

Chapter – 13

PRODUCTION RESTRAINTS AND MANAGEMENT IN MANDARIN AND AVOCADO FRUIT CROPS

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Mandarin Orange

The average productivity of citrus in India is 7.29 tonnes per ha which is far below the average productivity of 30-35 tonnes per hectare obtained internationally. In India, mandarin oranges (*Citrus reticulata* Blanco) are grown largely under tropical climatic conditions. For example, the famous Nagpur orange is grown in tropical vidarbha region of Maharastra in central India over 73 thousand hectares and Andhra Pradesh in South India. Over 56 thousand hectares enjoy a distinct tropical climate where there is no defined winter season with low temperature regime. The kinnow mandarins, however, is showing good promise and is commercially successful in North India states like Punjab, Haryana and Rajasthan falling under subtropical climate with distinct winter season. Similarly, the traditional mandarin growing areas of North eastern hills and the Coorg area of Karnataka state experience subtropical climate with high rainfall and low temperature during winter months. Mandarin oranges (*Citrus reticulata* Blanco) are fruit crops of worldwide importance and suited for subtropical climatic conditions. World production of mandarin in 1996 was about 15.6 million metric tons, which was about 15% of the world citrus total. The major producing countries (million t) were China (5.9), Japan (1.19, mostly Satsuma types), Spain (1.4), Brazil (0.76), Italy (0.45), Morocco (0.4) and the USA (0.5). However, by far the major exporters of fresh and processed mandarins were Japan, Spain and the USA. In India, the most important commercial citrus is the mandarin orange (Santras of Coorg, Assam, and Nagpur). Citrus fruits (mandarins, oranges, limes and lemons etc.) occupy 13% of the total area in fruits and contribute to 10.3% of the total fruit production.

Among citrus, the mandarins occupy nearly 41% of the total area under citrus, with an annual production of 13.4 lakh tonnes. The areas where mandarin is commercially cultivated have distinct problems of varied nature. The major production constraints are:

- Uncertainty about the remunerative returns due to high density planting.
- Unidentification of suitable rootstock scion combinations on a specific soil type.
- Irregular flowering.
- Inefficient irrigation and fertigation.
- Absence of promising diagnostic techniques leading to an efficient diagnosis of nutritional problems.

Production constraints in mandarins are varied from the soil and climatic requirements to enhancement of fruit qualities and they can be classified as follows:

Soil and Climatic Conditions

Soil Mandarins can grow well in a wide range of soils, but unsuitability of the soil could also lead to the failure of the crop. Soil properties like soil reaction, soil fertility, drainage, free lime and salt concentrations are some of the important factors that determine the success of mandarins. It thrives well in deep, loose, well aerated soils devoid of any hard pan layers of calcium carbonate in the root zones. A pH of 5.5 – 7.5 is ideal for mandarins. However, with suitable management the citrus could thrive well in highly acidic (pH 4.5) soils and in soils containing free lime (pH 8.5). Drainage of the soil is an important factor, while poor drainage is highly detrimental. Excess drainage leads to various nutritional imbalance problems. Presence of calcium pan within the feeding root zone adversely affects the permeability and aeration of the soil.

Mandarins are grown throughout the main citrus belt between 45°N and 35°S in the frost-free subtropical to semi-tropical climate. Being evergreen, citrus has no specific requirements for winter chilling, but cessation of growth activity during winter months helps in flower bud induction, resulting in spring flowering. The climatic factors like temperature, moisture (rainfall and atmospheric humidity), wind and light intensity are of principal importance for citrus, of which temperature plays a key role. Usually, a low temperature of –6.66 to –4.44°C is injurious to young trees and a temperature of –11.11 to –8.88°C is injurious to mature old trees. The Kumquats mandarins, *C. latipes*, *C. ichangensis* can tolerate low temperature. Hot winds and excessive heat during flowering and fruit set period are highly detrimental for good bearing and causes fruit drop and fruit sun-burn.

