Topics in Subtropics Newsletter

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News from the Subtropical Tree Crop Farm Advisors in California

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Editor's Note:

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Please also let us know if there are specific topics that you would like addressed in subtropical crop production. Copies of Topics in Subtropics may also be downloaded from the county Cooperative Extension websites of the Farm Advisors listed.

Mary Bianchi
Editor of this issue

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In this issue:

The terms mandarins and tangerines are used interchangeably in the U.S. and include subgroups of varieties such as the Clementines and the Satsumas and individual varieties such as W. Murcott Afourer and Dancy. Within the subgroups there are a number of varieties themselves. For example the Clementine subgroup includes Algerian Clementine, Clenenules or Nules Clementines and others. In this issue, we use the term 'mandarins' to refer to the larger group, 'clementines' to the subgroup of varieties of Clementines, and 'Clementine' when referring to an individual variety.

An Introduction to the Problem of Honey Bees and Mandarins

By Craig Kallsen
Citrus/Pistachio Farm Advisor – Kern County

This issue of Topics in Subtropics features articles related to producing certain varieties of mandarins and how growing these mandarins has engendered conflict with beekeepers. The problem is focused on the production of a group of mandarins called clementines and one specific variety of mandarins, W. Murcott Afourer. Some mandarin varieties, such as the clementines and W. Murcott, become seedy if cross-pollinated with other varieties of citrus, such as tangelo, lemon, some grapefruit and pummelo, and some other mandarins (like each other, for example). The principal carrier of pollen, in many citrus orchards, is the honey bee. Honey bees are able to carry pollen great distances, perhaps up to two miles or more. Therein lies the conflict between clementine/W. Murcott growers and beekeepers: growers make their living selling seedless mandarins while bee keepers make their living selling honey and renting bee hives to almond and other growers of California crops. For beekeepers, more money is made from renting hives than from honey. Bees are vital to agricultural crops in California that require cross-pollination to produce fruit. A large portion of this pollination market is for fruit and nut crops that generally flower before citrus, like almonds and cherries. Some crops that require bees, like kiwi, flower at about the same time as citrus. Bees are generally not required to produce citrus fruit, but citrus provides a source of food to maintain the bees when few other crops are flowering and for production of citrus-flavored honey.

So why grow clementine and W. Murcott mandarins? Assuming they are grown so that they are seedless, the main attraction of these fruit is that they can be profitably sold into a market that has been ready made by growers from Spain and countries in Africa, like Algeria and South Africa. The fruit does ship well for a mandarin and has an attractive deep orange color. Clementine and W. Murcott mandarins have a similar appearance and taste, but clementines mature early in the season (late October to mid December in the San Joaquin Valley), while W. Murcott matures later (early January through March). By growing both, the marketplace is supplied with a similar product over an extended portion of the year. Other mandarin varieties exist that are genetically seedless, like the Satsuma and Gold Nugget that are early and late maturing. However, these varieties have characteristics of their own, that at least presently, appear to make them less desirable candidates for commercial production on the scale of what is happening with clementines and W. Murcott.

In the 2005 United States Department of Agriculture Statistics Service report, the documented increase in acreage of clementines and W. Murcott in California is phenomenal. The 2005 California acreage report shows over 5,000 acres of W. Murcott and nearly 8,000 acres of clementine mandarins exist out of a total of about 18,400 acres of all mandarin varieties. Over 9,000 of the approximately 13,000 acres of W. Murcott and clementines were classified as non-bearing in 2005. Most mandarins are in Kern and Tulare counties, although numbers are increasing rapidly in Fresno. Most counties in the citrus producing regions of California have some W. Murcott, clementines or other mandarins. To beekeepers the handwriting is on the wall. If large bee-free areas surrounding a clementine or W. Murcott grove are created, most of San Joaquin Valley and parts of the southern coast will be off limits to bees during the citrus bloom period.

