raised by budding scion varieties on the suitable rootstock. The rootstocks impart certain desirable characters e.g. improved fruit quality, higher productivity, adaptability to agro-climatic conditions, resistance to diseases, pests, etc. In Punjab, rough lemon (Jatti Khatti) is the most commonly used rootstock for most of citrus varieties. Its seeds are extracted in August-September. For Blood Red sweet orange, Cleopatra should be used as rootstock. Its seed ripens in January and should be sown in the first week of February. Pectinifera is recommended rootstock for Mosambi variety of sweet orange and its seed should be sown during August-September. Daisy and W. Murcott mandarins should be propagated on Carrizo rootstock.

Procurement of Seed

The citrus rootstock seeds should be procured from a reliable source, as the health and productivity of the orchard depends upon the right rootstock. It is better to procure the fruits and to undertake the extraction operation on the nursery, as sorting of off-type seeds is very difficult. Moreover, unscrupulous seed sellers tend to mix the seed of other citrus fruits to obtain easy profits. To ensure maximum purity rootstock plants should be grown in the mother block nursery itself. This would ensure better-quality seed with a high percentage of germination. The fallen fruits and those hanging close to ground should not be used for seed due to their high probability to *Phytophthora* infection.

Seed Sowing

The seeds of rough lemon can be sown in September and again in February-March. September is the preferred time of the year for sowing the seed. Usually, the sowing done in the first week of September gives the best results. If the sowing of seeds is delayed beyond the third week of September, the germination is reduced owing to the onset of winter and the growth of seedlings is slowed down.

CITRUS ROOTSOTCKS



Rough Lemon



Pectinifera



Cleopatra

Citrus seeds should be sown immediately after extraction, as storage usually reduces their viability. To facilitate easy sowing, it is better to wash the extracted seeds with tap-water and to dry them in shade, so that they could be easily handled. To avoid *Phytophthora* infection seeds are dipped for ten minutes in hot water at 52°C.

Nursery

In field nurseries, the eradication of soil born pathogens like *Phytophthora* and *Fusarium* is very difficult, as a result concept of containerized nursery system is gaining popularity. First step in containerized citrus nursery production is preparation and sterilization of potting mixture. The potting mixture consist of two parts of soil, one part of farmyard manure and one part cocopeat. Care should be taken to use virgin soil for the potting mixture.

Soil Sterilization: Thoroughly mixed potting mixture is spread as 45 cm thick layer on the concrete floor. Mixture is completely drenched with water followed by covering it with 100 μ thick UV stabilized transparent polythene sheets in summer months (May-June) when atmospheric temperature is very high. The edges of polythene sheet are completely sealed with soil to avoid vapour loss. Soil sterilization is done for 4 to 6 weeks.

The solarized soil is further fumigated with Basamid (Dazomet 98%) granules applied at 50g/m² for 45 cm thick layer of potting mixture. Dazomet is a soil fumigant which releases poisonous methyl isocyanide gas on coming in contact with moisture. This gas eliminates most of the soil born pathogens, weed seeds, pests, etc. It completely eliminates *Phytophthora*, *Pythium*, *Rhizoctonia* and *Fusarium* species from the soil.

Solarized and fumigated potting mixture is used to fill trays and polythene bags. Trays are used for seed sowing and polythene bags are used for raising transplanted seedlings.

Seed sowing: The rough lemon seeds (2 seeds per bag) can be

sown directly in black polythene bags (size 12" x 7", 250 gauge) filled with sterilized potting mixture in the second fortnight of August under screen house/ polycarbonate roof screen/ shade net house. The seeds start germinating in about 3 weeks and when the seedlings become 10 cm tall retain only one nucellar seedling per bag by uprooting all other seedlings. Then the seedlings should be sprayed with 1.5% urea at monthly interval. The polythene bags containing seedlings should be shifted in glasshouse/ polyhouse during winter (mid-November till end of February) which should again be transferred to screen house/ shade net house (50% shade) during first week of March. More than 75 per cent seedlings will become buddable in the first fortnight of May. The budding operation can be started from May onwards under shade net house which will become saleable during September-October and remaining plants will become saleable in next March.

Selection of Mother Plants

Most commercial citrus nurseries use grafting to produce new plants. However, there are more than 30 kinds of citrus pathogens which can be transmitted by grafting, via infected budwood. These include citrus greening, tristeza, exocortis, xyloporosis, psorosis, etc. Once a plant is infected, such diseases may have a serious influence on growth and productivity. They shorten the life-span of the orchard, reduce yield and fruit quality.

The bud-wood should be obtained from true to type mother plants, known for consistent high yield of good quality fruits. The selected mother trees are kept under protected cover i.e. in screen houses covered with 40 mesh wire screen. The selected trees should be regularly indexed against ring spot, exocortis, greening and tristeza diseases.

Budwood should be fully developed, with mature leaves. Round mature buds with outer skin still tender and not woody should be selected. The one or two buds at the base of branch, which are blind buds or not fully developed should be discarded. After the budwood is

cut, the leaves should be cut off immediately to avoid desiccation. If the budwood is not needed immediately, it can be sealed inside a plastic bag and stored in a refrigerator. If the scions need to be stored for longer period, they should be kept inside a sealed plastic bag with wet tissue/ newspaper to avoid desiccation.

Budding

Successful T budding requires that the rootstock be in a condition of active growth such that the “bark is slipping”. This means that the vascular cambium is actively growing and the bark can be peeled easily from the stock piece with little damage. In Punjab, February-March and August-September are suitable times for budding.

Budsticks should be on branches exhibiting good growth during the current season. Slender branches from the interior of tree with closely spaced, small buds should be avoided. Leaf blades are clipped from the budsticks, leaving the petioles intact. This leaves a convenient “handle” for holding the bud while it is cut from the budstick. The bud and a small sliver of the wood underneath it are cut from the budstick using an upward slicing motion. The cut should begin about 1/2 to 3/4 inch below the buds, and should go deep enough into the wood so that when the cut is finished about 1/2 to 3/4 above the bud, the bark and a small sliver of wood are cut off. A perpendicular cut across the top of the upward cut will separate it from the bud stick. Budding knives should be kept very sharp, so that as little damage as possible is done to the bud. Dull knives strip and tear the wood, leaving cuts that do not heal properly. Buds must be cut from the bud stick just prior to grafting, otherwise they will dry out.

Before budding is started, the stocks should be prepared well by removing the leaves and thorns around the place into which the bud is to be inserted. Budding in the nursery is usually done when the seedlings are of a diameter equal to that of a pencil. A vertical cut, about 9 inch above the ground level, is made on the stem of the rootstock. The cut should be deep enough to ensure that the bark will separate at the cambium, followed by a perpendicular cut at the upper

end of the vertical cut. The bark is carefully slipped from the stem of the rootstock exposing a “pocket” into which the bud shield can be placed. Care should be taken not to tear the flaps of bark in the process of spreading them. The bud shield is carefully slipped in between the bark flaps. The top of the bark strip on the bud shield is trimmed to fit tightly against the horizontal cut (the cross of the T) so that the bud fits within the flaps snugly. The bark flaps are held tightly against the bud as they are wrapped with polythene tape. This polythene tape must be removed after the union has healed, if not removed it will girdle the rootstock. After the union has healed, rootstock above the union can be cut away or lopped to force the bud to grow.

Selection of Healthy Nursery Plants

Always purchase plants from reliable source, preferably from the nurseries run by the government, university or government approved nurseries and make sure to book the plants at least a season in advance, as demand for plants from dependable and well reputed nurseries is quite heavy. Before making the purchase look for the overall health of the nursery, if majority of plants are diseased or in poor health then avoid that nursery. The plants should be inspected in the nursery before they are lifted/dug out and only good ones should be selected. The following points must be looked into at the time of purchase:

- The budding height should be at least 9 inches from ground level and bud union should be smooth.
- The plants should be free from visible diseases and pests.
- Weak plants with defective framework do not make good croppers, thus should be avoided.
- The rootstock on which plants have been budded should not be too old. Girth and colour of rootstock trunk give a good idea of its age and vigour.
- All the plants should be of uniform vigour.

The nurserymen have a tendency to dispose off their older stock to the unsuspecting buyer. These older plants should be avoided as they are less vigorous, hard to handle and difficult to establish.



Virus-free citrus nursery production



'T' method of budding

At the time of digging out the plants from the nursery, the ball of soil should be properly wrapped up. These balls should be 25-30 cm long to preserve the maximum part of the root system. The plants from which the soil has been broken should be rejected.

At the time of buying plants from the nursery, make sure that the desirable rootstock has been used for budding and the varieties selected are true-to-type.

Purchase 10 per cent extra plants of the same stock to make allowance for replacements later on in the event of casualties. A healthy plant will have large thrifty leaves and bright clean bark.

Transportation and Handling of Nursery Plants

The nursery plants should be handled very carefully during their transportation from nursery to planting site. Always protect the roots, stems and foliage during transportation. To prevent the breakage of earthen balls, a layer of cushioning material like paddy straw, dried grass, etc. should be spread at the bottom of the vehicle before loading the plants. Also do not forget to instruct the driver to avoid pot holes on the road and jerky driving. The plant tops should be shielded from winds and direct sun, particularly if these are to be transported to a long distance. Never pick up a plant by the trunk. Lift plants from underneath the root ball carefully.

Upon arrival at the planting site and prior to planting, plants should be temporarily stored in a cool, shaded (dark), wind-protected area such as on the north side of a building, under a tent or under trees. The roots should be kept moist to prevent desiccation and maintain good plant health. Plants grown in containers should have their growing media kept moist at all times. Minimize the interval between removal of plants from nursery and final planting. All plants should be handled so as to eliminate potential stress or injury.

PLANTING OF ORCHARD

The land on which young citrus-trees are to be planted should be prepared well in advance. The soil should be levelled with tractor mounted leveller or with laser leveller. If there is sufficient time before planting, then green-manure crops, such as, guara or senji can be grown to enhance soil fertility and to increase organic matter. These leguminous crops add organic matter to the soil and increase its fertility.

In Punjab, citrus plants can be planted twice in a year i.e. in spring season (mid-February to mid-March) and in the rainy season (August to October). Citrus is commonly planted when rains have set in and the weather has sufficiently cooled down. As regards the planting distance in citrus fruits, plant to plant and row to row distance is kept 6 meters. The Kinnow mandarin can be planted at a distance of 6 x 3 meter spacing, row to row distance is kept 6 meters and plant to plant distance is kept 3 meters. Rows are extended in north-south direction. This high density system ensures higher returns per unit area, particularly during the initial years. However, alternate tree within the rows should be removed after 15 years of age to prolong longevity of the orchard. Close spacing requires high initial cost, regular pruning and additional plant protection measures.

After the land has been properly prepared, layout is done carefully and location of each plant is marked with a wooden peg. Before digging the pits, two additional pegs are fixed in the side notches of the planting board and marking-stake is then removed, leaving the

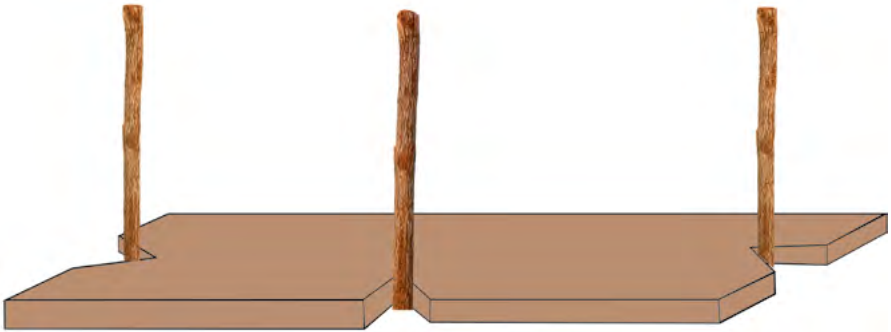
end pegs as guides for digging the pits and for subsequent planting of trees. Exact location of plant can be marked with these pegs after the filling of pits.

To facilitate better root penetration and to provide congenial conditions for the growth of young plants pits of 1 x 1 x 1 meter should be dug. However, if the soil is heavy or have hard pan then digging of pits become necessary. Hard pan must be broken during digging. When the soil is taken out of the pit, the soil from upper half is kept on one side and from lower half on other side. This soil is allowed to weather for 2-4 weeks during summer months so that any type of infection in soil may be destroyed by sunlight. Pits should be filled with a mixture of equal quantities of well-rotten farm yard manure and top soil, about 10-15 cm higher than the ground level and irrigated thoroughly, so that the loose soil settles down firmly. To each pit add 5 ml of Chloropyriphos 20 EC mixed in about 2 kg sand for protection against white ants.

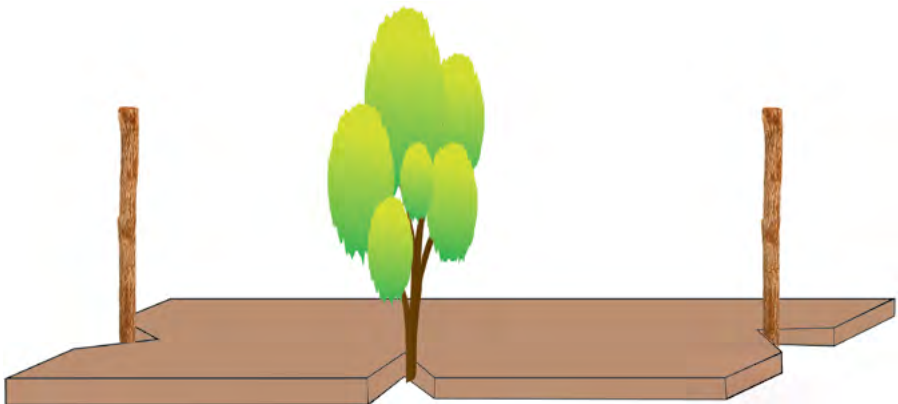
After the pit is ready, the position of plant is marked with the planting-board and a slightly bigger hole than the size of earth ball is dug. The wrapping material is removed from the ball and unwrapped earth ball is put in the hole in such a manner that the union of plant remains at least six inch above the ground level. After placing the plant in the hole, the soil taken out from hole previously, is pressed firmly around it so that the plant is set firmly in the field. Care should be taken while pressing so that the earth ball should not get broken. Immediately after planting, irrigation should be applied. Regular checking of plants is essential to detect the faults like sinking of soil, tilting of plant and cracking in basin of plant after planting. The tilted plants must be straightened-up by firming the soil around them.

Care of Young Plantation

The early years in a plant's life are very important. This is the time when the plant produces structure for future fruit bearing and it should be forced to produce the maximum vegetative growth during the first three or four years. Such growth will require optimum



The planting board is placed in such a way that the central notch fits the plant position marked by a wooden stick. Two sticks are driven into the side notches.



After digging and refilling the pit, the planting board is fitted in the side sticks to set the plant in the right position.

irrigation, fertilization, cultivation and protection from high or low temperature and strong winds.