Atmospheric humidity has bearing mainly on the physical characters of fruits whereas temperature imparts effects on fruit quality. Low humidity usually favours better colour development of fruits, while in more humid conditions the fruits are juicier with thin rinds. Availability of quality planting materials and importance of certified nurseries Selection of rootstocks should be made in a region specific manner based on their ability to tolerate or resist the different viral and soil borne fungal diseases that occur on Citrus. Bold seeds from such rootstocks are to be selected and raised with sufficient quantity of organic manure in a well drained fertile soil free from soil borne pathogens and nematodes. Seeds should also be treated with fungicides to avoid seed borne infection. The off type seedlings of sexual or hybrid origin are to be rouged out to maintain true to type nucellar seedlings which are uniform in plant stand. The optimum temperature for germination is highly variable with the rootstock and it varies from 25°C for *P. trifoliata* to 32.5°C, for Rangpur lime x Troyer citrange.

Selection of Bud Wood

The bud donor trees are selected based on their true to type nature, high vigour and yield. The buds from the donor trees are budded on indicator plants in insect-proof scion houses to screen for the occurrence of the viral diseases. The standard indicator plants employed for the indexing are Kagzi lime, West Indian lime for tristeza virus, Etrog citron and Rangpur lime for exocortis virus; sweet orange for psorosis virus and sweet lime and Orlando tangelo for xyloporosis virus. By this process, disease free donors are selected. Bud wood certification programme Bud wood certification and registration programme has been initiated at four centres located at Poona, Ludhiana, Tirupati and Kahikuchi (Assam) for different varieties of citrus. At each centres, the certified bud woods can be produced following procedures as 56 detailed above. Australia is relatively free from the citrus virus problems because of the effective adoption of the bud wood certification programme.

Importance of Propagation Methods and Rootstocks

The propagation of mandarins is mainly as seedlings or as T-budding. Since most of the citrus species and varieties are polyembryonic, the propagation of nucellar seedlings alone carries the true characters of the mother plants, thus enabling to retain the clonal characters as in vegetative propagation. The phenomenon of polyembryony also helps in raising uniform seedlings. However, for grafting or budding, proper selection of rootstock is of profound importance to impart marked effects on the vigour, precocity, productivity, physico- chemical characteristics of fruits, longevity of trees, disease resistance, adaptability to soil – climatic conditions, etc.

Root stock studies at Horticultural Research Station, Thadiyankudisai revealed that the Mandarins on Rangpur lime rootstock recorded better performance among the six rootstocks (viz., Rough lemon, Cleopatra mandarin, Carriza citrange, Troyer citrange, trifoliate orange and Rangpur lime). The mandarin orange on Rangpur lime recorded the maximum plant height of 3.78m and produced the highest yield of 21.2kg/tree. This was followed by the trees on Rough lemon rootstock with a tree height of 3.58m, with a tree yield of 18.6 kg. Jattikatti (*C. jambhiri*) has been found to be the best rootstock for Kinnow mandarins of Punjab. For Nagpur mandarins, Florida rough lemon was found to be superior to karnakatta, while trifoliate orange was incompatible. The rootstock Kodakithuli (*C. resnyi* Lush) has been found to perform well in Pannaikadu region.

Planting and Spacing

In the north-eastern region of India, seedling-origin Khasi mandarin orange orchards are usually very closely spaced and in the old orchards, trees are found to grow even 2-3 metres apart in an irregular way. Mandarin orange being more or less upright in growth habit, particularly, when raised from seeds can be planted at a distance of 5-6 metres. In Haryana conditions, a spacing of 5x4.5m was found to be optimum for Kinnow mandarin budded on jatti khatti (*C. jambhiri*) rootstock, while a closer spacing of 3x3m was found to be unsuitable for Nagpur mandarin budded on rough lemons. Coorg mandarins are planted at a spacing of 4.5m.