As in most conflicts, middle ground probably exists so that seedless clementine and W. Murcott can be grown and bee keepers can continue to produce citrus honey. In the late 1970s, beekeepers and citrus growers came to a long-lasting agreement that protected bees from pesticide applications during bloom, in a way that was workable for citrus growers. Before that settlement was reached and codified in the California Code of Regulations, conflict between beekeepers and citrus growers was just as harsh as it is now between beekeepers and some mandarin growers.

Questions exist that tend to polarize opinion. For example, is it fair to plant a grove of clementine mandarins and then ask neighboring citrus growers to do any of the following: remove citrus that might cross pollinate with these clementines, remove kiwi orchards that require bee pollination, cease keeping bees if they have hives, and/or cease allowing independent beekeepers to produce honey as they have in the past? On the other side, is it fair that an individual develops new clementine groves far from existing citrus with the intent of growing seedless fruit, and then finds that beekeepers are placing hives on adjacent oil-field property (for example)? In this example, the beekeeper did nothing to develop the pollen and nectar resource and no previous resource existed, yet his or her activities are severely impacting the economic returns of the mandarin grower who did.

Plant breeding activities have already provided a partial solution to this problem. ‘Tango’, a new variety of seedless mandarin, has been released that is nearly identical to W. Murcott. Since Tango is nearly seedless, bees or no bees, the cross-pollination issue disappears. Many existing blocks of W. Murcott will probably be grafted over to Tango as budwood becomes available. Until a similar seedless development occurs for the early-maturing clementines or some middle ground can be found, relations between the two groups are probably going to remain tense and litigious.

Birds do it; bees do it, even citrus with seeds do (did) it.

Part 1 - The biology behind seedlessness in mandarins.

By Tracy L. Kahn
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Sex is the norm even in plants. We don’t usually think of sex and plants together, but generally flowers produce gametes, eggs and sperms, that combine to make the next generation which, in the case of flowering plants, are the seeds. This may not seem obvious to growers in California, because many of the commercial citrus varieties we commonly grow are seedless such as the many strains of navel oranges and Satsuma mandarins. Since citrus is propagated by grafting, seeds are not needed to produce more trees. Yet the issue of pollination and seed set has lately become an important and controversial topic for those who grow mandarins, or what we commonly call tangerines. The importance surrounds the demand for and increased revenue for seedless mandarins since they generate three to four times the price of seeded ones. The controversy revolves around the fact that some mandarin varieties are seedless no matter what is grown around them, others are seeded in all locations, and still others will be seedless if “isolated” from cross pollination but will be quite seedy if not. Honeybees are a player in this controversy since they are the vector for cross pollination, or the transfer of gametes contained inside pollen (male side), to the female parts of other flowers. This article is the first of a two part series about the biology behind pollination and seediness in mandarins. This part will focus on why some mandarin varieties are normally seeded all the time, some normally seedless, some may be seedless or low seeded, and others are only seedless when under certain conditions.

Mandarins or tangerines are a large, varied group which includes Clementine and Satsuma varieties as well as many other mandarin varieties. The fruit of mandarins are almost always flattened and depressed at both the stem and stylar (opposite) ends of the fruit and the inside has a hollow core with segments that tend to pull away from each other at maturity. Mandarins are often called “zipper skinned” fruit because of the tendency for the peel to be loose at maturity. Over the years, citrus breeders have made crosses between mandarins and other citrus types such as sweet oranges to develop “tangors” and with grapefruit or pummelos to develop tangelos. These hybrids share some of the mandarin characteristics including differences in level of seediness.

Mandarin flowers have both sexes within a single flower. The pollen contained within the anthers holds the male gametes or sperm. In the center of the flower, the pistil is the female part. The pistil has an ovary or spherical structure at its base. The ovary of the flower develops into the fruit. Within the ovary of the flower are the ovules that will become seeds if pollen is delivered to the pistil and the gametes are able to combine to trigger seed development. Variations in this process are responsible for the differences in seediness. On the next page is a table in which the mandarins, tangors and tangelos that are available from the Citrus Clonal Protection Program (CCPP) as budwood from registered CCPP Foundation citrus trees are categorized based upon their seediness and the biological variations responsible for their level of seediness.