The young plants are more prone to damage from high and low temperatures during winter months. The most common method to save the plants from frost is to put thatches on them. The thatches can be of dried grass, rice straw or polyethylene sheet. The plants are covered on all sides except south-west so that the plant gets sufficient sunlight. This thatching material is used in winter months and may also be used in summer months for shading. During summer months frequent irrigation (at 7 days interval) is essential to save plants from desiccating winds and regular weeding of plant basin is required to eradicate weeds.

The sprouts which develop on the trunks of the trees below the bud union should be removed. However, heavy pruning during the first few years should be avoided, only undesirable, dry or diseased branches should be removed. The plants of most of citrus varieties, particularly Kinnow, will blossom and set few fruits in the third year. It is not advisable to retain all the fruits at this stage, as it hampers the proper development of the young trees. Thus, the fruit on young Kinnow trees must be thinned out judiciously soon after setting in May.

NUTRITION

Plant nutrient management is a need to chalk out nutritional programme by keeping in mind growth and phenological cycles of the citrus plant. It can influence flowering, fruit set, fruit size and other plant characteristics. The strategic management of nutrients is helpful to identify appropriate time and growth stage for application of fertilizers. Citrus is grown on largest area among fruit crops in Punjab but its yield and quality is far behind the other citrus growing countries of the world. Inadequate nutrition is one of the major constraints in limiting productivity, decrease in fruit quality and may also result in decline. In sub-mountain zone of Punjab, surveys revealed wide spread potassium deficiency in the Kinnow orchards, almost all the orchards surveyed had foliar potassium levels below optimum. Wide spread deficiency of zinc and manganese was observed in most of Kinnow orchards of Punjab.

Citrus requires judicious application of fertilizers for sustained high economic yield. The citrus, like other plants, requires 17 elements for normal growth and production. The application of excess or less dose of nutrients results in abnormal functioning of the plant system. The identification of these symptoms is very useful for assessing the nutrients deficiency of a particular element and their imbalance in the soil.

Deficiency Symptoms and Control

In citrus, the excess and unbalanced use of fertilizer has created the problem of nutrient imbalance resulting in physiological disorder

and pollution of underground water. Presence of excessive free lime in soils leads to the deficiencies of phosphorus, manganese, zinc and lime induced chlorosis. The appearance of visual deficiency symptoms of a particular element may indicate its actual deficiency. It is very important for a citrus grower to diagnose nutrient deficiency symptoms, and to provide need based fertilizers for higher economic production.

Nitrogen

Nitrogen is the major element and the efficiency of other elements is based on it. In citrus, nitrogen deficiency symptoms first appear on the older leaves and the leaves become dull green, which later on turn yellowish including yellowing of mid rib and veins. Newly emerged leaves remain smaller in size and have narrower petiole angles with twigs and stunted growth. The deficiency of nitrogen can be corrected by the soil application of nitrogenous fertilizers in two or three split doses.

Phosphorus

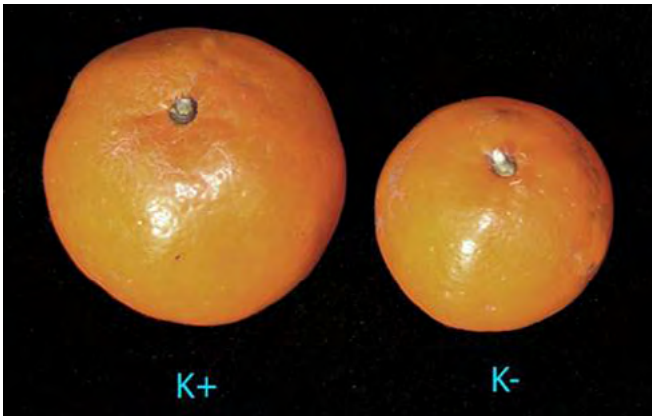
Phosphorus element quickly moves to the new leaves and the deficiency symptoms first appear on the older leaves in citrus. The new leaves appear healthy while the older become dull green, lusterless and abscise prematurely. Water-soaked and bronze necrotic areas on margins and tips can be seen on some older leaves due to the deficiency of phosphorus. The growth of the plant becomes stunted. The fruits become coarse with thick rinds and have lower juice content having higher acidity. The deficiency can be controlled by soil application of phosphatic fertilizers as per schedule.

Potassium

The deficiency symptoms first appear on the older leaves. The leaves of citrus plant become yellow from the tips and margins. Thereafter, the yellow part of the leaves becomes dead, turning reddish brown or brownish grey. The growth of the citrus plant becomes stunted. The leaves show bronzed necrosis, crinkling and cupping. The fruits become small having a very thin, smooth and well coloured rind



Nitrogen deficiency



Fruits remain small due to potassium deficiency

and may be subject to splitting and/or drop. The deficiency of potassium may be ameliorated by applying muriate of potash as soil application. Three foliar sprays of potassium nitrate 1.0 % at the end of May, June and July may also be helpful in improving the fruit quality in Kinnow mandarin. During surveys in Bhunga and Hoshiarpur blocks it was observed that some of the successful citrus growers apply 1.5 to 2.0 kg muriate of potash to bearing Kinnow plants.

Sulphur

The deficiency of sulphur first appears on the younger leaves in citrus. The leaves become uniformly yellow, later on they become thick and leathery, and abscise prematurely. Deficiency can be ameliorated with the soil application of single super phosphate or ammonium sulphate. Application of Gypsum @ 2.0 to 5.0 quintals per acre may also be helpful for the deficient soils.

Zinc

In citrus, zinc deficiency symptoms first appear on new leaves as irregular chlorosis commonly known as “mottled leaf”. The terminal leaves become small and narrow and the inter-nodal length is reduced. Fruit bud formation is severely reduced giving rosette appearance to the twigs followed by die-back. Excessive use of nitrogenous and phosphatic fertilizers may also induce zinc deficiency in citrus. Mostly deficiency of zinc appears alongwith manganese deficiency, so it is advisable to spray zinc along with manganese. The combined foliar application of 1000 ppm zinc (4.7 g zinc sulphate/ litre water) and 1000 ppm manganese (3.3 g manganese sulphate/ litre water) during end-April and mid-August to Kinnow mandarin improve yield and fruit quality by correcting the deficiencies of these micronutrients.

Manganese

In the initial stage of manganese deficiency in citrus, the leaf lamina becomes light green with fine network of green veins with normal leaf size. Thereafter, the whole leaf lamina becomes chlorotic except narrow green bands along with the midrib and lateral veins.



Iron deficiency



Zinc deficiency



Manganese deficiency



Magnesium deficiency



Sulphur deficiency

During acute deficiency, the light green/yellow areas of leaves change to grey or even whitish which are more pronounced on sunny side of tree. The size of the leaves remains normal. Generally, the deficiency of manganese occurs in the alkaline soils. The combined foliar application of 1000 ppm zinc and 1000 ppm manganese during end-April and mid-August to Kinnow mandarin improve yield and fruit quality by correcting the deficiencies of these micronutrients.

Iron

Yellowing of terminal young leaves with a green network of veins on light coloured background are the peculiar symptoms of iron deficiency in citrus. Young terminal leaves become completely yellow. Under severe deficiency the bleaching of young leaves may occur. The leaves become whitish and premature defoliation may occur. The fruit yield and quality are reduced. Generally, the deficiency of iron occurs in the light and alkaline soils. The deficiency can be corrected with three to four sprays of 0.18% (1.8 g/litre of water) ferrous sulphate in the months of April and August.

Copper

The deficiency symptoms first appear on the fruits than on the other parts of the citrus plant. Fruits become misshapen and have dark reddish brown gum soaked areas of varying size. There are gum pockets in the albedo. During the mild deficiency, the leaves become large, dark green on long soft angular shoots. Young shoots may develop into branches which appear curved or “S-shaped,” referred to as “ammonization” usually resulting from excessive nitrogen fertilization. Blister-like pockets of clear gum at nodes are formed on the twigs. Severely affected twigs commonly die back from the tip with new growth appearing as multiple buds or “witches broom”. During severe deficiency, necrotic-corky areas on the fruit surface may sometimes occur. Spray of Bordeaux mixture solution, by dissolving 2 kg copper sulphate and 2 kg lime in 250 litres of water, is very effective for controlling the copper deficiency.

Boron

In citrus, the boron deficiency occurs as browning and necrosis of growing points which slowly dies back for some distance. Older leaves become irregularly shaped and develop small necrotic areas. The fruits develop darkish coloured spots in white albedo of fruit and sometime in central core. Fruit may be somewhat misshapen with a lumpy surface. This deficiency has great negative impact on fruit quality. It can be corrected by foliar sprays of 0.05 to 0.25 % sodium borate solutions.

Magnesium

Due to deficiency of magnesium in citrus, a yellowish green blotch develops near the base of leaf between the midrib and outer edge. The yellow area enlarges until the only green remaining is at the tip and base of the leaf as an inverted V-shaped area on the midrib. During severe deficiency, leaves become entirely yellow-bronze and defoliation may occur. The deficiency can be ameliorated through the foliar applications of magnesium sulphate.

Leaf Sampling and Analysis

Nutritional status of citrus plants can be judged through the leaf analysis technique. This technique is the most reliable guide to diagnose or confirm deficiencies or toxicities and to determine nutritional status of macro and micro elements of citrus plant. Four to eight months old leaves immediately behind the fruit or middle leaf from non-fruiting shoots are taken for the analysis. April growth is suitable for judging the nutrient status of the citrus trees. Take 4 to 8 leaves per tree, two from each side at the working height of 1-2 meter and take total of at least 100 leaves. Take sample diagonally from about 10 to 15 % trees representing an uniform area and plant material. Collect leaf samples in a polythene bag, keep the bags in an ice box and then send to leaf analysis laboratory of the Department of Fruit

Science, PAU, Ludhiana.

Leaf nutrient standards for citrus fruits

| Symbol (Unit) | Deficient | Low | Optimum | High | Excess |
|---------------|-----------|-------------|-------------|-------------|--------|
| N (%) | < 2.2 | 2.2 - 2.4 | 2.5 - 2.7 | 2.8 - 3.0 | > 3.0 |
| P (%) | < 0.09 | 0.09 - 0.11 | 0.12 - 0.16 | 0.17 - 0.30 | > 0.30 |
| K (%) | < 0.7 | 0.7 - 1.1 | 1.2 - 1.7 | 1.8 - 2.4 | > 2.4 |
| Ca (%) | < 1.5 | 1.5 - 2.9 | 3.0 - 4.9 | 5.0 - 7.0 | > 7.0 |
| Mg (%) | < 0.20 | 0.20 - 0.29 | 0.30 - 0.49 | 0.50 - 0.70 | > 0.70 |
| Mn (ppm) | < 17 | 18 - 24 | 25 - 100 | 101 - 300 | > 300 |
| Zn (ppm) | < 17 | 18 - 24 | 25 - 100 | 101 - 300 | > 300 |
| Cu (ppm) | < 3 | 3 - 4 | 5 - 16 | 17 - 20 | > 20 |
| Fe (ppm) | < 35 | 35 - 59 | 60 - 120 | 121 - 200 | > 200 |
| B (ppm) | < 20 | 20 - 35 | 36 - 100 | 101 - 200 | > 200 |

Manuring and Fertilization

Managed nutrition programme is a key to economize the use of inputs for quality production of citrus fruits. Citrus plant needs an application of the manures and fertilizer at critical growth stages when the plant really has a demand of nutrition. Under Punjab conditions, the fertilizer schedule given by the Punjab Agricultural University, Ludhiana should be followed. The quantity of fertilizers can be adjusted as per the soil testing report and nutritional status of the soil.

Fertilizer schedule for citrus plants (other than Kinnow) in Punjab

| Age of the tree (year) | Dose per tree | | |
|------------------------|-----------------------|--------------|------------------|
| | Farm yard manure (kg) | Nitrogen (g) | Urea (46% N) (g) |
| 1-3 | 5-20 | 50-150 | 100-300 |
| 4-6 | 25-50 | 200-250 | 400-500 |

| | | | |
|--------------|-------|---------|----------|
| 7-9 | 60-90 | 300-400 | 600-800 |
| 10 and above | 100 | 400-800 | 800-1600 |

Fertilizer schedule for Kinnow mandarin in Punjab

| Age of the tree (year) | Dose per tree | | | | |
|------------------------|-----------------------|--------------|------------------|-----------------|--|
| | Farm yard manure (kg) | Nitrogen (g) | Urea (46% N) (g) | Phosphorous (g) | Super-phosphate (16% P ₂ O ₅) (g) |
| 1 - 3 | 10-30 | 110-330 | 240-720 | - | - |
| 4 - 7 | 40-80 | 440-770 | 960-1680 | 220-385 | 1375-2400 |
| 8 & above | 100 | 880 | 1920 | 440 | 2750 |

Entire farm yard manure should be applied during December. Split the nitrogen dose into two parts and apply the first half in February (before flowering) and the second half in April-May (after fruit set). Apply the full phosphorous dose along with the first dose of nitrogen.

IRRIGATION

The availability of proper, timely and assured supply of water is an important determinant in citrus production. This is primarily because water is a fundamental element to maintain normal physiological activities. Since much horticultural produce is sold by weight and water is the major component. Management of water relations usually involves maintenance of high water status through proper irrigation scheduling. In other cases, water stress can be used to stimulate flowering in crops such as guava or litchi orchards. The existing resources are further declining due to heavy biotic pressure and lack of management of existing resources. The orchards should be given light and frequent irrigations to make more water available to fruit plants for longer period. Certain important strategies of efficient water use and irrigation scheduling have been identified for enhancing horticulture development in Punjab and to produce quality fruits in citrus orchards.

Water is a key component in photosynthesis, and plants must undergo photosynthesis in order to grow and produce fruit. Like all living organisms, fruits contain a high percentage of water. Water is an essential ingredient for growing plants that produce bountiful crops of healthy fruits. The water is essential to the process, and the sugar produced is food for the plant that most often collects it in the form of fruits. Plants that produce fruits must collect water for further growth. They store the water in the fruits as well as in the plant leaves and stems. Many plants contain more than 80% water, demonstrating the

importance of water in their production and growth. Healthy plants must have high water content in order to produce healthy plant cells, which are the building blocks of stems, leaves and fruits.

Requirement of Irrigation Water

The amount of water requirement of the citrus orchard depends on a number of factors, including crop growth stage and environmental conditions (temperature, wind, relative humidity). The speed at which soil moisture is depleted depends on crop use and the soil type. Applying adequate amounts of moisture requires a basic understanding of soils and the general water use of the crop. Proper soil moisture content is essential for proper fruit set and to maintain optimum fruit growth and development. For getting optimum and sustainable production in citrus orchard, proper irrigation scheduling should be followed.

Irrigation Methods

It is very important for orchardists to adopt a proper method of irrigation for getting quality produce in citrus. Traditionally, citrus orchards are being irrigated through flood method which is highly detrimental to the citrus orchard. In contrast, drip irrigation system in citrus gives better results as far as quality and water use efficiency is concerned. Following different irrigation methods are generally being followed in the citrus orchards.

