



Citrus production in the Central Valley of California



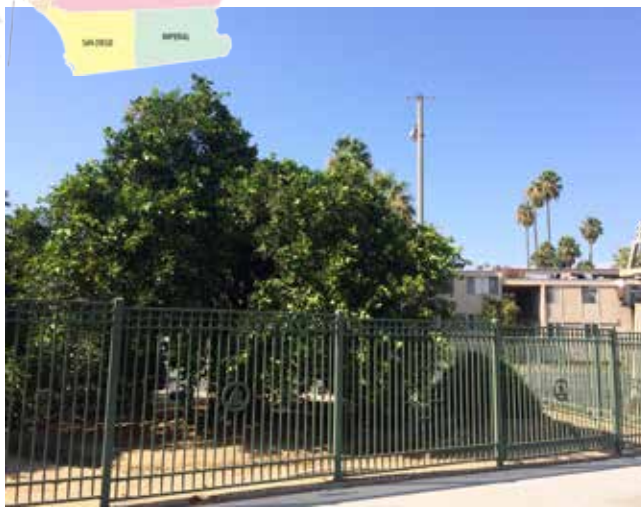
The state of California and its counties. Close to 90% of California's citrus fruit is now produced in five southern and central counties, viz. Fresno, Kern, Tulare, Ventura and Riverside.

Citrus was introduced to California in 1769 by missionaries, or so-called 'padres'. Back then, citrus trees were mainly grown in and around San Diego in the South, towards San Jose in the North, and in gardens of Los Angeles and Riverside. The first small citrus orchard was planted in 1804 at the San Gabriel mission east of Los Angeles.

The first commercial citrus orchard, however, was established by William Wolfskill in 1841, near the current center of downtown Los Angeles. The industry was initially concentrated in three Southern Californian counties, Los Angeles, San Bernardino and San Diego (See map left). In 1870, the first 'Washington' navel sweet orange trees were introduced to California from the United States Department of Agriculture, which sent two trees to Eliza Tibbetts in Riverside. Completion of the transcontinental railway enabled fruit distribution to eastern states. Together with the discovery of gold, these events led to a massive boom in citrus production and the subsequent establishment of the famous Californian citrus industry.



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Above: One of the first 'Washington' navel sweet orange trees is still growing in Riverside in southern California on the corner of Arlington and Magnolia Avenue.

One of the first 'Washington' navel trees is still growing in Riverside today (left), amidst threats from the dreaded Huang-longbing (HLB) or Asian Greening Disease that was recently reported in this Southern Californian county.

In 1875, the total commercial citrus plantings in California were made up of $\pm 90\,000$ 'Washington' navel trees. This number increased rapidly to approximately 2 million trees by 1885 after introduction of lemon and grapefruit, and to 4.5 million trees by the early 1900s when the first commercial 'Valencia' orchards were planted.



The Californian citrus industry today

Urbanization has ringed the necks of southern citrus businesses in and around the major cities of Los Angeles, San Diego and Riverside. Close to 90% of California's citrus fruit is now produced in five southern and central counties, viz. Fresno, Kern, Tulare, Ventura and Riverside, but most of the fresh citrus fruit is produced towards the regions north of the Tehachapi mountains in the central counties of the San Joaquin Valley, viz. Fresno, Kern and Tulare.

The total hectares of bearing citrus orchards in California amounts to $\pm 108\,000$, from which a total of 4 million tons of fruit was produced in the 2016/17 season, which is more than half of the total USA production. Sweet orange hectares make up 70% of the total Californian citrus acreage, mandarin plantings 15%, lemons 10% and grapefruit 5%. Marketing of high-quality easy-peelers under brands such as halo and cutie, has established a popular demand for a premium seedless soft citrus fruit in a massive, but highly-competitive local market. Twenty years ago, the total mandarin plantings in California amounted to approximately 2 000 hectares. This figure has increased ten-fold since then, and by 10% in the last three years alone. More than half of this area consists of 'Tango' mandarin trees, with the rest made up mainly of 'W. Murcott' and 'Clementine' orchards (pic under title on page 66).

The Central Valley

The Central Valley is one of the most productive agricultural regions in the world. The Valley is located at the heart of California and is bound by the Sierra Nevada Mountains towards the east and the Pacific Ocean towards the west. The Valley is 60 to 100 km wide and stretches approximately 750 km from north to south. Of the total 47 000 km² more than half is under irrigation with intensively cultivated vegetables, citrus, grape, pome and stone fruit orchards, as well as pistachio, walnuts and almonds.