Seeded Varieties: *Varieties that will have seeds no matter where they are planted.*

Mandarin varieties such as ‘Dancy’, ‘Fallglo’ and ‘Sunburst’ have flowers with both pollen and ovules that contain gametes that are capable of combining to produce seeds. Yet varieties can differ in the amount of functional pollen and ovules they have which will affect the level of seediness. The amount of functional pollen can also be affected by environment conditions such as excessive heat or cold and low relative humidity which can reduce the ability of pollen to germinate and produce pollen tubes. Pollen germination is necessary since the pollen tubes deliver the male gametes to the female gametes within ovules in the ovary. So if there is less functional pollen, the seediness of fruit will be reduced.

List of Mandarin, Tangor and Tangelo Varieties Available from the Citrus Clonal Protection Program			
Seeded Varieties: *Varieties that will have seeds no matter where planted.*	**Seedless Varieties:** *Varieties that will be "seedless" with only an occasional seed no matter where planted.*	**"Seedless to Low Seeded"** - *Varieties that will be commonly "seedless" or low seeded. May have more seeds when cross pollinated.*	**Seedless Only If…** *Varieties that will be seedless if cross pollination is prevented - "Self-incompatible".*
Clementine Monreal	Aoshima Satsuma	Shasta Gold ™	Clementine Algerian
Dancy	Armstrong Satsuma	Tahoe Gold ™	Clementine Caffin
Dweet	China S-9 Satsuma	Yosemite Gold ™	Clementine Carte Noir
Encore	Dobashi Beni Satsuma		Clementine Corsica #1
Fallglo	Frost Owari Satsuma		Clementine Corsica #2
Fortune	Gold Nugget		Clementine de Nules (Clemenules, Nules)
Freemont	Kawano Wase Satsuma		Clementine Fina
Honey (California Honey)	Kiyomi		Clementine Fina Sodea
Kara	Kuno Wase Satsuma		Clementine Marisol
Kinnow	Miho Wase Satsuma		Clementine Nour
Murcott tangor (Florida Honey)	Miyagawa Satsuma		Clementine Oroval
Pearl tangelo	Neopolitana Satsuma		Clementine Sidi Aissa
Ponkan	Okitsu Wase Satsuma		Clementine SRA 63
Sue Linda Temple	Pixie		Clementine SRA 92
Sunburst	Seedless Kishu		Ellendale
Temple	Silverhill Satsuma		Fairchild
Wekiwa	Tango		Koster
Wilking	Xie Shan Satsuma		Lee
Willowleaf			Minneola Tangelo
			Nova
			Orlando tangelo
			Ortanique
			Page
			Robinson
			W. Murcott Afourer (W. Murcott, Afourer)

Seedless Varieties: *Varieties that will be "seedless" with only an occasional seed no matter where planted.*

Some citrus varieties such as the different selections of navel orange and Satsuma produce very few or no functioning pollen and very few or no functioning ovules. These varieties will be seedless or have an occasional seed. Mandarin varieties such as 'Gold Nugget', 'Pixie' and 'Seedless Kishu' also have very few or no functional ovules and pollen so there are no functioning gametes to combine to produce seeds. If other varieties with functional pollen are grown adjacent to these varieties and honeybees deliver this functional pollen to the pistils of varieties like 'Pixie' or 'Gold Nugget', they will not produce seeds because they do not have functional ovules capable of becoming seeds. So in the case of these varieties, it does not matter what is grown near them because they are not capable of producing seeds or rarely produce seeds. Also these varieties can not produce functional pollen or rarely produce functional pollen that will pollinate other varieties that do have functional ovules.