Flooding

Free flooding is one of the most used methods by the Kinnow orchardists. Here no importance is given to water economy or efficiency of irrigation system, rather sole purpose is labour economy. Water flows from one end to the other due to minor slope of the field. The major disadvantages of this system are that feeder root system gets damaged, the soil fungi flourish resulting in to *Phytophthora* foot and root rot. Since the whole area is irrigated, weeds flourish and become a nuisance, besides, there is leaching of nutrients along with wastage of water.

Furrow irrigation

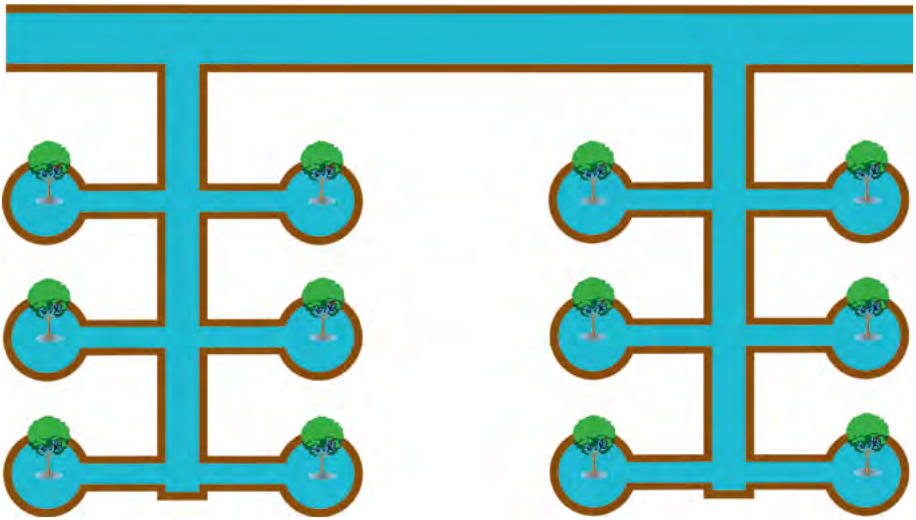
Two long parallel ridges one on either side of the plant are raised. These channels are connected to main supply channel and the water flows from one end to other as in free flooding. The water supply should be disconnected from main channel, when still two to three plants are yet to receive water. This will save water as well as leaching of nutrients. Transmission of diseases particularly *Phytophthora* from one plant to another is more in this system. This system is much suited for the cultivation of intercrops like moong, mash, lentil and wheat in pre-bearing citrus orchards.

Modified basin system

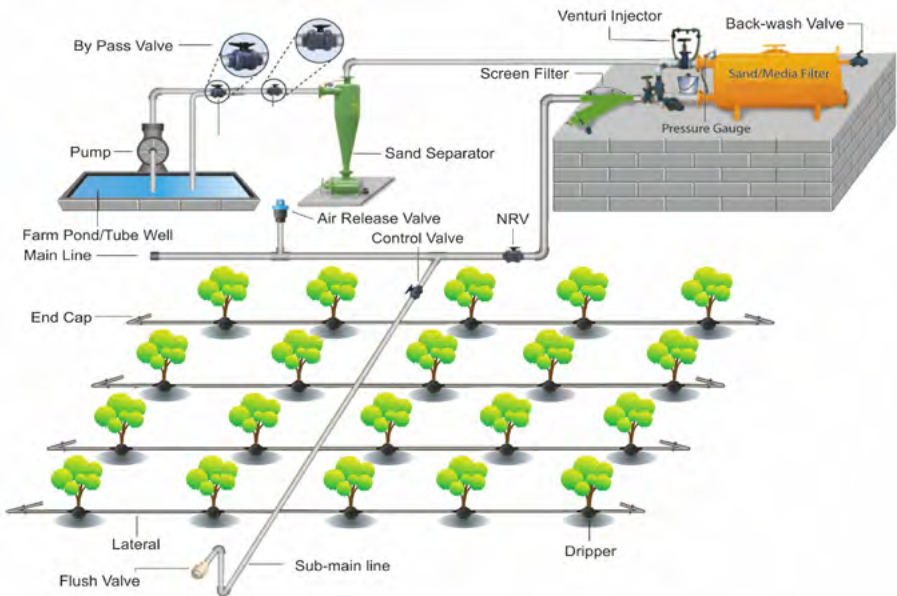
In this method, basins are made around plants with radius of about 50 cm in first year and then by increasing the basin size as fruit plants grow. This increase is necessary to apply more water to meet the growing needs of the plants. The channel is prepared in between two plant rows. Small channels are made to connect the circular basins around the plants. Only desired quantity of water can be applied. Nutrients and diseases do not move from one plant to the other. Weeds can easily be controlled as alternate rows do not have any water channel. Manual presence is required to apply irrigation to each basin of plant.

Drip irrigation

This system is the most efficient system of irrigation in citrus orchards. In this method, water is supplied in the root zone, drop by drop, through nozzles fitted on the rubber pipes. This method has great potential in salt affected arid region where canal water can be stored and subsequently used for irrigation. This system is also best suited for the kandi area of the Punjab state where the land is undulating. This system is desirable in Kinnow orchards planted at close spacing. In this system, water soluble fertilizers like urea, potassium nitrate, mono ammonium phosphate, etc. can be applied efficiently with irrigation water to meet nutritional requirement of the citrus plants.



Modified basin system of irrigation



Basic layout of drip system of irrigation

Irrigation Scheduling

Irrigation scheduling requires great caution. Citrus trees demand good soil aeration and over-irrigation is highly detrimental. Too frequent and heavy irrigations may affect root development and yield and lead to leaching of nutrients. The experts at Punjab Agricultural University, Ludhiana have developed irrigation schedule matching the stages of crop growth. Thus, irrigation during critical stages results in the maximization of crop yield as well as efficient water usage.

- The young citrus plant up to the age of 3-4 years should be irrigated at weekly intervals whereas, older tree be irrigated after 2-3 weeks intervals depending upon the climate, rainfall and type of soil.
- Water application is crucial before sprouting in February, after fruit set in April and in hot weather, otherwise the growth of tree may be adversely affected resulting in excessive shedding of flowers or fruits.
- Excessive irrigation is detrimental to the citrus orchard as it may lead to the citrus foot and root rot, a very serious fungal disease caused by *Phytophthora* fungi. Water logged conditions around the tree trunk should be avoided.
- In South Western districts, canal water should be used for irrigation as the underground water is brackish and excessive use of such water results in accumulation of certain undesirable salts leading to the problem of toxicity.

For efficient use of water and for higher production Kinnow orchards should be irrigated through drip irrigation system. Punjab Agricultural University has already standardized age and month wise water requirements of Kinnow through drip system.

Amount of water (litre/day/plant) to be applied to Kinnow Mandarin through drip irrigation.

| Month | Age of plants (years) | | | | |
|-----------|-----------------------|-----|-----|-----|-----------|
| | 0-2 | 3-4 | 5-6 | 7-8 | 9 & above |
| January | 3 | 6 | 9 | 12 | 15 |
| February | 6 | 12 | 18 | 24 | 30 |
| March | 9 | 18 | 27 | 36 | 45 |
| April | 13 | 26 | 39 | 52 | 65 |
| May | 16 | 32 | 48 | 64 | 80 |
| June | 17 | 34 | 51 | 68 | 85 |
| July | 13 | 26 | 39 | 52 | 65 |
| August | 12 | 24 | 36 | 48 | 60 |
| September | 11 | 22 | 33 | 44 | 55 |
| October | 8 | 16 | 24 | 32 | 40 |
| November | 5 | 10 | 15 | 20 | 25 |
| December | 3 | 6 | 9 | 12 | 15 |

Note

1. Amount of irrigation water may vary from 10-15 % depending upon the prevailing weather conditions of the region.
2. For lifting water from canal storage tank, a booster pump with electric motor of 2.0 HP will be sufficient for 10 acre Kinnow orchard. However, a booster pump with electric motor of 3.0 and 5.0 HP will be required for lifting water for 15 and 25 acres respectively.
3. In the young plants, 1-2 drippers per plant are required which may be increased to 4-5 depending on the soil type and age of the plant. For efficient use of water, sub-lateral loops of the dripper should be used around each plant.

Precautions for Drip System of Irrigation

1. In salt affected zone, during the exceptionally low rainfall year use of brackish irrigation water causes accumulation of salts in the root zone, hence, leaching of salt is necessary by using flood irrigation (as and when available) with canal water once a year to

avoid stress to plants.

2. In case of canal water supply, the water should be first stored in storage tank. Then, it should be pumped into drip system through sand filter and mesh filter.
3. After 3-6 months remove algae or bacteria formation from the drip pipes should be removed using one litre of hydrochloric acid in 1000 litres of water. It should be pumped for 15-20 hours in them and flushed out.
4. The use of Phosphoric acid as phosphorus fertilizer reacts with available calcium and forms an insoluble phosphate which precipitates and leads to the clogging of drippers. So the pH of the medium should be decreased below 7 by using high dose of phosphoric acid in the water tank to avoid precipitation of phosphates.

INTERCROPPING

As citrus trees take longer time to yield any profit to the grower, it is desirable to supplement one's income by growing some short-term crops particularly during the first four to five years. Judiciously selected and grown intercrops, besides providing additional income, suppress weed growth, reduce the evaporation of soil moisture and add considerable quantities of organic matter to soil. However, it must always be kept in mind that our major interest lies in the fruit-trees. Good growing conditions for the trees should be maintained at all times and the pests and diseases of both the crops must be kept under control. Short statured leguminous crops such as moong, mash, cowpea, gram, pea, groundnut, etc., can be grown as intercrop in citrus. In sweet orange orchards, guara-wheat can be taken during the first 5-6 years, with guara as green manure. Crops requiring more water than the citrus plants should be avoided, particularly barseem and potato. Tall growing crops which tend to overshadow the young plants and crops which tend to climb on trees should not be grown as intercrops.

Sufficient space should be left unsown around the young plants to make unrestricted growth. The fruit trees and intercrops should be provided with independent irrigation system and their fertilizer requirements should be met separately.

TRAINING AND PRUNING

Pruning healthy, mature citrus trees usually reduces yield in proportion to the amount of foliage removed and can delay fruiting of young, non-bearing trees. Pruning should therefore be limited to that required for future canopy bearing surface development and for the conduct of efficient cultural and harvesting operations. Proper control of vegetative growth is essential for the maintenance of healthy, productive citrus orchards. Most orchards must be pruned at some time during their development to avoid problems associated with dead wood and overcrowded trees. When pruning should begin will depend to a large degree on the initial tree planting density. Crowded conditions result in poor light availability, loss of lower foliage and bearing wood, relocation of fruiting to the upper tree canopy areas and reduction in fruit yield, size, and external quality. Good management therefore, dictates the need to prune before the occurrence of these undesirable effects.

The response to pruning depends on several factors including variety, tree age, vigour, fruiting habits, growing conditions and production practices. As no one system or set of rules is adequate for the numerous situations encountered in the field, growers are encouraged to gain a clear understanding of the principles involved in pruning.

Sunlight

The importance of sunlight intercepted by the tree canopy on

the production of high yields of good quality fruit cannot be overemphasized. Light provides the energy for photosynthesis in which carbon dioxide from the air and water from the soil are combined in the leaves to form the basic foods upon which trees live, grow and bear fruit. Light becomes a limiting factor in crowded orchards and pruning improves light access. Adjustments must be made to maximize sunlight penetration into the tree canopy. Sunlight not only influences flowering and fruit set but also enhances fruit quality and colour development.

In citrus, carbohydrates are stored in leaves, twigs, and branches with only a minor amount going to the root system. The maximum amount of stored food is reached in spring just before the onset of growth flush activity. The foliage of citrus trees therefore acts as an important food storage area and heavy pruning causes the tree to produce vegetative growth at the expense of fruit production.

Basic Pruning Methods

Heading back and thinning out are the main types of pruning cuts and are used for somewhat opposing objectives. Heading back removes the terminal portion of a shoot or branch, destroying apical dominance and stimulating lateral bud breaks. This tends to produce a more bushy and compact tree. As the individual tree increases in size, internal wood may become less productive and eventually die. Thinning out involves the removal of complete branches to laterals or to the main trunk and is done by selective pruning with hand-held equipment. It encourages longer growth of the remaining terminals and can result in a larger, more open tree. This type of pruning may be done for better light penetration into the tree

Pruning Severity

The balance between tree growth and fruitfulness appears to depend, to some extent, upon the relationship between carbohydrates and nitrogenous compounds within the tree. When both are adequate, moderate growth and high yield occur. When both are low, citrus trees

grow and fruit poorly. A tree low in carbohydrates and high in nitrogen tends to produce vigorous vegetative growth at the expense of fruit production. Since carbohydrates are manufactured and stored in the leaves, heavy pruning which removes a large portion of the leaf area can result in this condition. Too much nitrogen after pruning can aggravate the problem, causing thick and puffy fruit peel. Reducing nitrogen applications avoids an imbalance when heavy pruning is done. Omitting a nitrogen application before heavy pruning and possibly after will reduce both costs and excessive vegetative growth. The length of time this limitation should continue will depend upon the severity of pruning and the rate of top recovery. Light maintenance pruning should not affect fertilizer requirements.

The orientation of branches in space has a marked effect on growth and fruiting. A decrease in growth rate and an increase in flowering occurs when branches are bent to a horizontal position. A possible explanation for this phenomenon is a change in the distribution of growth substances and carbohydrates. Favouring horizontal branches over upright ones should result in better growth control and more fruit production.

Severe pruning stimulates vigorous new vegetative growth, especially when done before a major growth flush. This happens because an undisturbed root system is providing water and nutrients to a reduced leaf area. The larger the wood is cut, the larger the subsequent shoot. Vegetative response to pruning is greatest where the most severe cuts are made, resulting in a strong tendency for pruned trees to resume their natural shape. Severe pruning reduces fruiting and increases fruit size and juice content, it decreases soluble solids and acid, with usually no change in the soluble solids/acid ratio. Such pruning of a severely crowded orchard typically results in a crop reduction in the first year, recovery of yield in the second or third year, and higher yields thereafter, although this can vary with tree vigour, orchard conditions and the size of the previous crop.

Pruning in Young Trees

Severe pruning and training of young, non fruit-bearing trees tend to delay fruit production and should be avoided. Most trees usually need no pruning for the first few years in the orchard except for removal of sprouts on the trunk. These can be easily brushed off when young and tender moreover, the wounds will be small. Larger sprouts should be cut off carefully without injuring the trunk. Occasionally, a vigorous sucker will dominate a weak tree or a sucker may arise from the rootstock. These should be removed early before they compete with more desirable growth. Selection of permanent scaffold branches during the first few years is rarely successful since the natural growth habit of these trees is so unpredictable. New growth may occur at unexpected places and become dominant over selected branches. When the tree is 3 or 4 years old, depending on its growth, branches that are too closely spaced or are crossed and entangled may be removed. This pruning should be light, just sufficient to establish a desirable framework without stimulating excessive vegetative growth. Optional pruning during the next several years should be limited to removal of water sprouts, dead wood and occasional branches which interfere with the growth of scaffold limbs.