High Density Planting in Mandarin

Mandarins are characterized by precocity and heavy bearing which has initiated the idea of close spacing in the initial years of bearing to realize better returns. A high density spacing of 6.0x3.0m under hedge row system (ie) 6.0m between hedges and 3.0m within row produced more yield per ha with regards to Nagpur mandarins and the fruit quality was also not much reduced as compared to the regular spacing of 6.0x3.0m (Ingle and Athawale, 2001). High density planting is also practiced to maximize the yield per unit area. High density planting of Satsuma mandarin accommodating 1666 to 3333 plants/ha considerably increased fruit production. Practising ultra high density planting with more than 5000 plants/ ha of Satsuma mandarins in Japan, a significant increase of fruit production has been recorded. However, in high density plantation, the life span of a cultivar may be reduced. Though the planting is usually done during the monsoon season, it is better not to plant at the time of heavy rains to avoid any waterlogging near the planting pits. Weather should not be too wet or too dry at the time of planting.

Manures and Fertilizers I yr II yr

Nutritional Management for Manadarin Orange

Manuring and Fertilization

Mandarin is a nutrient loving plant and about 15 elements have been known to play an important role for proper growth and development of the fruit. In addition to the major nutrients like N, P, K, Ca, Mg and S, citrus requires micro-nutrients like Zn, Cu, Mn, Fe, B, Mo, etc. Inadequate plant nutrition causes serious disorder in citrus and may eventually lead to decline of the orchards. Nutrient uptake studies for profitable production of mandarins are 182kg N, 54kg P₂O₅, 205 kg K₂O. In bearing stage of Khasi mandarin, a dose of 300g N, 250g P₂O₅ and 300g K₂O per tree applied annually was found economical for increased production.

Application of 600g N, 200g P₂O₅, and 400g K₂O annually per plant is recommended for Coorg mandarin. In Turkey, the highest fruit yield of Satsuma mandarin was obtained with 475g N, 320g P₂O₅ and 355g K₂O annually per plant. 2 5 2 Leaf nutrient status can be used as an index for fertilizer application. The following doses of manures and fertilizers are recommended for mandarin under Pulney hills in Coffee based cropping systems. III yr IV yr FYM (kg) V yr 10 15 VI yr 20 N (kg) 0.100 0.200 25 25 30 0.300 P (kg) 0.040 0.080 0.400 0.500 0.600 0.120 K (kg) 0.050 0.100 0.160 0.160 0.200 0.200 In Shervoroyan Hills (Trees > 6 yrs) 700:375:600g NPK with VAM @ 1kg per tree is applied every year. Trials conducted at Horticultural Research Station, Yercaud revealed that application of 'P' as enriched FYM (0.5 kg P₂O₅ /tree mixed with 20kg FYM) along with 700g 'N' and 600g K₂O/tree recorded the highest yield and improved the fruit quality of mandarin. 0.300 0.300 0.400 In light textured (sandy clay loam) acidic (pH 4.5) soils of Assam, application of Neem cake (7.5 kg/ plant) along with full dose of 600:300:600g NPK (T4 and T5) was found to maintain soil availability of NPK and produced the maximum yield and pest quality khasi mandarin (Huchche *et al.*, 2001).

In a trial at Horticultural Research Station, Yercaud, application of 375 g of P₂O₅ as mussoriphos and 500g VAM recorded the highest yield of 35.35kg with 386 fruits pr tree. Nutritional experiments conducted at AAU, Tinsukia revealed that the application of 600:300:600g N, P₂O₅ and K₂O with 7.5 kg neem cake / 2 5 2 plant recorded the maximum growth and yield (180kg/ plant) in khasi mandarin under Tinsukia conditions. Slow release for N is very much essential for well drained soil and hill zone mandarins, the leaching losses of N are very high.

Slow release fertilizers like gypsum and neem cake coated urea was found suitable for Nagpur mandarins with enhanced yield and leaf nutrient concentration (Borah *et al.*, 2001). To combat this problem, foliar spray after the new leaves have expanded to at least 2/3rd of their normal

Micronutrients Deficiencies

Magnesium: In acid soils / leached soils - yellow blotches start along the midrib.

Calcium: Found in acidic soils and in areas with high rainfall where leaching loss is great. Twig dieback and profuse flowering. Premature shedding of flowers and weakened stems.