Seedless or Low Seeded Varieties - *Varieties that will be commonly "seedless" or low seeded. They may have more seeds when cross pollinated.*

New mandarin varieties such as Yosemite Gold ™, Shasta Gold ™ and Tahoe Gold ™ were bred by hybridization to have three sets of chromosome, or triploid, instead of the normal two copies. Having three copies of chromosomes causes a genetic imbalance that makes it difficult for these varieties to produce functional gametes. On occasion, a genetic accident will make it possible for them to produce a few functional gametes. In a cross pollination study of 'Tahoe Gold ™' flowers with 'Clementine de Nules' pollen in 2002 and 2003 conducted by Thomas Chao, he demonstrated that a small percentage of 'Tahoe Gold ™' flowers were capable of producing fruits with a small number of seeds. So although 'Tahoe Gold ™' was capable of producing only a few functional ovules, numerous functional pollen grains from the variety 'Clementine de Nules' increased the chances of their gametes combining to produce seeds.

Seedless Only If… *Varieties that will be seedless if cross pollination is prevented - "Self-incompatible".*

Certain mandarin varieties such as most of the Clementine selections, 'Page', 'Minneola' tangelo' and 'W. Murcott Afourer' have many functional pollen grains and many functional ovules, but are self-incompatible. Self-incompatibility is a genetically controlled system in which self pollination or transfer of pollen within or between flowers of the same type is not capable of allowing the gametes to combine so that no seeds are produced. For example, if pollen from 'W. Murcott Afourer' is transferred to the female part of the same flower or to another flower of 'W. Murcott Afourer', the fruit will be seedless because the gametes were not able to combine. However, if functional pollen from another variety such as 'Clementine de Nules' is transferred to the pistils of 'W. Murcott Afourer' flowers, the fruit will be seedy because the gametes are capable of combining. This explains why self-incompatible varieties that are grown in mixed variety blocks such as the UCR Citrus Variety Collection or the CCPP Foundation Block at Lindcove Research and Extension Center will produce seedy fruit.

A future article will address cross pollination issues such as crossing relationships between varieties, isolation distances, and strategies that help prevent cross pollination of self-incompatible varieties.

Honey Bees in California

By Eric C. Mussen
Extension Apiculturist, UC Davis

Honey bees (*Apis mellifera*) were imported into what is now the United States in 1622. Beekeepers were able to transport colonies of honey bees into San Jose in 1853 and moved them to some of the best honey producing locations in the country, in southern California, about 16 years later. As the acreage of citrus expanded in California, following their introduction in 1873, beekeepers located apiaries near citrus groves to provide sustenance for the bees and, on a good year, obtain a crop of premium "orange blossom" honey.

Recorded numbers of colonies kept by US beekeepers eventually reached a peak of about 5 million during WWII, then steadily declined to the current USDA figure of about 2.4 million honey producing colonies, of which 500,000 (21%) are resident in California. Not all commercial colonies are used for honey production, so the number is an underestimate. Also, there are many feral colonies, living on their own, throughout the country.

During the period from October to early or mid-May, an additional 800,000 or so colonies are brought to California (total 1.3 million) from at least 35 other states to meet the almond industry's demand for pollinators. As demand for additional honey bee colonies increases with the expanding almond acreage, many more colonies will be placed near citrus. This will occur because the conditions at the point of origin of many imported colonies are inappropriate for immediate return.

The diet of bees consists of water, nectar and pollen. While gathering pollen, bees pollinate flowers. Worker honey bees forage for those foods over distances exceeding four miles from the hive location. If food is abundant, most honey bees will forage within three-quarters of a mile from the hive. From early spring to early fall, each honey bee colony requires an acre equivalent of blossoms to meet the daily needs of the colony. If more blossoms are available, extra nectar is collected, processed, and stored as honey.