The Valley has a semi-desert Mediterranean climate and receives an average annual rainfall of ± 100 mm from October to March. Fruit production is highly dependent on water-supply from melting snow falls on the Sierra Nevada Mountains that are intricately canaled towards production regions across the Valley floor. Other water sources are mostly that of ground-water and banked or district water. The irrigation water has a high pH that has to be adapted with sulfuric acid. The soils are of deep sandy loam character and have a pH of between 7 and 8.

In the Central Valley, citrus fruits are mainly produced for fresh consumption and are harvested almost throughout the entire season. For most parts of the year, the major citrus production regions experience low relative humidity, which makes pathogen disease pressure on fruit in the orchards almost negligible. The snow-capped peaks of the Sierra Nevada's, and cool South-Westerly winds continuously breezing through the orchards further enable fruit to hang on

Opposite page top: A new 'Tango' mandarin planting in the Maricopa region in the Central Valley.

Above: The Maricopa area is located at the foot of the Central Valley in a basin south of Bakersfield and north of the Tehachapi Mountains. The area is the earliest, in which mostly 'Clementines', early navels and lemons are grown.



Above left: Almost every orchard has gas-driven fans installed to break and mix inversion layers of warm and cold air and protect fruit and young trees from freeze damage. The foothills of the Sierra Nevada's are seen in the background.

Above right: To avoid cross-pollination and unwanted seed development, temporary drape-nets are mechanically erected over individual rows and left covering the complete tree canopy. After 60 to 90 days, the drape-nets are individually removed, rolled up, and covered with a plastic sheet and left at the edge of each row until the next spring.



the trees to very late in the season. In some late navel and 'Valencia' orchards, fruit are held on the tree as late as June, which, in South Africa, relates to mid-summer or the month of December.

Quarantine insect pests include the Glassy-Winged Sharpshooter, the Fullers Rose Beetle, and Bean thrips, with the latter being especially problematic in navels as the cavity at the stylar-end provides refuge for these insects when they move over to citrus orchards from neighboring summer crops. The major insect pests causing damage to citrus orchards include Red mites, Citrus thrips and Californian Red scale. Due to an abnormally warm season this year, a 5th generation of red scale was detected in citrus orchards in Kern County in October (April in South Africa), which according to local entomologists is a very rare occurrence and extremely problematic. Control options are extremely narrow towards harvest due to strict MRLs.

Production challenges and technology

Major frosts that used to happen only every ten years now occur more frequently. Catastrophic frosts hit the Valley in 2012 and 2014. To protect fruit and young plantings, almost every orchard has fans installed at a cost of six to eight thousand dollars per hectare (above left). When cloudless, cold nights are anticipated, orchards are irrigated with micro-jet sprinklers to increase humidity, and fans are activated to break and mix inversion layers of warm and cold air. Early frosts before the major winter rainfalls are the most dreaded, as orchards are dry and air humidity low. The autumn flush has not yet fully hardened by then, and fruit at this stage have a low sugar content which makes them highly susceptible to freeze damage.

Californian citrus growers have mastered the art of

producing seedless 'Clementine' and 'W. Murcott' fruit on a massive scale. To prevent pollination and fertilization, growers cover their trees each spring with $\pm 12 \times 400$ m temporary drape-nets that are mechanically erected over individual rows and cover the complete tree canopy, dirt scooped over the edge of the net holds them in place. After 60 to 90 days, the drape-nets are individually removed, rolled up, covered with a plastic sheet and left at the edge of each row until the next spring (above). According to growers, the specially-woven drape-nets have no effects on penetration of foliar sprays, and successfully avoid cross-pollination and unwanted seed development without significantly reducing fruit set, or negatively affecting fruit quality.

Cultural practices

The predominant rootstocks used are 'Carrizo' and 'C-35', especially in 'Tango' and 'W. Murcott' plantings. Trees on 'C-35' appear less vigorous in growth habit and are planted at narrower spacing.

A 'W. Murcott' $\times$ 'C-35' combination appears to be a good option. General tree spacing is 5.5×2.5 m, or 6×3 m. Drip irrigation is applied to young trees and a micro-jet-sprinkler system in older orchards. Almost all the trees are planted on ridges and orchards are free of weeds, which is critical to effectively manage spells of frost.