Pruning in Mature Trees

These require little pruning until trees approach containment size. Deadwood may be removed every year, since it can scar fruit and be a source of infection. All cuts should be made into live wood. When an orchard is laid out, each tree is allotted a unit of space in which to grow. When this space is exceeded crowding occurs resulting in inadequate light conditions, loss of foliage and fruit production in the lower portion of the tree. Cultural and harvesting operations are also adversely affected.

Some farmers remove some of the branches in dense canopy of Kinnow trees to improve sun light penetration, resulting in increased production of better quality fruits in the interior of the tree. Such pruning is referred as 'window pruning'.

Crop Regulation

Kinnow is known for its heavy bearing, however, this habit becomes problematic in the first 3-4 years of plant age. Kinnow tends to bear heavy crops during the first 3-4 years of age, sometimes 400-500 fruits are borne per plant. As excessive bearing during the first few years exhaust the tree, plant health suffers seriously resulting in decline of some plants. Fruits on young Kinnow plants must be thinned out judiciously soon after setting during May-June to prevent overbearing.



Over-bearing in young Kinnow plant

WEED MANAGEMENT

Favourable climate of Punjab allows quick weed seed germination and growth, particularly in spring and rainy seasons. Weeds compete with citrus trees for nutrients, light, water, space, besides harbour diseases, insects and rodents that attack citrus trees. Competition between weeds and mature trees for nutrients and water is a major problem resulting in yield reduction. Thus, the objective of any weed control operation is the suppression of the undesirable effects of weed populations to an acceptable level. Positive responses in terms of tree growth and productivity have been observed with the control of weeds in citrus groves.

A successful weed control programme depends on proper identification of weed species and selection of the most efficient control practices. Weeds can be controlled by following mechanical and chemical methods. Mechanical means include control of weeds by rotavating, clean cultivation, manual hoeing, discing, etc. As citrus are shallow rooted plants so deep and frequent hoeing should be avoided, only need based shallow tilling operations should be undertaken. Chemical weed control, by the use of herbicides, is becoming popular with the citrus growers. Herbicides are very effective if properly applied, but are also potentially hazardous if not applied properly. Care should be taken that herbicide solution does not fall on citrus trees. Chemical weed control minimizes labour, reduces damage to tree roots and trunks at the same time improves movement within the orchard. When properly selected and applied, herbicides will not injure healthy



Weed control in Kinnow orchard by manual hoeing



Weed control in Kinnow orchard by weedicide application

citrus trees. Herbicides used in groves are divided into two groups i.e. soil-applied pre-emergence and foliar-applied post-emergence. Control of specific weeds is dependent on herbicide selection, application rate and weed species. In Punjab, most of weeds in citrus orchards can be controlled with by spraying Glycel 41 SL (Glyphosate) @ 1.6 litre/acre as post emergence (second fortnight of March) followed by Glysel 41 SL or Gramaxone 24 WSC (paraquat) @ 1.2 litre/ acre (in second fortnight of July) in 200 litres of water.

HARVESTING AND POST-HARVEST HANDLING

The horticultural crops, including citrus fruits are characterized by peculiar problems of being highly seasonal, perishable and bulky in nature. Due to this, citrus fruits need high degree of care at harvest and post-harvest phases. Losses in post harvest of citrus fruits are estimated at about 25-35% as the product moves from citrus grooves to ultimate consumers. Activities like sorting, grading and standardization, packing are not taken care of by the growers resulting in decreased profitability. Most of the traditional packages have been developed on the basis of easy availability of material. Moreover, growers are not familiar with maturity indices and produce of differing maturities, grades and conditions are packed together. Produce harvested at the correct maturity stage, well graded and packed according to its requirements, can guarantee a profitable return.

Judging Maturity

Citrus fruits do not ripen after picking. They must be fully ripe when harvested. A sour fruit may lose some acidity after picking, especially if allowed to dehydrate but it will have an insipid taste. Immature fruits when harvested will give poor quality and erratic ripening. Similarly, delayed harvesting increases their susceptibility to decay resulting in poor quality and hence, low market value. Fruits should be allowed to develop proper flavour on the tree. There are number of indices that can be used to judge maturity of citrus fruits. Fruit colour and size are two most important characters employed by small orchardists to judge maturity. However, this method is not

reliable in Kinnow as colour break in it starts in October-November, when fruits are still immature. Ratio of total soluble solids to acidity (TSS/acid ratio) is very reliable index for judging maturity in citrus fruits. But it is usually difficult for small and medium sized farmer to adopt this method. Most commonly adopted standards for harvesting different citrus fruits are given in the following table:

Table: Maturity indices for citrus fruits in Punjab.

| Variety | Fruit colour | Flesh colour | TSS/ acid ratio | Maturity time |
|--------------------------|--------------------------------|------------------------|-----------------|-----------------------------|
| Mandarin | | | | |
| Kinnow | Golden orange | -- | 12:1 to 14:1 | Mid-January to Mid-February |
| Local | Cadmium | -- | -- | December-January |
| Sweet Orange | | | | |
| Mosambi | Greenish-yellow | Pale yellow or whitish | 30:1 | November |
| Jaffa | Orange yellow to orange red | Light orange | 14:1 | December |
| Blood Red | Cadmium yellow | Partial to full red | 14:1 | December-January |
| Valencia Late | Deep golden | Orange | 10:1 | February-March |
| Grapefruit | | | | |
| Star Ruby | Yellow with red blush | Deep red | 7:1 | November |
| Red Blush | Deep yellow with crimson blush | Crimson | 6:1 | Last week of November |
| Foster | Pale yellow | Pink | 6:1 | November-December |
| Marsh Seedless | Light yellow | Greyish green | 7:1 | December-January |
| Duncan | Yellow | Creamy | 6:1 | January |
| Lime & Lemons | | | | |
| Eureka | Lemon yellow | -- | 2:3 | August-September |
| Baramasi | Lemon yellow | -- | 6:5 | July-October |
| Galgal | Yellow | -- | 5:5-7:5 | Early September |

Harvesting and Handling

Harvesting and handling of citrus fruits especially Kinnow need great attention to preserve the quality of fruit. Bruises and injuries later show up as avenues for micro-organism attack and lead to rotting. It is a popular misconception that citrus fruit can withstand rough handling. Citrus is more durable than many other fruits, but it does bruise easily. The difference is that citrus bruises may take several days to become evident, by which time the fruit usually has been transported. Consequently, rough handling should be avoided during harvesting operations. The fruits should not be pulled from the branches during harvesting as the skin from stem-end can get ruptured. Harvest with the clipper retaining a non-protruding short fruit stalk (button). Long stems left on the fruit at picking must be removed during packing, which reduce packing efficiency. Of more importance is the fact that stems left on the fruit can damage other fruits, thereby causing spoilage and fruit loss. Fruits born on high branches are difficult to harvest. Commonly a long pole with a curved blade is used to harvest such fruits. Use of *Dangi* not only spoils the fruit but also causes twig breakage. Ladder is the best mean to reach high fruits. Ladder placement in the tree should be done carefully to avoid damaging fruit on the tree and limb breakage. Experienced pickers ease the ladder edgewise into the tree before rotating it into climbing position. Harvesting during early hours of the day when there is dew on fruits or immediately after rains should be avoided, as skin at this time is turgid and very susceptible to injury. The fruits should be collected in picking bags carried over the picker's shoulders. The sack is then lowered into appropriate containers and unhooked to open the outlet at bottom. The fruit are pooled in the shade for grading and they should not be exposed to direct sun rays to prevent scorching.

Grading of fruits

For getting premium price and assuring quality to consumers, the fruits are graded for different sizes and variation within one grade range should be minimum, not more than 10% or as permitted by the importers. Grades of citrus fruits are based on soundness, firmness, cleanliness, size, weight, colour, shape, disease scars, insect damage



Kinnow harvesting clippers

Proper method of harvesting citrus fruits



Properly harvested Kinnow fruits

and mechanical injury. Grading and sizing of fruits is done manually or mechanically or both methods are employed in combination. For export purpose the APEDA (Agricultural and Processed Food Products Export Development Authority) has given the following grades:

Table : Grades of Kinnow fruit.

| Grade | Fruit Diameter (mm) | No. of fruits per 10 kg box |
|-------|---------------------|-----------------------------|
| A | 60-64 | 84 |
| B | 65-69 | 72 |
| C | 70-72 | 54 |
| D | 72-74 | 54 |
| E | 75-79 | 51 |
| F | 80-85 | 45 |
| G | 50-60 | 96 |
| H | 45-50 | 120 |

Packaging and Storage

Citrus fruits are usually packed in wooden boxes for transportation to distant markets within the country, while for nearer markets baskets of various sizes made from split bamboo are used. Chopped straw, dry grass and news papers are used for padding. Fruits are packed in gunny bags also which are loaded in trucks for transportation to different markets. The packages are handled very carelessly by labour resulting in huge losses in transit. Progressive farmers are using Corrugated Fibre Board Boxes with the name of farm printed on the boxes. Fruits packed in CFB boxes are sold at premium in market. The fruits can be packed in boxes in 3 or 4 layers in such a way that they do not get pressed while in transit. Normally, a box size of 45 cm x 24 cm x 18 cm having 10 kg capacity is acceptable and suitable for distant marketing. The box must have 5 per cent area punched as holes for ventilation.

The Kinnow fruits harvested at optimum maturity, packed in ventilated corrugated fibre board boxes can be stored at 5-6 °C and 90-95% relative humidity. The quality of fruits stored in this way remain acceptable for 45 days.

Kinnow washing, grading and waxing machine



Kinnow fruits being washed in machine



Kinnow fruits of different grades collect in different containers



Proper packaging of waxed and graded Kinnow fruits



Storage of Kinnow fruits in HDPE bags



Shrink wrapped Kinnow fruits have longer shelf-life



Packed fruits ready for transportation

The wax coating helps in checking the water loss from fruit surface, imparts fresh glossy appearance and prevent secondary infection during handling. After harvesting, the Kinnow, Daisy and Star Ruby fruits should be washed in clean water followed by a dip in 0.01 per cent chlorinated water (Sodium hypochlorite 4% @2.5ml/l water). The fruits are partially dried and Citrashine wax should be applied. The waxing of fruits can be done either mechanically (spray brush or spray nozzle type application) or manually (with foam pad, mist spray or dip method). After waxing, the fruits are again dried. This technique helps in improving the appearance and maintains the fruit quality during transit, storage and marketing for 2 weeks.

Shrink wrapping of Kinnow and Star Ruby fruits with 15-micron thick shrink wrapping film has been found to improve the appearance and maintain fruit quality during marketing upto two weeks. For shrink wrapping harvested Kinnow fruits should be washed with 0.01 per cent chlorinated water (Sodium hypochlorite 4% @ 2.5 ml/l water). The fruits are surface dried under shade, placed in paper moulded trays followed by wrapping with shrink film.

The healthy unbruised Kinnow harvested during the 1st week of February can be stored for 8 weeks at prevailing room temperature by individual seal packing in 10 micron thick high density polyethylene bags. Healthy fruits free from injuries, blemishes, and insect and disease attack are harvested at full maturity. These fruits are washed in 0.1% aqueous solution of sodium hypochlorite followed by rinsing in clean tap water. The fruits are dried in shade followed by packing in HDPE bags. These bags are sealed with electric sealer or with rubber bands.

Larger sized Marsh Seedless grapefruits store better than the small sized fruits at room temperature. These can be stored for 60 days at 15-20°C. Treatment of harvested fruits with GA₃ at 30 ppm and wrapping in polythene (100 gauge) considerably improve the storage life. For preparing 30 ppm GA₃, dissolve 1.5g GA₃ in a small quantity of ethyl alcohol (30-50 ml) and make volume to 50 litres with water.

Daisy has short harvesting period of 20 days i.e. November 1 to 20. By ethephon treatment duration for which Daisy mandarin can be marketed can be increased. Degreening with ethephon improve fruit colour as well as fruit quality. Daisy fruits harvested at colour break stage develop orange colour in 3-4 days after dip in Ethephon (a.i. 1000 ppm) for 5 minutes. Dissolve 2.5 ml ethephon in one litre of water to make 1000 ppm ethephon solution. Similarly, fully mature, light green and smooth skinned fruits of Baramasi lemon-1 can be degreened in 6-7 days in first week of June at room temperature after dipping in 1250 ppm ethephon solution for 5 minutes, followed by packing in CFB boxes with paper lining for advance marketing of summer crop.

OTHER DISORDERS

Sun Burn

Sun burn usually occurs during May-June. Damage symptoms appear on leaves, stems and fruits. Fruits of south-western side of the tree are affected maximum. Symptoms on leaves appear as burning and affected tissue become brown. Damaged areas on fruits have advanced colour break and in later stages drying of exposed portions of peel and pulp occurs. As black colour absorbs more heat, so fruits covered with sooty mould are more prone to heat damage. Moisture stress during summer months aggravates this problem.

Cold injury

Frost can damage both tree and fruit of all citrus varieties, but some are more sensitive than others. Limes and lemons are the most tender, oranges and grapefruit are of intermediate hardiness and mandarins are the most hardy. The fruit is usually damaged when temperatures fall below 3.3 °C for a period of several hours.

Young trees can be successfully protected from frost by providing irrigation when frost is expected, covering them with rice straw thatches or plastic bags. If plastic bags are to be used make sure to build a frame to keep the plastic away from tree foliage.

Fruit cracking

This is believed to be a problem of disturbed water relations in plant, peel thickness and peel maturity of the fruit. Trees take up water from rain or irrigation and fruit expands, cracking the peel of the fruit.

Fruit cracking is a particularly serious problem in Baramasi lemon. Frequent light irrigations during summer months reduce the incidence of fruit cracking. Plants should not be exposed to water stress.

Granulation

Granulation is a physiological disorder in citrus that results in reduced extractable juice and sometimes vesicle shrivelling. While segments appear dry, the disorder is not caused by drying, but by gel formation within the vesicles. Many factors have been associated with the development of granulation in citrus, including advanced fruit maturity, large fruit, excessive tree vigour, severe mite damage, composition of the juice, and cool, dry, windy weather conditions. Tree water status and irrigation have also been reported to affect granulation with researchers reporting less granulation with less irrigation. Cultural practices that encourage vigorous tree growth have also been reported to promote the development of granulation.

Hail damage

Hails injury appears as bruising, shredding, defoliation or physical mangling of foliage and stem. Tattered holes may be obvious in larger leaves. Fruit, twigs and even larger stems may exhibit open, ragged-edged wounds in the skin or bark. With time the wounds on twigs and limbs get surrounded by callus tissue. Damage to fruits nearing maturity can resemble bird pecking damage. In addition to the direct damage caused by hail, wounds caused by impact can serve as the infection point for fungal and bacterial diseases.