Zinc: Severe mottling of leaves. Little leaf and sparse foliage. Inter-vein chlorosis and resetting of terminal leaves occurs.

Copper: The foliage of copper deficient trees may be dense and dark green in colour, later twigs die back, leaving very small, yellow green leaves which fall off easily. Gum pockets between the bark and the wood at or near leaf nodes may be present.

Boron: The general symptoms of B deficiency are a tendency to leaf thickening, wilt, buckling of leaves, yellow veins, corky veins, thick leaves, puckering along the midrib, small water-soaked spots becoming translucent with maturity on the leaves.

Iron: Characteristic chlorosis (Interveinal chlorosis). Young leaves are affected first.

Manganese: Immature growth is mottled with light green or yellowish-green areas between the major veins. Leaf size remains unreduced. The leaf veins and small adjacent areas of the veins remain green. Shady side of the leaves show more pronounced symptom. It is common in acidic coastal soils and alkaline soils.

Molybdenum: Light green spots appear in 3 to 4 months old fully enlarged leaves. The spots are fairly small in mandarins. Size can be undertaken using the following chemicals: Zinc sulphate, Copper sulphate 2.5kg, Manganese sulphate 1.5kg, Magnesium sulphate 1.0kg, Ferrous sulphate 1.0kg, Borax or boric acid 1.0kg, Urea 0.5kg, Lime 5.0kg, Water 4.5kg, 450litres among the different foliar application of micronutrients on mandarin, at Horticultural Research Station, Thadiyankudisai, Magnesium and Manganese at 0.5 % conc. with 1% Urea spray recorded the maximum plant height (449.20 cm).

Foliar spray with zinc and manganese at a similar concentration along with urea produced maximum number of fruits (276.6) and fruit weight (140.29). With respect to the quality, both the treatments produced fruits with the same brix (9.0°). Application of ZnSO₄, MnSO₄ and MgSO₄ at 0.5 percent and CuSO₄ at 0.25 per cent on Coorg mandarin revealed that Zn, Mg alone and combined spray of Zn+Cu+Mg reduced chlorosis as well as the deficiency symptoms of the elements and significantly increased the growth parameters. Foliar application of Fe-EDDHA at 250 to 500ppm 0.5% FeSO₄ increased yield and improved fruit quality of Balady mandarin in Egypt.

Flowering and Fruit Regulation

Flowering

Major blooms of all citrus species occur during the early spring (February - March) when the atmospheric temperature starts rising after the cold winter and soil moisture condition also improves. However in South India, with no well defined winter the flowering season is very long and well defined with two crops or more. The flowering can be regulated by inducing soil – water stress or through fruit thinning by chemicals and adjustment of fruit harvesting. In the absence of sufficient low temperatures in central India, soil water stress is usually practiced for induction of flowering in Nagpur mandarins. The success of flower induction depends upon the right quantum of water stress as a function of the soil physico-chemical properties. Regulation of flowering by use of growth promoters revealed that in Satsuma mandarins the flower bud formation was inhibited by foliar GA₃ level in October and that high IAA and ABA contents in December also promoted the percentage of leafless inflorescences and the number of flower buds per node. Mepiquat chloride (1000ppm, one spray) and cycocel (2000ppm, 2 sprays) were found highly effective in improving the flowering intensity of irregular flowering orchards of Nagpur mandarin. In Baladay mandarins the application of the paclobutrazol (2000ppm) at the beginning of flower bud induction reduced the intensity of alternate bearing and regulated cropping in the subsequent year. Application of 2,5,6-Trichloro-2-Pyridoxylacetic acid) at 10mg/lit after june drop gave best results in terms of fruit size, yield and fruit quality in clementine mandarins. GA₃ reduced the alternate bearing tendency of Kinnow mandarin trees particularly when applied at 20ppm.

Fruit Set

Unfavourable conditions like late frosts, drought or excessive rains results in poor fruit set and high fruit drop resulting in poor yields.