The two most critical times of the year for brood rearing are in the spring and late summer/fall. In the spring, colonies have to build back to full sized populations from their smallest seasonal size during the preceding winter. The colonies require access to large amounts of pollens and nectar to provide food to the queen that may be laying up to 2,000 eggs every day. Three days later, those eggs hatch into a similar number of larvae that require continuous feeding for the next six days, before they pupate in capped cells. This is a daily routine, so nearly 12,000 larvae are demanding feed generated from pollens, every day. Locations providing abundant early bee food sources for 1.3 million colonies are not plentiful in California.

For decades California beekeepers have relocated between 250,000 and 350,000 colonies within flight range of citrus plantings to ensure the development of their colonies to a strength that will allow the bees to survive and build up to be available for pollinating more than 50 additional crops during the rest of the summer season, survive the winter, and provide almond pollination the next spring. The colonies not located near citrus are moved to limited, non-agricultural areas where wildflowers may be abundant enough to support the growth of colony populations, if adequate rains and permissible flight conditions occur. Beekeepers have to be careful not to choose apiary locations where plants poisonous to honey bees are in bloom: California buckeye (*Aesculus californica*), cornlily (*Ixia campanulata*), death camas (*Zigadenus elegans*) and locoweeds (*Astragalus* spp.). The current 500,000 colonies are at the carrying capacity of California for commercial beekeeping. All readily accessible, not too distant, apiary locations are inhabited by honey bee colonies, each year. The influx of extra honey bees for almond pollination simply reduces the food for each colony through competition, if beekeepers locate extra colonies near historic apiary locations of resident beekeepers.

With a four mile foraging radius around each hive, honey bees from a single colony may be foraging anywhere in a 50 square mile area. California has a land mass of 156,537 square miles. If each of California's 500,000 commercial colonies were separated by eight miles, with no foraging overlap, they would require 25.13 million square miles of space, which is 160 times greater than the land mass of California. The United States has only 3.48 million square miles of land mass.

Obviously, commercial beekeepers cannot own enough land, containing honey bee attractive plants, to feed their colonies adequately. Beekeepers rely on private land owners and supervisors of various public agencies to allow them to place apiaries, usually 40-100 colonies each, on their properties. Beekeepers try to select locations that will at least meet the minimum nutritional requirements of the bees. In years when honey plants are abundant, beekeepers can harvest a honey crop.

Information, gleaned from 2005 county crop reports, relates that California beekeepers generated $39.8 million in honey production, nearly half (46.6%) of which came from Tulare County and was predominantly citrus honey. Honey production contributed 23% to the total beekeeping income of the state and is vitally important to the economic survival of beekeepers in the San Joaquin Valley and southern California. Pollination income was about four times greater than honey income ($122 million), but the colonies have to be healthy and strong to command a good price for pollination and to survive the stresses of inadequate food supplies and pesticide exposure when used for saturation density crop pollination later in the season.

In recent years, some citrus growers have been planting varieties (mandarins) that are most attractive to consumers when the fruits contain no seeds. While navel oranges do produce some pollen, growing a seedless variety near navels probably would not be problematic. However, planting two or more compatible varieties of mandarins near each other can be very problematic. The pollen from one variety will set seed in the other. Currently, varieties planted in the San Joaquin Valley produce crops that mature at different times of the year. But, they bloom simultaneously and are very compatible.

To avoid seeds in their mandarins, San Joaquin Valley growers are attempting to convince beekeepers not to place colonies within two miles of their 10,000 acres of mandarins that will be in bloom. Beekeepers are reluctant to abandon apiary locations that have provided sustenance, and sometimes a honey crop, to their colonies for many decades, if not generations within many beekeeping families. However, some growers became insistent. Lawsuits were threatened for loss of marketable mandarin crops to trespassing bees. Then, the approach shifted to a proposed effort by California Citrus Mutual (the organization that previously worked with the beekeepers to provide pesticide protection legislation for the bees during citrus bloom) to have new legislation introduced that would require all honey bee colonies to be moved two miles away from the boundaries of any planting of six acres or more of mandarins in Fresno, Kern, or Tulare Counties. An area extending two miles around a six acre plot covers approximately 8,038 acres or 12.56 square miles. A similar area extending around a 640 acre (one square mile) plot covers approximately 23,368 acres or 36.51 square miles.