Wind scars

This damage occurs as the result of twigs, thorns or leaves rubbing against young fruits. The injured area grows with the fruit and become large as fruit grow. Unlike insect damage scars, this type of scar is usually superficial and the shape or pattern of the scar may suggest the source of abrasion. The damage is usually cosmetic, however, it decreases the grade of fruit and invasion of injury site by micro-organisms can cause rotting of fruits. To reduce wind damage,



Frost injury



Heat injury



Fruit cracking



Granulation



Hail injury on twigs



Hail injury on fruits



Stionic incompatibility



Protruded areole formation in some fruits of Kinnow

dead and diseased wood should be removed soon after fruit harvesting. In very windy areas, wind breaks should be planted to reduce the wind speed.

Rootstock-scion incompatibility

The inability of two different plants, grafted together, to produce a successful union and to develop into one plant is termed as incompatibility. In the initial years incompatible stionic combination grows normally, however with the passage of time plant starts declining. Incompatibility becomes evident as an anatomical disturbance at the graft union like, crease formation, necrotic bark, etc. Translocation of water and nutrients is hindered within the plant. Incompatibility has been observed between Mosambi on rough lemon, Blood Red on rough lemon and Karna Khatta.

Protruded areole in Kinnow fruits

In some fruits of Kinnow, protruded areole formation occurs. It appears that under certain climatic conditions, particularly at the time of flowering, lead to expression of this character. The areole formation is a normal character of King mandarin, one of the parents of Kinnow mandarin.

INSECT AND MITE PESTS

Citrus psylla

Diaphorina citri Kuwayama

Host plants

Citrus, *Murraya paniculata*, *Cardia cordata*, *C. cordifolia*, *Cleusenia lansium*, etc.

Damaging stage(s): Nymphs and adults

Identification of damage

Both the nymphs and adults suck plant sap. Nymphal stage causes more damage than the adult stage. Heavy de-blossoming may occur. Leaves show chlorotic symptoms. Size of the leaves gets reduced and leaves become distorted and curled. The infested twigs die-off from tip backward, probably due to toxin released by psylla during feeding. This insect excretes honeydew, which is covered with a waxy secretion of circumanal glands. In case of severe damage, waxy material falls under tree on ground giving the ground a whitish look. Unlike secretions by aphids and scale insects that results into growth of sooty mould, honeydew excreted by psylla does not results in deposition of sooty mould on leaves. Ants can be seen commonly moving at the site of infestation. It is a vector of greening disease and one of the major factors for citrus decline. Damage of this pest has been observed in most of the orchards surveyed in Punjab.



Citrus psylla; (a) Nymphs, (b) Waxy secretions by nymphs, (c) Adults, (d) Damage

Peak activity period

March-April, July-August and September-October.

Management

This insect is difficult to control as its adults can live for about 6 months. Egg laying capacity of females is tremendous. Each female can lay more than 800 eggs. There are 10 overlapping generations. This insect is available in the orchards throughout the year except in winter where only adults are observed.

Spray 1250 ml Rogor 30 EC (dimethoate) or 200 ml Crocodile/ Confidor 17.8 SL (imidacloprid) or 160 g Actara/ Dotara 25 WG (thiamethoxam) or 6.25 litre MAK HMO (Horticulture Mineral Oil) in 500 litres of water per acre during March or with the appearance of the pest and again in the first week of September. Time of application may be adjusted with the appearance of the pest.

Note: There should not be any water stress at the time of application of HMO. Time of application may be adjusted with the appearance of the pest.

Citrus leaf miner

Phyllocnistis citrella Stainton

Host plants

Citrus, bael, willow, *Murraya exotica*, *Larantes* sp., etc.

Damaging stage(s): Larva

Identification of damage

This is the most harmful insect-pest of citrus nursery and young plantations. Its infestation coincides with the flush periods. Larvae feed in epidermis of leaves making serpentine silvery mines usually on the ventral side. When the infestation is severe, mines also appear on dorsal side of the leaves. The serpentine mines become silver coloured because of entrapped air in these mines. Tiny pupae can be seen in the damaged leaf in the mines. Such leaves are folded from the edge due



Citrus leaf miner; (a) Damage on leaf (silvery serpentine mines), (b) Damage on twig, (c) Larva feeding inside Kinnow leaf, (d) Adult (magnified)

to spinning of cocoons by the larvae. Leaves get distorted, crumpled and curled from margins towards inner side. Ultimately, the damaged leaves dry up and fall down. Mines appear on tender twigs also. Severe defoliation may occur, which results in reduced growth of nursery plants. The leaves folded due to damage by leaf miner serve as shelter site for harmful insects like mealybugs, grey weevil and citrus psylla and useful biocontrol agents like coccinellid beetles and spiders. Citrus leaf miner is known to enhance citrus canker disease.

Peak activity period

Last week of April to mid June and last week of July to first week of November.

Management

This insect is very difficult to manage under nursery conditions as its life cycle is very short and there are 16 overlapping generations in a year. Moreover, larvae hide themselves in the mines.

Spray 500 ml Sumicidin 20 EC (fenvalerate) or 1000 ml Ripcord 10 EC (cypermethrin) or 1250 ml Triazophos 40 EC or 1875 ml Durmet/ Massban 20 EC (chlorpyrifos) or 200 ml Crocodile/ Confidor 17.8 SL (imidacloprid) or 160 g Actara 25 WG (thiamethoxam) in 500 litres of water during April-May and again during September-October. Repeated application of synthetic pyrethroids should be avoided on full-grown trees as this may enhance chances of development of resistance to these pesticides and they also enhance the damage caused by mites.

Citrus whitefly & blackfly

Citrus whitefly: *Dialeurodes citri* (Ashmead)

Citrus blackfly: *Aleurocanthus woglumi* Ashby, *Aleurocanthus husaini* Corbett

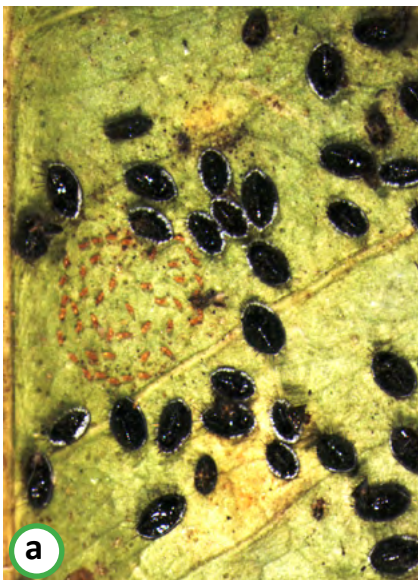
Host plants

Whitefly: Citrus, pomegranate, jamun etc.

Blackfly: Citrus, grape, mango, guava, pear, plum, pomegranate,



Citrus whitefly; (a) Pupae, (b) Eggs and adults



Citrus blackfly; (a) Eggs (in spiral form) and black pupae, (b) Adults

sapota, banana, poinsettia, *Gardenia jasminoides*, etc.

Damaging stage(s): Nymphs and adults

Identification of damage

Both nymphs and adults suck plant sap and reduce the vigour of the plant. Severely infested foliage turns pale green to brown. Foliage may also become curled and ultimately shed. Infested tree gives blackish appearance due to sooty mould growing on honeydew. Few flowers are produced on such trees and fruits developing from such flowers have insipid taste. White and black pupae of whitefly and blackfly, respectively can be seen on the underside of the leaves.

Peak activity period: April-May and September-October

Management

Spray 1000 ml Fosmite 50 EC (ethion) or 1250 ml Triazophos 40 EC in 500 litres of water per acre during April-May and again during September-October.

Aphids

Black citrus aphid: *Toxoptera aurantii* (Boyer de Fonscolombe), *Aphis craccivora* Kuch

Green peach aphid: *Myzus persicae* (Sulzer)

Cotton aphid: *Aphis gossypii* Glover

Host plants

Black citrus aphid : Specific on citrus

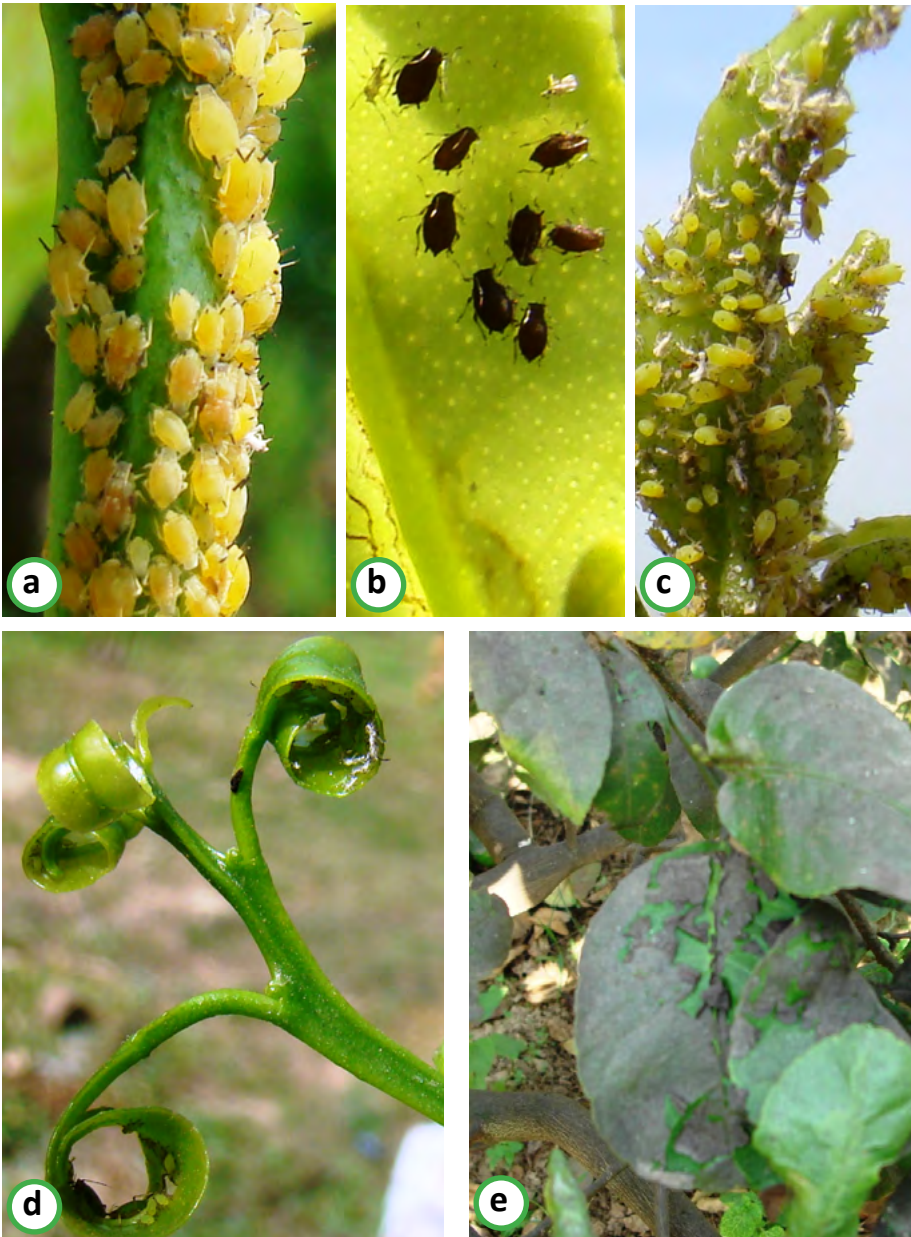
Green peach aphid: Polyphagous

Cotton aphid: Polyphagous

Damaging stage(s): Nymphs and adults

Identification of damage

Nymphs and adults suck sap from tender leaves and shoots. Affected leaves turn yellow, get curled, deformed and dry up. Growth of young shoots is adversely affected. Plant growth is stunted. Sooty mould is produced on honeydew excreted by aphids. Infestation of aphids at the time of flowering is associated with reduced fruit set.



Aphids; (a) Nymphs of cotton aphid, (b) Nymphs of citrus black aphid, (c) Nymphs of green peach aphid, (d) Damage by green peach aphid (leaves curled), (e) Sooty mould due to aphids

Black aphids and green peach aphids are vector of citrus tristeza virus (CTV). This pest has been observed in most of the citrus orchards surveyed in sub-mountain zone.

Peak activity period

- **Black citrus aphid and green peach aphid:** February-April, August-October,
- **Cotton aphid:** August-October

Management

Spray 1250 ml Rogor 30 EC (dimethoate) or 1000 ml Metasystox 25 EC (oxydemeton-S-methyl) or 200 ml Crocodile/ Confidor 17.8 SL (imidacloprid) or 160 g Actara/ Dotara 25 WG (thiamethoxam) or 6.25 litre MAK HMO (Horticulture Mineral Oil) in 500 litres of water per acre during March or with the appearance of the pest and again in the first week of September.

Citrus thrips

Scirtothrips citri (Moulton)

Host plants: Citrus

Damaging stage(s): Nymphs and adults

Identification of damage

Thrips have become serious pests of citrus nursery and young plantations. They are minute insects but can be seen with naked eyes. They cause damage to flowers, leaves and young as well as grown-up fruits by lacerating, rasping and sucking the cell sap. The attacked flowers dry up and shrivel. On leaves, two whitish lines parallel to the midrib can be seen. Leaves become cup shaped, leathery, distorted and wrinkled. Thrips damage in nursery cause stunted growth of plant. Silvery-white irregular patches and a circular ring appear around the neck of fruit is a peculiar symptom of thrips damage on fruits. Fruits become discoloured, thereby reducing the consumer preference for such fruits.



Citrus thrips; (a) Damage (Leaf distorted and wrinkled), (b) Damage (Leaves distorted and wrinkled), (c) Damage on fruit (Circular ring pattern), (d) Nymph (magnified)

Peak activity period

First week of March to third week of April.

Management

Spray 1250 ml Triazophos 40 EC or 1000 ml Fosmite 50 EC (ethion) twice in 500 litres of water. First spray may be given in mid-March and second in mid-April.

Citrus mites

Citrus mite: *Eutetranychus orientalis* Klein

False spider mite: *Bravipalpus* sp.

Host plants: Citrus, pear, peach, pomegranate, etc.

Damaging stage: Nymphs and adults

Identification of damage

Mites do not fall into the category of insects. They are very minute creatures though visible to naked eye. *Eutetranychus* mite sucks sap usually from the upper surface of the leaves and tender shoots. Affected leaf surface loose normal colour, become dull yellowish brown and tend to collect lot of dust, which impairs photosynthetic activity. Such leaves ultimately drop down. *Bravipalpus* mite cause damage to citrus fruits and is associated with rind disorder. Zigzag lines appear on fruits, reducing the consumer's acceptability.

Peak activity period

May-June and August-September

Management

Spray 1000 ml Fosmite 50 EC (ethion) or 750 ml fenazaquin 10 EC or 670 ml Rogor 30 EC (dimethoate) in 500 litres of water as soon as mite population appears on the underside of the leaves. Repeat the spray if needed.