Major pruning is done mechanically and mainly focused on increasing the efficiency of the drape-net process, optimizing penetration of foliar sprays, and increasing maneuverability and vehicle access in and around the orchards (opposite above left).

The majority of mineral nutrients are applied via fertigation and spread throughout the season until as late as September. The total nitrogen (N) application averages between 150 to 180 kg N per hectare



per annum (at 555 trees per ha) and rate of potassium fertilization is approximately two thirds that of N, slightly higher for mandarins. Micro-nutrients such as Zinc, Copper and Manganese are applied by foliar sprays, with up to 6 sprays per season.

Only a few plant growth regulators, which must be registered for use in California, are available for citrus production. The more important are: (i) 2,4-D to prevent preharvest fruit drop used with GA₃ to prevent rind senescence of late-harvested navels; (ii) GA₃ to increase fruit set or delay fruit senescence in mandarins; and (ii) use of 2,4-D on most cultivars to increase fruit size. Late navels such as 'Barnfield' are kept on the tree until mid-summer, but a problem arising from this appears to be a negative effect of the previous crop on flowering and fruit set of the next. The practice is nevertheless rewarding, considering the financial returns from navels in the summer market.

The Maricopa area

The Maricopa area is located at the foot of the Central Valley in a basin south of Bakersfield and north of the Tehachapi Mountains (page 71). The area is the earliest, in which mostly 'Clementines', early navels and lemons are grown. Trees are planted in a North-to-South row-direction and general spacing for 'Clementine' orchards are 5.5 × 2.5 m, or 6 × 3 m. Flowering period for 'Clementines' is spread for 4 to 5 weeks, and fruit set strategies consist of two to three GA₃ foliar sprays combined with girdling of the main trunk. Girdling is effective on young trees, but less frequently applied to adult trees. 'Clementine' orchards visited included 'Nules', 'Orogrande', 'Clemenpons' and 'Fina' selections. The selection most suited to the region appeared to be 'Nules' with trees producing generous fruit loads, with a good

fruit size distribution, and smooth rinds.

Early navel orchards visited in the Maricopa area included young orchards of the ultra-early Australian 'M7' navel, adult 'Beck' navel orchards, 'Fukumoto', and 'Newhall' navels. The 'M7' trees bear its fruit mostly inside the tree canopy, underneath the foliage (above). Unlike the other early navels, 'M7' fruit are round, the fruit have a smooth rind, and variable size of navel-end openings. The 'Beck' navel fruit were more elongated than the M7, had thick rinds, but fruit had a very good taste.

Suid-Afrikaners trap diep spore in Kalifornië

Ek het die voorreg gehad om vir drie maande die Universiteit van Kalifornië in Riverside, en vir 'n week die Central Valley in Kalifornië in die VSA te besoek. Ek is ontvang deur Prof Etienne Rabe, die vise-president van Wonderful Citrus, die grootste sitrus produsent in die VSA. Ek het vir 'n week lank saam met hom sitrusboorde in Kalifornië besoek en eerstehands meer uitgevind oor die dinamika van so 'n groot en suksesvolle sitrus-industrie. Dit was lekker om ook weer saam met 'n oud-kollega van CRI, doktor Arno Erasmus in Delano by Wonderful Citrus te kuier. Op 11 Oktober het ons drie die jaarlikse Kaliforniese sitrus kongres in Visalia bygewoon. Groot was my verbasing om nog twee Suid-Afrikaners, Henk du Plessis en Henk Griffin daar raak te loop. Op een stadium was ons vyf Suid-Afrikaners om een tafel. Dit het my baie trots gemaak om te sien watter diep spore Suid-Afrikaners trap in so 'n groot industrie ver weg van hulle mense, en watter groot respek Suid-Afrikaners afdwing in die breër internasionale sitrus gemeenskap. Kalifornië is 'n indrukwekkende plek en mens kan baie daar leer, maar ons as Suid-Afrikaners kan ook baie trots wees op ons sitrus industrie.

Above left: A 'W. Murcott' orchard in the Central Valley that received an early-summer mechanical pruning.

Above right: The 'M7' navel trees bear its fruit mostly inside the tree canopy, underneath the foliage.