Considerable loss in the soil moisture can be reduced by mulching the soil to reduce the fruit drop. Nei lei *et al.* (2000) found that girdling or ringing increased the fruit set percentage in Shatianyou pummelo by 164.3% and the yield was increased by 21.8%. Application of gibberelin sprays has been found to be beneficial in Clementine mandarin. However there were some undesirable effects on the fruit quality with gibberelin treatment.

Fruit Drop

High rate of fruit drop is a serious problem of citrus in India. Application of GA₃ (200ppm), at one month after anthesis increased the fruit set by 65% and reduced abscission of fruits, however the fruit size was relatively smaller in the treated plants than the untreated plants. GA₃ and 2, 4-D proved effective in reducing the fruit drop in Darjeeling mandarin. Spraying with 50ppm of 2, 4-dichlorophenoxypropionic acid in May increased the fruit weight of the Satsuma mandarins by up to 15% over the control.

Physiological Disorders

Granulation Juice sacs of citrus fruits become comparatively hard, assume a greyish colour and become somewhat enlarged, with an increase in pectin, lignin and other polysaccharides resulting in considerable decrease in juice, TSS, acid and water content. Several factors, such as high RH and temperature during spring, time of picking, tree vigour, etc., influence granulation in citrus. Some success has been reported in reducing the incidence of granulation by lime spray at 35 to 40lb per 100 gallon water, less frequent irrigation, delay in the onset of granulation by spraying of 2,4-D at 16ppm and treatment with Zn+Cu+K (0.25 per cent each) three times between August and October.

Avocado

The avocado (*Persea americana* Mill) is originally a fruit of Mexico in Central America. It belongs to the family Lauraceae. It is commonly called as butter fruit. It is not exactly known when it was first introduced into India but it seems it may have been introduced in the south and west coasts of India about 50 to 75 years ago from Ceylon. In South India, it is at present grown only experimentally in a few orchards at Bangalore, Shevroys, Nandi Hills, Lower Palnis, and at the Kallar and Burliar Fruit Stations in the lower foot hills of the Nilgiris.

In western India, avocado was for the first time imported from Ceylon in the year 1941 and planted at the Ganeshkhind Fruit Experiment Station, Poona.

Varieties

Three races of avocado have been recognized, the Mexican, the Guatemalan and the West Indian. These three races are botanically classified into two distinct species of *Persea drymifolia* and *Persea americana*. The Mexican race is included in the group *Persea americana*. West Indian varieties Fuchsia, Peterson, Pollock, Simmonds, Trapp Guatemalan varieties Taylor, Eagle rock, Itzamma Linda, Schmidt, Wagner, Queen, Challenge, etc. Mexican varieties Gottfried, Puebla, San Sebastian, Duke Inter-racial hybrids 1. Guatemalan x West Indian (a) Collinson (b) Winslowson: Fuerte, The purple, The Green, TKD-1. Propagation using grafting techniques and overcoming Avocado is commonly propagated by seed. Treating the seeds with GA at 100 or 1000ppm or in deionised water for 24 hours resulted in earlier germination. Seed germination could be accelerated by slicing off 3-4 cm of the seed at the base and tip. Removing the seed coat also hastens the germination. Stratification of the seed accelerated early germination. Soaking the seeds in water at 30°C or 40°C for 8 hours improved the germination by 97 percent.

Planting System

The distance at which the trees should be planted in the orchard will have to be determined according to the vegetative vigour developed by the tree of a particular variety in a given set of environment, type of soil and by the shape of grove. The practice now is to plant the trees about 7 m apart and there is even a tendency to plant more closely. Under Poona, 8 to 9 m spacing is given for purple and green varieties. Before planting, pits of 60 x 60 x 60 cm have to be dug and filled with leaf mould, top soil and well rotten farmyard manure.

Nutrition Management

In avocado, flushes of shoot and root growth appear to be synchronizing and alternate on 30 to 60 day cycles. Shoot growth virtually ceases during late autumn and winter, but root growth, though it slows down during winter, continues throughout the year. Therefore, avocado requires heavy manuring.