Citrus mites; (a) Damage on Kinnow leaf (webbing), (b) Damage on grapefruit leaf (webbing), (c) Damage on Kinnow fruit (irregular wavy lines), (d) Eggs and mites (magnified)

Fruit sucking moths

Eudocima fullonia (Clerck), *Eudocima materna* (Linnaeus) and *Acanthodelta janata* (Linnaeus)

Host plants

Polyphagous (Citrus, grape, mango, guava, *ber*, pomegranate, castor, etc.).

Damaging stage

Only adult moth causes damage. This insect is a unique example of damage by a moth in an adult stage. Its semilooper larvae are leaf defoliators and feed on other host plants, usually wild plants and creepers like *Tinospora cardifolia* (Giloe). Caterpillar of *A. janata* feed on leaves of castor.

Identification of damage

Adult moth sucks the juice of ripening fruits after dusk (sun set) during the rainy season. The moths have a strong proboscis with sharp spines with which they pierce the ripening fruits. A circular pinhole like spot appears at the feeding site. Later on, the area around the damaged portion turns yellowish-brown. As many as 16 holes have been recorded on a single fruit of Kinnow. On squeezing such fruits, jet of fermented juice comes out from each hole. The punctured fruits are easily infected with bacteria and fungi. As a result, the fruit get rotten and falls prematurely.

Peak activity period

July to October (mainly in the sub-mountain zone of Punjab, particularly in the Kandi belt of District Hoshiarpur and Pathankot near the forest areas). During 2010-2013, about 70 to 100 per cent fruit damage was observed in Kinnow and sweet orange orchards in Kandi belt of District Hoshiarpur.

Management

This insect is difficult to control as its caterpillar feeds on weeds and other plants around the orchards. Moreover, moths cause damage

after sunset.

- Destruction of other hosts like wild weeds and creepers, especially *T. cardifolia* around the citrus orchards is very important.
- Fallen fruits should be disposed off as they attract the moths.
- Bagging of fruits at small scale is effective.
- Creating smoke in the orchards after sunset repels the moths away from the orchards.
- Spray trees with 1 kg of Sevin 50 WP (carbaryl) in 500 litres of water per acre at the time of maturity of fruits.

Mealybugs

Planococcus citri (Risso), *Planococcus lilacinus* Cockerell, *Nipaecoccus viridis* Newstead, *Maconellicoccus hirsutus* Green, *Drosicha mangiferae* and *Drosicha stebbingi*.

Host plants

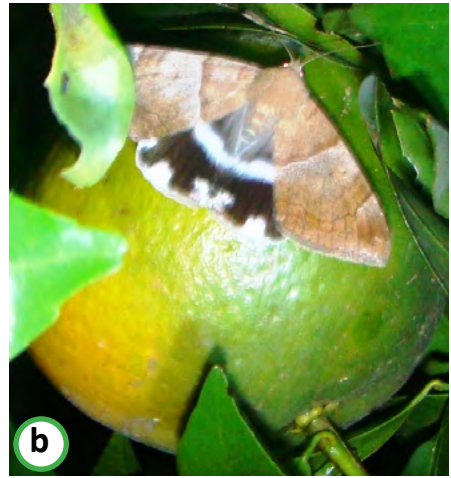
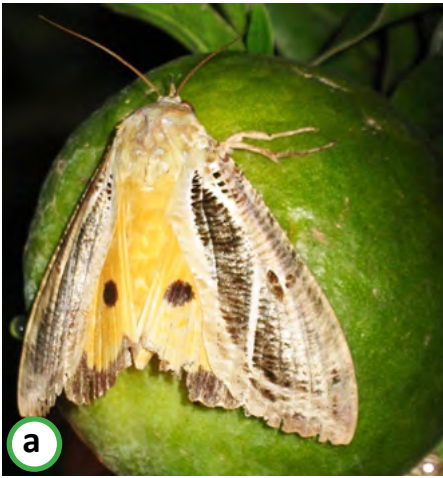
Polyphagous (citrus, guava, ber, aonla, pomegranate, jamun, sapota, etc.)

Damaging stage: Nymphs and females. Males are harmless.

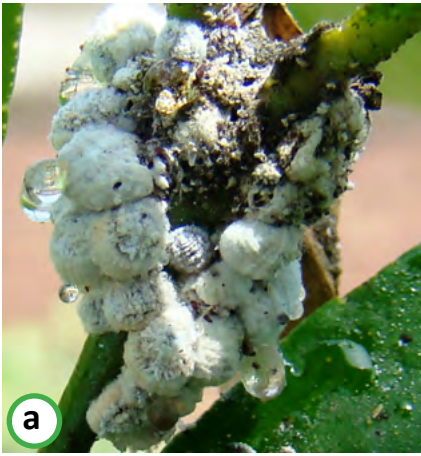
Identification of damage

Nymphs and females suck sap from leaves, twigs, tender shoots, and from fruits at the base near the fruit stalk. Besides, they also excrete honeydew on which sooty mould fungus grows, giving the plant a blackish look. Flowers and fruit dry up and fall. They also damage citrus nursery seedlings. Black ants are associated with mealy bug infestation and number of ants can be seen moving up and down on the trees infested with mealybugs. In winter, all these species of mealy bugs hibernate (winter sleep). Damage of this pest has been observed in most of the citrus orchards surveyed, particularly under high density planting.

Peak activity period: April-October



Fruit sucking moths; (a) *Eudocima materna* adult feeding on Kinnow fruit, (b) *Acanthodelta janata* adult on Kinnow fruit, (c) Damage on Kinnow fruit, (d) *Eudocima fullonia* adult



Mealy bugs; (a) *Nipaecoccus viridis* on nursery plant, (b) Twig of nursery plant dried due to damage by *N. viridis*, (c) Mealybug on mature Kinnow fruit, (d) Damage by *N. viridis* in nursery plant (distorted leaves)

Management

- Do not grow tall crops like cotton, chari, bajra, maize, barseem, okra and creeper like vegetables in the orchards.
- Regularly monitor the infestation of trees by these insect.
- Sanitation of the orchard is extremely important as weeds act as additional hosts. Uproot and destroy congress grass and castor plants in the vicinity of the orchards.
- Do not allow the branches of trees to touch the ground.
- Prune or remove the infested branches and destroy them.
- Destroy the ant nests in the orchards.
- Drench spray of 1875 ml Durmet/ Dursban/ Coroban/ Massban 20 EC (chlorpyrifos) in 500 litres of water first on the appearance of the pest and repeat the spray if required.

Fruit flies

Bactrocera zonata (Saunders), *Bactrocera dorsalis* (Hendel) and *Bactrocera cucurbitae* (Coquillett)

Host plants

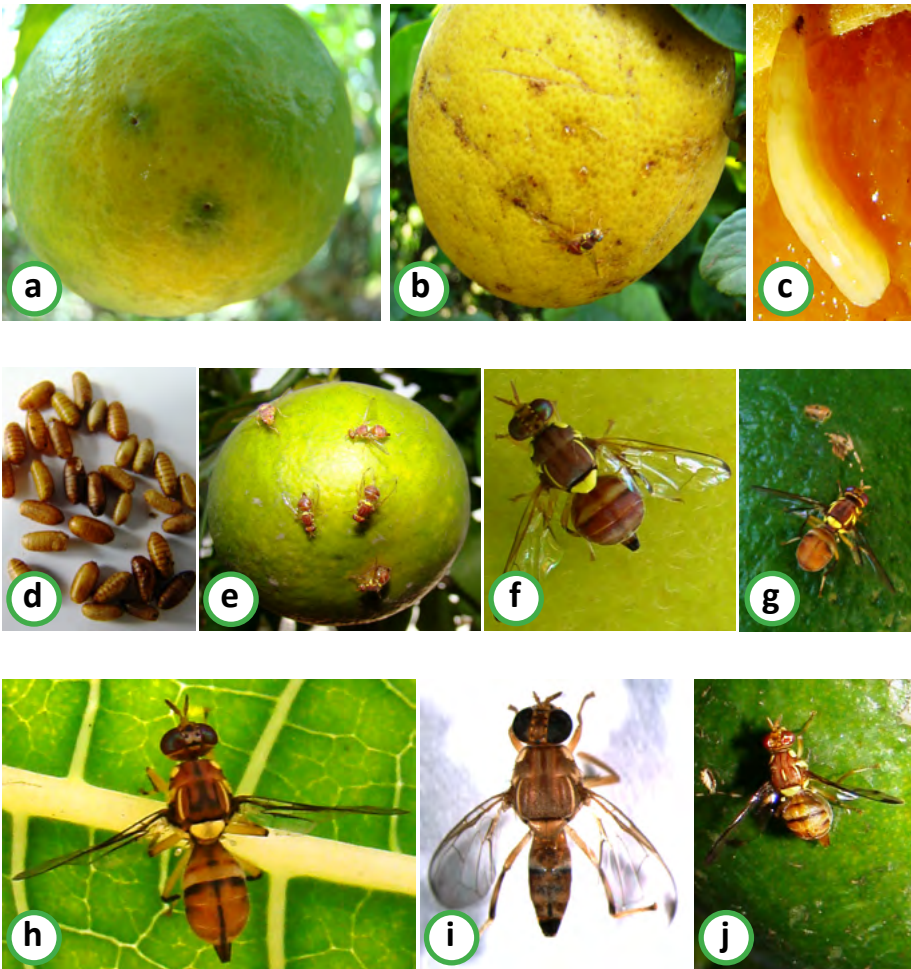
Polyphagous (Citrus, guava, peach, pear, plum, mango, loquat, sapota, fig, wild fig, phalsa, papaya, grapes, etc.)

Damaging stage

Female flies and maggots. Male do not cause any damage.

Identification of damage

The female adult fruit fly punctures the ripening fruits by penetrating its needle like ovipositor and lays the eggs inside the fruit. On hatching, the maggots feed on pulp. Fruits at colour break stage are more prone to its damage. Infested fruit shows many dark green depressions due to punctures caused by insertion of ovipositor by female fly. Later on, the damaged area around the punctures becomes enlarged and yellow. On squeezing the infested fruit, a number of jets of juice comes out, as there are many holes on a single fruit. Rotting of the fruit occurs due to fungal and bacterial infection through the



Fruit flies; (a)Ovipositor punctures due to fruit fly on Kinnow fruit, (b) Damage of fruit fly on lemon fruit, (c) Maggot of fruit fly, (d) Pupae of fruit fly, (e) Female fruit flies ovipositing on Kinnow fruit, (f) Female of *Bactrocera zonata*, (g) Male of *Bactrocera zonata*, (h) Female of *Bactrocera dorsalis*, (i) Male of *bactrocera dorsalis*, (j) Female of *Bactrocera cucurbitae*

puncture hole and due to feeding by maggots, resulting in premature fruit fall. Apart from Kinnow, fruits of other citrus species like grapefruits, sweet oranges, mosambi and lemons have also been observed damaged by fruit flies. The damage is more prevalent in sub-mountain zone and central zone as compared to arid irrigated zone. An outbreak of fruit flies was observed in Kandi belt of District Hoshiarpur in 2004. Since then, damage from 25-80 per cent has been recorded every year. Damage on citrus fruits is increasing due to carryover from other crops as it is a highly polyphagous pest.

Peak activity period: August-November

Management

Fix PAU fruit fly traps @ 16 traps/acre in the second week of August. If effectiveness of traps decrease, then new traps should be used. Proper sanitation measures should be followed in the orchards to avoid re-infestation. All the infested fruits should be destroyed by burying in at least 60 cm deep pit as each fruit carry more than 30 maggots. Female fruit flies emerging from most of these maggots will cause re-infestation of healthy fruits. Pits should be covered with soil after every 2-3 days.

Citrus caterpillar or lemon butterfly

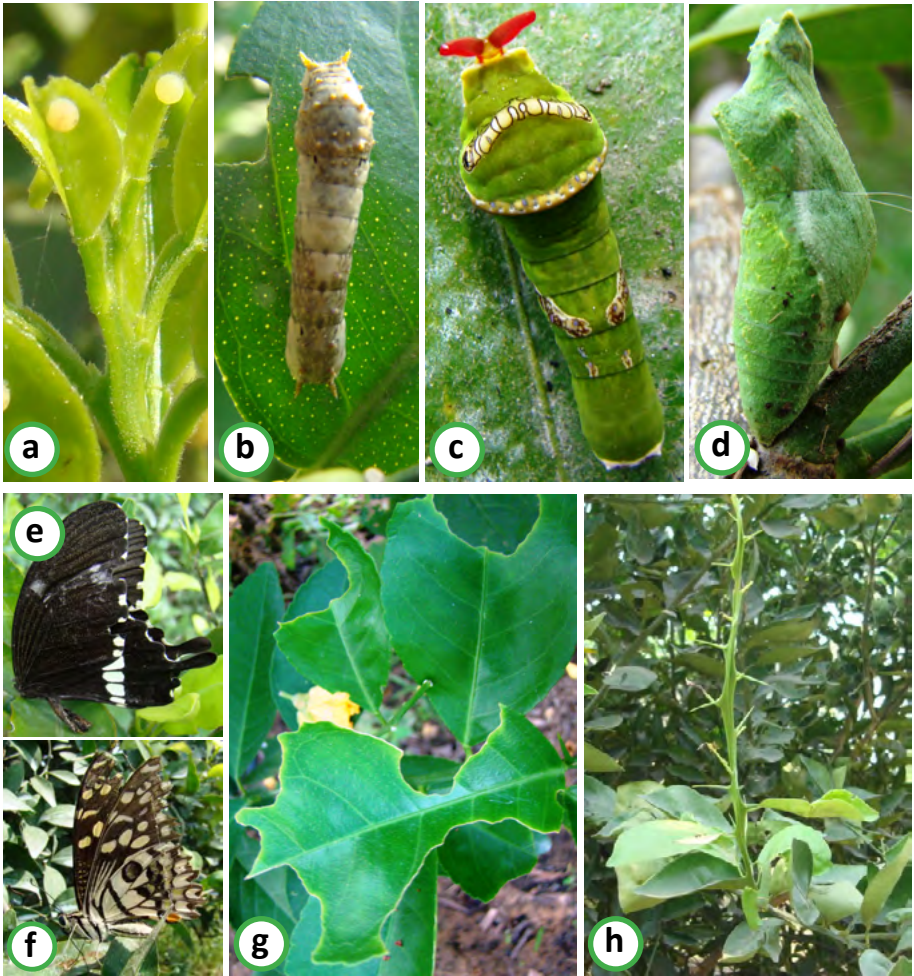
Papilio demoleus Linnaeus and *Papilio polytes* Linnaeus

Host plants: Citrus, *bael*, etc.

Damaging stage: Caterpillar

Identification of damage

This is a very serious insect under nursery conditions and in young orchards. Larvae appear like bird dropping in early instars. Full-grown larva turns green. Leaves are eaten from the edges to the midrib. In case of severe attack, only midribs are left behind. Complete defoliation may occur resulting in stunted growth of the plant. Caterpillar, when feels threatened or frightened, produces a jet of fluid having strong odour from a fleshy organ (shaped like a snake tongue) behind the head known as osmeterium. This is a natural defence



Citrus caterpillar or lemon butterfly; (a) Eggs, (b) Grown-up caterpillar, (c) Full-grown caterpillar, (d) Pupa, (e) Adult of *Papilio polytes*, (f) Adult of *Papilio demoleus*, (g) Damage on leaves (leaves eaten from margins), (h) Severe damage (complete defoliation)

mechanism in this insect.

Peak activity period

April-May and August-October

Management

The insecticides recommended for the control of whitefly can be used in case of severe attack.

Citrus leaf folder

Psorosticha zizyphi Stainton

Host plants: Citrus, ber, bael, etc.

Damaging stage: Larva

Identification of damage

Larvae roll the tender leaves by secreting silken strands and feed inside the folded leaves from tip downwards. Excreta can be seen on the other leaves near the site of infestation. Plant growth is stunted.

Peak activity period

July-August. Earlier, it was a serious insect-pest of young orchards and nurseries, but now it has become a sporadic and minor pest. In July 2012, its damage was observed in orchards in Bahawal in Hoshiarpur district. Now, it has become a regular pest of citrus nursery.

Management

Spray 1250 ml Dursban 20 EC (chloropyriphos) or 1000 ml Ekalux/Quinalmass 25 EC (quinalphos) in 500 litres of water.

California red scale

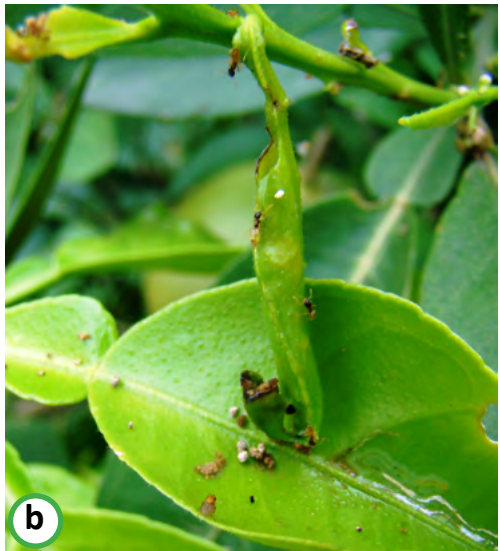
Aonidiella aurantii (Maskell)

Host plants: Citrus, grape, fig, etc.

Damaging stage(s): Nymphs and adult

Identification of damage

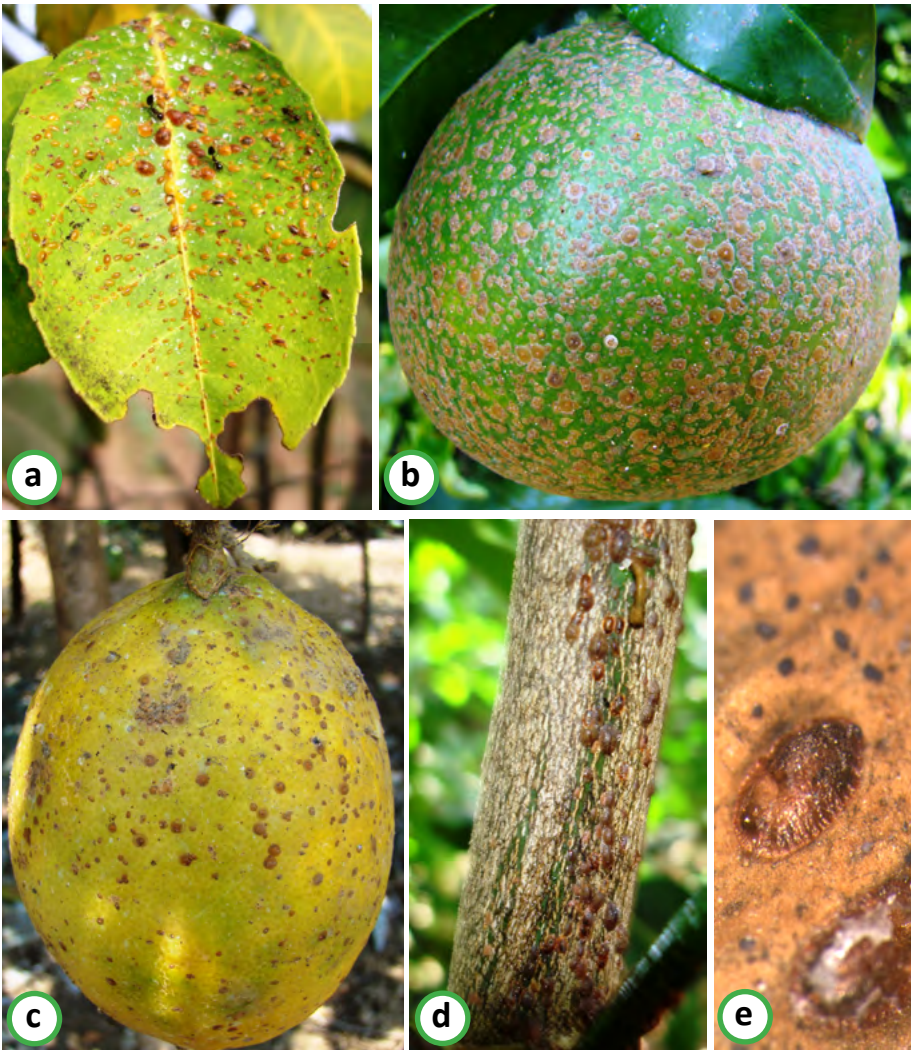
Small round scale insects suck sap from leaves, twigs and fruits.



Citrus leaf folder; (a) Adult, (b) Damage by citrus leaf folder larva on Kinnow leaf



Bark eating caterpillar; (a) Larva of bark eating caterpillar, (b) Damage by larva of bark eating caterpillar



California red scale; (a) Scale insects on lemon leaf, (b) Scale insects on Kinnow fruit, (c) Scale insects on lemon fruit, (d) Scale insects on Kinnow twig, (e) Nymphs of scale insect (magnified)

Waxy covering can be seen on the infested plant parts. Yellow spots appear at the feeding sites. Leaf fall occurs in case of severe damage. Sooty mould develops on honeydew produced by scales. Branches gradually dried up. In case of severe attack, fruits may be deformed.

Peak activity period: March-April and July-October

Management

Spray 1875 ml chloropyriphos 20 EC in 500 litre water per acre.

Bark eating caterpillar

Indarbela quadrinotata Walker

Host plants

Polyphagous (Citrus, mango, guava, jaman, loquat, mulberry, pomegranate, ber, litchi, aonla and number of forest and ornamental plants, etc.).

Damaging stage: Larva

Identification of damage

Damage is usually observed in neglected and old orchards. Larvae make holes in the stems and limbs for hiding and feed on the bark. Webbing consisting of silken threads, frass and excreta can be observed on the bark of the main stem especially near the forks. Severe damage can result in the death of attacked stem. Blackish larva can be observed underneath the fresh webbing.

Peak activity period: September-October

Management

Remove the webbing and inject kerosene oil into the holes during September-October and again in January-February.

DISEASES

1. Foot rot/Gummosis

Causal organism: *Phytophthora parasitica*

Factors favouring disease development

Various cultural practices like flood irrigation, low budding, deep planting, injuries to the trunk and roots during orchard operations, piling of manure near the tree trunk, thick weed growth under the tree canopy, growing of incompatible intercrops and use of the same site for nursery raising make the trees more susceptible to the disease. The optimum range of 25-28°C temperature is favourable for the occurrence of the disease.

Symptoms

- The disease causes hidden damage by decaying the feeder roots of nursery and grown-up plants. It is fatal to the trees, if they are not early diagnosed and timely treated, especially at initial stages of infection.
 - Profuse gumming on the trunk, limb and branches, pale green foliage and shedding of leaves during the months of November-January are the diagnostic symptoms of the disease in the orchard.
 - The first symptom is the oozing of gummy drops on the bark surface of the trunk, usually below or just above the bud union. The colour of the bark and wood below the bark becomes dark brown. The bark develops vertical cracks.
-



Gummosis on trunk

- Lesions that may spread around the circumference of the trunk, slowly girdle and kill the trees.
- Infected trees usually produce large number of flowers, which shed before fruit set and the plants die before fruits mature.

Management

Preventive measures: The disease is soil-borne and once it enters in nurseries and orchards, it becomes very difficult to eradicate the disease. So “prevention is better than cure”. Obtain the planting material from disease free nurseries. Keep the bud union 6 to 9 inches above the ground level at the time of planting. Avoid flood irrigation. Keep the tree basin slightly elevated to avoid water stagnation around the trunk. Avoid injuries to the trunk and crown roots during cultural practices. Don't pile soil around the trunk. Remove the trees that show trunk lesions (girdling) on half or more of the circumference.

Chemical control: Scrap the infected bark portion, along with some healthy green part, and disinfect the wounds with disinfectant solution. Collect and destroy the scrapped diseased bark by burning to avoid further spread of the pathogen in the soil. Apply paint of Ridomil Gold MZ 68 WP or Curzate M 8 or Ridox 72 WP or Metamil 72 WP or Matco 8-64 @ 2g/100 ml of linseed oil to the surgical portion with the help of brush, twice in a year during February-March and July-August. Clean the root zone of the tree by hoeing. Dissolve 25 g of any of these fungicides in 10 litres of water for treating one tree and drench the root area with the solution followed by light irrigation in February-March and July-August. Give two sprays of Aliette 80 WP (Fosetyl-AI) @ 2.5g/litre of water in April and September.

2. Fruit drop

In Kinnow, excessive fruit drop is a major bottleneck causing reduction in yield and quality of harvested produce. The Kinnow fruits continue to drop at various stages of the fruit growth and development.

Distinct periods of fruit drop

First drop (Post setting drop)

It occurs soon after flowering. Generally, the trees bear large number of the flowers and fruits, all of which they are unable to carry to maturity. This initial drop occurs due to the abscission of weak flowers, fruit lets with defective styles or ovaries and the flowers that do not receive sufficient pollen during pollination.

Second drop (Pea size drop)

It occurs in early summer, a few weeks after the first drop. During this drop, fruits have a 3-5 cm diameter. This drop is particularly severe in hot dry climate and under improper soil moisture conditions.

Third drop (Pre-harvest drop)

It usually starts during July and continues till harvest. This drop in the months of September and October is the most detrimental, as the fruits have already reached near maturity and have drawn nourishment from the tree. This drop is of much economic importance and if left uncontrolled it can seriously reduce yield and returns.

The dropping of fruits in citrus can be attributed to two main causes i.e. physiological and pathological.

A) Physiological fruit drop

This drop starts from April, becomes serious in May-June and occurs again in September-October:

Causes

- i. Heavy bearing.
- ii. Improper fertilization.
- iii. Sudden change in temperature and low humidity.
- iv. Prolonged spell of frost.
- v. Improper soil moisture conditions.
- vi. Prolonged flooding and improper irrigation.
- vii. Drought.

- viii. Mineral nutrient deficiency of Ca, Mg, S and Zn.
- ix. Hormonal imbalance.

Symptoms

This drop is diagnosed by observing the development of an abscission layer at the point of attachment of fruit with the twig (stalk end). The dropped fruits are light green in colour and show development of orange colour around the stalk end with intact green promodia.

B) Pathological fruit drop

Causal organism: *Colletotrichum gloeosporioides*, *Diplodia natalensis*, *Alternaria citri*

Factors favouring disease development

- High inoculum (Black dot like fruiting bodies) of these fungi built up on the dead twigs, leaves and fruit stalks serves as a source of primary inoculum for initiation of die-back and fruit drop in the next season.
- High humidity and temperature alongwith rainy season are more conducive for the development of pathological fruit drop. The disease initiates from diseased twigs during spring season (February-March) and stops its development during April-June in hot summer days and further rains from July onwards provide favourable conditions for the development and rapid spread of the disease causing maximum fruit drop in mid-September to mid-October.

Symptoms

- This drop can be recognized by the appearance of small, circular, light brown lesions around the stalk end of the fruit.
- The dropped fruits are deep yellow to brown colour and show dark brown coin like rotting around the stalk end. The affected area around the fruit rots resulting into pre-mature fruit drop.
- In some fruits, lesions are present on both stalk end as well as styler end of fruits.
- Sometimes fruits shrink due to late infection; become black, light in weight, mummified and remain attached to the stalks for a



Fruit drop in Kinnow



Physiological fruit drop in Kinnow



Pathological fruit drop in Kinnow

longer period.

Management

- Prune and burn all the diseased twigs in January-February and again before monsoon to reduce the inoculum potential followed by spray of Bordeaux mixture (2:2:250) or copper oxychloride 50WP (3g/litre of water).
- Do not pile the pruned wood near the orchard as it acts as source of infection.
- Remove and destroy the mummified fruits on the trees as well as the fallen fruits under the trees. Do not keep heaps of these fruits anywhere in the orchard.
- For the management of physiological and pathological fruit drop, spray the trees with 1250 ml Ziram 27 SC or 500 ml Propiconazole 25 EC or 500 g Carbendazim 50 WP in combination with 5 g 2,4-D (sodium salt of horticulture grade) using 500 litres of water in mid-April, mid-August and mid-September. Give two additional single sprays of 1250 ml Ziram 27 SC or 500 ml Propiconazole 25 EC or 500 g Carbendazim 50 WP using 500 litres of water in end-July and end-September.

Caution: Spray 10 g GA₃ per acre in 500 litres of water instead of 2,4-D when cotton or other broad leaved crops are cultivated in or around the citrus orchard.

3. Die-back/Anthracnose

Causal organism: *Collectotrichum gloeosporioides*

Factors favouring disease development

Neglected and poor management conditions of the orchards predispose citrus plants to this malady. Extreme moisture, temperature around 25°C and wind make the plants more vulnerable to the disease.

Symptoms

- The disease appears in several forms, including die-back of twigs, leaf spotting and rotting and dropping of fruits.



Anthracnose



Die-back of twigs

- Drying of twigs starts from tip downwards producing typical die-back symptoms and numerous black dot like fruiting bodies of the fungus appear on the dead twigs.
- Leaves show light green spots which turn brown and finally become grey in the centre with brown margins. The greyish areas show numerous fruiting bodies arranged in concentric rings.
- The stem-end infection of immature fruits appears as a small brown area. As the area enlarges, a soft dark brown pliable rot develops.

Management

- Prune and destroy the infected twigs during February to reduce the primary source of inoculum.
- Spray the plants with Bordeaux mixture (2:2:250) or Copper oxychloride 50 WP (3g/litre of water) during March, July and September.

4. Citrus canker

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

Factors favouring disease development

This disease appears with the onset of rains in the first week of July and thereafter it goes on increasing as high humidity and well distributed rainfall are favourable for disease development. The infected nursery plants, contaminated budding tools, wind-driven rains and insect (citrus leaf miner) are the main sources of disease spread.

Symptoms

- The disease causes extensive damage to the leaves, twigs and fruit. It becomes very destructive in nurseries and 2-3 years old plants.
- Canker appears as tiny, circular, water soaked yellowish spots, which gradually enlarge and give a rough, corky and brownish appearance surrounded by a chlorotic yellowish halo or rings.
- The lesions are raised on both sides of the leaves.