Young avocado plants should be fertilized with fertilizer mixture containing N: P: K = 1: 1: 1, while the older trees should be given at a proportion of 2:1:2 nitrogen fertilizer alone reduces the yield and considerably increases the percentage of fruit with physiological disorder as compared to combined application of N, K and Mg. Autumn fertilization with N and P has been found to increase the mean yield of avocado. Floral behaviour Avocado trees have a mechanism of “Protogynous diurnally synchronized dichogamy”.

It is a cross pollinated crop. In avocado, dichogamy has been reported in that pistil mature before the stamens begin to discharge pollen. Alternate development of sex organs is decidedly synchronous for the tree as a whole and cross pollination is therefore essential for fruit setting. Under bright clear weather, avocado flowers exhibit a marked tendency to open and close in unison and to open and close for two distinct periods at different times during 24 hours. The pistil is almost receptive, only during the first period of opening; during the second period, the pollen is shed. In most varieties, there is little overlapping of the two opening periods, only a few of the flowers being open for the first time (Pistil receptive). When flowers open for the second time, pollens are shed. All varieties which opened for the first time in morning are grown up together in class A and all those having their first opening in the afternoon are grouped into class B. In both the groups, a second opening of the flower occurs, at which time the pistil is no longer receptive but the pollen is shed.

The intervening period of 18 to 36 hours separates the time of maturity of the sex organs in each flower. Weather conditions exercise a marked influence on both the time and periodicity of the flower opening; this periodicity is most marked in bright clear warm weather, it is least produced in cool cloudy weather. The pollen must reach the stigma at the proper time in the flower and pollination of the same type, close or cross, must take place for first set. There are three methods to enhance cross pollination, viz., planting trees of two varieties in the same hole, grafting of branches with pollinating varieties and alternating trees of different varieties. At Kallar and Burliar foothills of Nilgiris, it has been observed that November – December flowerings are occasional and not very dependable for successful fruit setting, but the March and April flowering set a successful crop. In California, it was reported that embryo abortion is the major cause for the non-setting of fruit and is associated with low mean temperatures during flowering and fruiting periods. For the variety, Fuerte, the critical temperature is 13.3°C and for increased fruit set, the temperature should be above this limit.

References

1. Bhattacharya, R. K. and Baruah, B. P. (1998) Citrus. In: A text book on pomology, Vol III (Ed. Chattopadhyay, T. K.), Kalyani Publishers, Ludhiana, pp. 1 – 71.
 2. Borah, S. C., Barbora, A. C. and Battacharya, D. (2001) Effect of organic and inorganic Manuring on growth, yield and quality of khasi mandarin (*Citrus reticulata* Blanco.). South Indian Hort. 115-118.
 3. Ghosh, S. P. (1996) Citrus In: Fruits of India. Tropical and Subtropical (Ed. Bose). Naya Prakash, Calcutta. pp.162 - 218.
 4. Huchche, A. D., Lallan Ram, A. K., Srivastava and Shyam sight (2001) Efficacy of coating treatments on urea nitrogen application in Nagpur Mandarin (*Citrus reticulata* Blanco.). South Indian Hort. 49, 119-121.
 5. Ingle, H. V., Athawals, R. B. (2001) Studies on high density planting in Nagpur mandarins. South Indian Hort., 49, 16-19.
 6. Jana, B. K. (1998) Avocado. In: A text book on pomology, Vol III (Ed. Chattopadhyay, T. K.), Kalyani Publishers, Ludhiana, pp. 260-269.
 7. Sanyal, D. (1999) Avocado. In: Tropical Horticulture. Vol. I. (Eds. Bose, T. K., Mitra, S. K., Farooqi, A. A. and Sadhu, M. K.) Naya Prakash, Calcutta. pp. 363 – 375.
 8. Shanmughavelu, K. G. (1987) Production technology of fruit crops SBA Publishers, Meredith st, Calcutta.
 9. Shirgure, P. S., Srivastava, A.K. and Shyam Singh (2001) Fertigation and drip irrigation in Nagpur mandarin (*Citrus reticulata* Blanco.). South Indian Hort., 49, 95-97.
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