Citrus canker on leaves



Citrus canker on twigs

- The lesions may coalesce to form large necrotic areas which lead to excessive leaf drop and twig die-back.
- Canker lesions on the fruit have similar appearance as on the leaves except that the yellow halo is usually absent. The lesions are only confined to the rind and do not impair the fruit pulp and juice.

Management

- Use disease free nursery plants for planting new orchards.
- Prune all the infected plant parts before monsoon and burn them. Disinfect the cut ends with Bordeaux paste.
- Dispose the infected fruits properly.
- Give three sprays of 50g of Streptocycline + 25g Copper sulphate in 500 litres of water per acre in the month of October, December and February. Bordeaux mixture (2:2:250) or Copper oxychloride 50 WP (3g/litre of water) can also be sprayed for reducing the canker. Spray the nursery plants particularly during rainy season (July-August).

5. Citrus scab

Causal Organism: *Elsinoe fawcetti*

Factors favouring disease development

High humidity, rainfall and temperature around 16-23°C are favourable for the infection. Under such conditions the fungus can readily invade the young leaves, tender twigs and developing fruits.

Symptoms

- The disease produces typical scab lesions on leaves, twigs, shoots and fruits. It is more common on the newly emerged leaves and shoots.
- On leaves, it appears as rough, irregular, raised, thorny lesions on the under side of the leaves.
- Scabby leaves become distorted, wrinkled, stunted and misshaped. Slightly raised and warty lesions appear on young



Citrus canker on fruits



Citrus scab on leaves

shoots.

- The lesions on fruits are corky having projections. Infected fruits become hard and often drop prematurely.

Management

- Use scab-free nursery plants.
- Clip off the scabby leaves & twigs in July before the onset of monsoon and burn them.
- Collect and destroy the infected and fallen fruits.
- Give three sprays of Ziram 27 SC (2.5 ml/litre of water) or Dithane M-45 (2.5g/litre of water) or Copper oxychloride 50 WP (3 g/litre of water) or Bordeaux mixture (2:2:250) starting from last week of June to August at 20 days interval.

6. Sooty mould

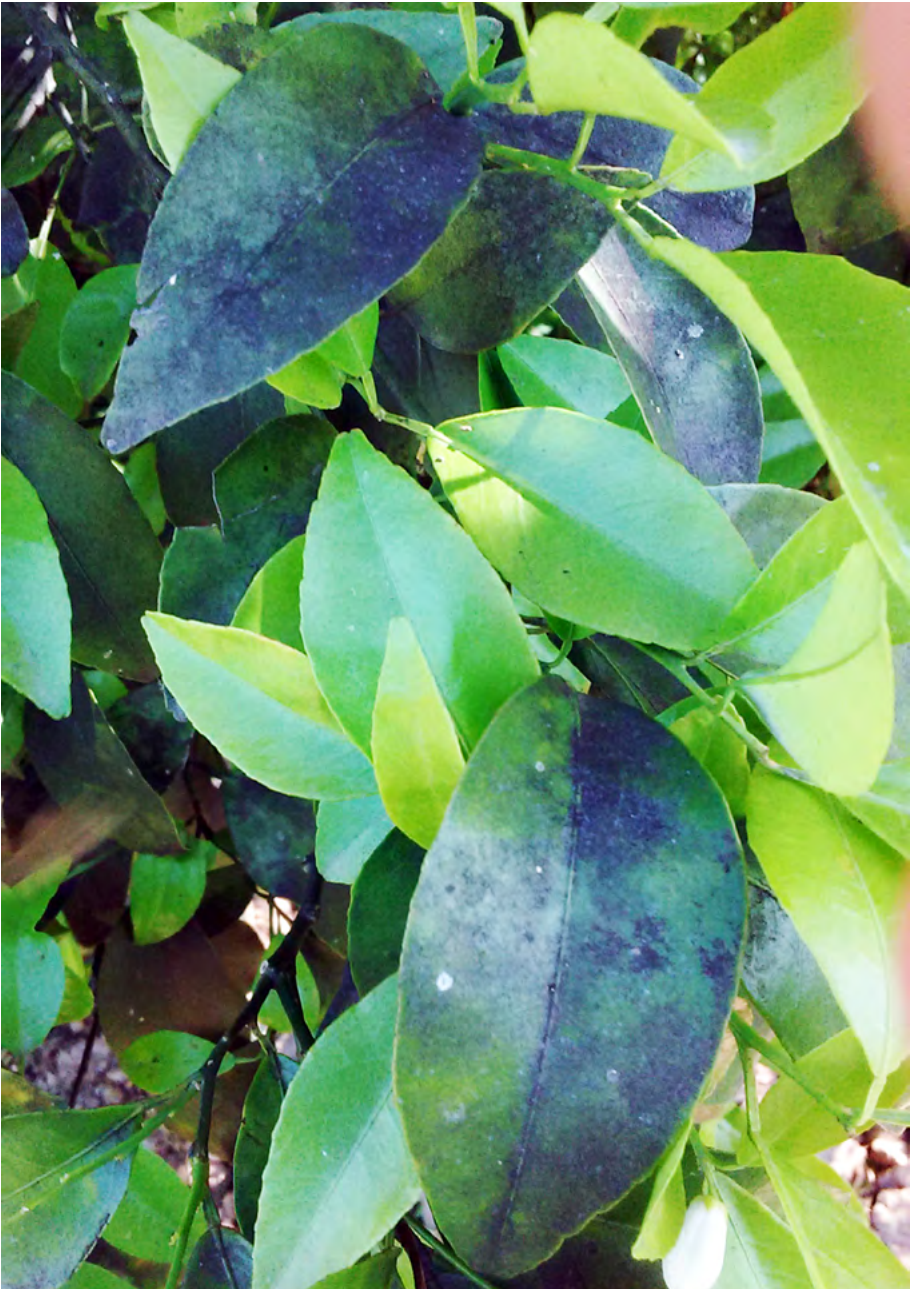
Causal organism: *Capnodium citri*

Factors favouring disease development

It is the most common disease of citrus in areas, where insect population is high. High humidity is favourable for the development of the disease. The incidence of the disease is more on shaded and closely spaced trees.

Symptoms

- This disease develops on the honey-dew excreted by whiteflies.
- Symptoms appear as black velvety superficial coating on leaves, twigs and fruits.
- The affected leaves exhibit curling and shriveling symptoms
- Heavy infestation leads to poor growth flushes, less flowers and fruits in next cropping season.
- The mould deposits may delay the fruit colouring. It becomes difficult to remove the fungus mass from the fruit rind in packing



Sooty mould

houses which results in poor market acceptability.

Management

- Give three sprays of Ziram 27 SC (1250 ml) + Ethion 50 EC (1000 ml) in 500 litres of water at monthly interval in August, September and October.

7. Citrus greening

Causal organism: *Liberobacter asiaticus* (fastidious bacterium)

Mode of Transmission

The disease is transmitted by budwood used for propagation from the infected plants. In nursery and orchard further spread of the greening is by citrus psylla vector.

Symptoms

- Initial symptoms appear as yellowing of foliage of only one limb or parts of tree canopy. The leaves of infected trees show a chlorotic pattern similar to zinc deficiency. A characteristic feature of greening is that the yellow areas are surrounded on one side by the green mid-ribs and on the other side by lateral veins. Appearance of green dots or islands in yellow background of leaves are peculiar symptoms.
- Diseased leaves are small, upright, leathery and drop prematurely.
- As the disease advances the plants show severe die-back symptoms.
- Infected plants flower earlier and infected fruits are small in size, lopsided and poorly coloured. Fruits remain green on the shaded side, hence the name “greening” disease.

Management

- Use disease free bud-wood obtained from certified nursery.
- Prune and burn dead wood and branches showing greening symptoms to reduce inoculum potential and its secondary spread by psylla.



Citrus greening symptoms on leaves



Citrus greening symptoms on fruits

- Control citrus psylla vector by spraying recommended insecticides.

8. Citrus ring spot

Causal agent: *Citrus ring spot virus* (CRSV)

Mode of Transmission

CRSV is transmitted by infected bud, dodder (*Cuscuta* sp.) and mechanical means.

Symptoms

- The mature leaves exhibit typical yellow rings (one to several per leaf with variable diameters) with green tissue in centre. Several rings coalesce to form big patches by covering the entire leaf. Later on, the infected leaves drop prematurely, resulting in heavy defoliation.
- Severely infected plants develop a thin canopy and show die-back and decline symptoms. Infected plants produce less fruits of small size and poor quality.

Management

- Use virus-free bud-wood for citrus propagation.
- CRSV free nursery plants can be raised by eliminating the disease by exposing the bud sticks to hot air treatment and shoot tip grafting.

9. Citrus tristeza

Causal agent: *Citrus tristeza virus* (CTV)

Mode of Transmission

The virus is transmitted through infected budwood. Further spread in the nursery and orchard is by aphid vector. The long distance spread of the virus is by using CTV-infected nursery plants.



Ring spot symptoms on leaves

Symptoms

- Honeycombing, a fine pitting of the inner face of the bark in susceptible rootstock portion below the bud union is the most diagnostic symptom for tristeza. In contrast, inverse stem pitting symptoms also appear in sour orange serving as diagnostic tools.
- Another characteristic symptom is vein clearing and flecking of young leaves in infected Kagzi lime (*Citrus aurantifolia*).
- The infected trees show partial or complete suppression of growth with various types of leaf chlorosis. Such trees are unable to absorb adequate water and nutrients which results into defoliation and die-back of twigs.
- Infected trees collapse suddenly within few days and the fruits often remain hanging.

Management

- Use certified elite planting material free of CTV and tolerant root stocks like Jatti Khatti (*Citrus jambhiri*).
- Eradicate and destroy the tristeza infected unproductive trees to check its further spread in the orchards.
- Control aphid vectors by spraying recommended insecticides.

10. Citrus exocortis

Causal agent: *Citrus exocortis viroid* (CEVd)

Mode of Transmission

The disease is transmitted through infected bud wood, dodder (*Cuscuta* sp.) and contaminated cutting tools. Spread of disease takes place by infected budwood or symptomless infected plants used for propagation of nursery. It is serious disease on susceptible rootstocks (Trifoliate orange, Rangpur lime and citranges).

Symptoms

- The diagnostic symptoms of disease appear as vertical splits in the bark of infected plants. The outer bark generally becomes partially loosened consisting of narrow, vertical, thin splits and imparts cracked and scaly appearance.

- The first symptom develops either at or below the ground line or at the bud union.
- The infected plants become stunted and give poor quality and quantity of fruits.

Management

- Remove and destroy the unproductive trees and use viroid-free budwood on tolerant rootstocks (Rough lemon, Cleopatra and Pectinifera).
- Prevent CEVd spread to healthy trees by disinfecting the horticultural tools (knife and secateur) with solution of sodium hypochlorite.

PREPARATION OF DIFFERENT FUNGICIDES

Wound disinfectant solution

| | | |
|-------------------|---|--------|
| Mercuric chloride | : | 1 g |
| Methylated spirit | : | 250 ml |
| Water | : | 750 ml |

Glass vessels or porcelain jars should be used for preparation and storage of the solution. Apply the disinfectant solution on the cut-ends and the wounded surface with a large swap of cotton. Allow the disinfectant to evaporate and cover the treated surface with Bordeaux paste which is applied with a brush.

Bordeaux paste

| | | |
|-----------------------------|---|-----------|
| Copper sulphate | : | 2 kg |
| Quick lime (Unslaked lime): | : | 3 kg |
| Water | : | 30 litres |

Dissolve 2 Kg of copper sulphate in 15 litres of water. Take another 15 litres of water. With a small quantity of the second lot of water slake slowly 3 Kg of quick lime. Add the remaining quantity of water to it. Mix both the concentrated solutions and stir. Apply the paste to cut surfaces and wounds with a brush.

Bordeaux Paint

| | | |
|------------------------------|---|----------|
| Monohydrated copper sulphate | : | 1 kg |
| Hydrated lime dust | : | 2 kg |
| Boiled linseed oil | : | 3 litres |

For the preparation of monohydrated copper sulphate, spread the copper sulphate crystals on a sheet of iron (Tawi) or a frying pan

over fire till they crumble into a white amorphous powder. Lime dust and copper sulphate powder are mixed thoroughly and then boiled and cooled linseed oil is added to the mixture. All the three ingredients are thoroughly homogenized. Bordeaux paint is now ready for application. It should either be stored in a closed vessel or made fresh, when required. Bordeaux paint makes the covered surface impervious to water. It is quite helpful in protecting the wounds from the wood rotting fungi.

Bordeaux mixture (2:2:250)

| | | |
|----------------------------|---|------------|
| Copper sulphate | : | 2 Kg |
| Quick lime (Unslaked lime) | : | 2 Kg |
| Water | : | 250 litres |

Wooden or earthen containers should be used for the preparation of Bordeaux mixture. The raw material should be of good quality. Use copper sulphate of 98 percent purity. Quick lime should be free from earth and sand. Solution of copper sulphate and lime should be made separately. For preparing the copper sulphate solution, dissolve 2 kg of copper sulphate in 125 litres of water. Copper sulphate dissolves slowly in cold water. Thus, use hot water or suspend copper sulphate in gunny sac into a wooden barrel or an earthen pitcher during winter season, so that the material remains immersed. Slake 2 kg of quick lime in another vessel and add water slowly, when the lime is completely slaked, add enough water to bring the volume to 125 litres. Then mix the two solutions either by pouring the copper sulphate solution into the lime solution slowly or the two solutions together into a third vessel. Strain the lime solution before mixing it with copper sulphate solution. Also, stir the mixture all the time while pouring. Stir and strain the mixture again when pouring into the sprayer pumps.

How to test Bordeaux mixture

- If the Bordeaux mixture contains excess of lime, it turns the red litmus paper blue and if it contains excess copper, it turns the blue litmus paper red. An excess of copper compound in the mixture is toxic to foliage.

- Dip a knife or an iron blade or a nail in the Bordeaux mixture and observe if copper deposits on it. A deposit of copper on the metal indicates that the mixture is unsafe. Add more lime solution to make the mixture safe.
- A more accurate test can be made with ferrocyanide of potassium. Add a few drops of the Bordeaux mixture to small quantity of ferrocyanide. If no change occurs, the mixture is safe but if it turns into reddish brown colour, it indicates that copper compound is present in excess. So, add more lime solution to make the mixture safe.

Bordeaux mixture should not be applied, when it is raining or on exceptional hot day when the plants are showing sign of temporary wilting. Fresh Bordeaux mixture should be sprayed as it loses its fungicidal activity on storage.

Whitewash mixture

| | | |
|-----------------|---|------------|
| Lime (slaked) | : | 25 Kg |
| Copper sulphate | : | 500 g |
| Gum/Suresh | : | 500 g |
| Water | : | 100 litres |

Dissolve the suresh/gum in hot water. Add all the constituents thoroughly. Whitewash the main trunk up to a height of 30 cm from the ground level in February-March and again, before the onset of monsoon (July-August).