According to industry statistics, there are about 250,000 acres of citrus grown in California, of which about 25,000 acres are planted to mandarins and about 10,000 acres of mandarins currently are mature enough to produce a marketable crop. If the 10,000 acres were planted in non-adjacent 640 acre blocks, there is the potential to eliminate honey bees from a maximum area of 13,396,666 acres, or 20,932 square miles. If the 10,000 acres were planted in a single, solid, square block (a 15.63 square mile area, with approximately 3.95 mile borders and a 5.59 mile diagonal), the protected area would cover 46,108 acres or about 72 square miles. A total of 189,577 acres are reported planted to citrus in the 2005 crop reports from Fresno, Kern and Tulare Counties. Thus, somewhere between a minimum of 24.3% (having all planted mandarin acres in a single, large block) and a maximum of 100% (for either individual 6 or 640 acre plantings) of the three-county citrus acreage would be off limits. The exact planting schemes are not available for more precise calculation. However, more and relatively smaller acreages are being planted every year.

Some citrus growers have tried to help beekeepers find substitute citrus locations, but often none were available. In other cases, long-standing citrus locations of one beekeeper were taken away from him or her and given to another beekeeper that had been forced out of a mandarin location. There are little or no unused citrus locations, due to the huge demand from so many colonies.

The beekeepers have serious reservations about how things are transpiring. First, does one agricultural industry, in the name of economically protecting its agricultural interest, have the right to inflict economic damage on another agricultural industry? What role will right-to-farm legislation have in protecting their right to move onto agricultural landowner's land with permission? How will new mandarin plantings affect growers of established crops requiring honey bee pollination plums, kiwi, mandarins, Minneola tangelos, pummelos and other seeded citrus, avocados, late cherries, early summer squash, among others.

Second, beekeepers fear that laws or regulations prohibiting the placement of apiaries within two miles of anyone desiring the absence of honey bees on his or her property would set a dangerous precedent. Such prohibitions, across the country, could eliminate essential apiary locations for honey bee colonies that are recovering after use in crop pollination or are making a honey crop. Suitable apiary locations already are difficult to find, without distance regulations. The beekeepers hope that efforts to enact such legislation will be discontinued.

The financial considerations of maintaining healthy, well nourished honey bee colonies throughout the year in California can be demonstrated from the data collected annually by county agricultural commissioners and published in their annual crop reports. In 2005, the latest year for which data is published, honey bee pollination was an essential factor in the production of $6.15 billion of fruits, nuts, vegetables, and seed crops. Eliminating an extremely important nutrient source for bees, fairly early in the season, will damage the bees, reduce their value for income production for the beekeepers, and affect the ensuing almond pollination season as well as other commodities for the rest of the year. Other solutions for the seedy citrus problem, ones more acceptable for the beekeeping industry and other bee-reliant commodities, need to be identified.

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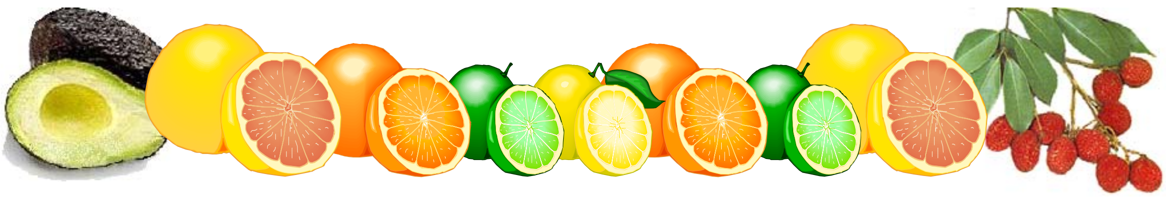
UPCOMING ISSUES OF TOPICS IN SUBTROPICS WILL ADDRESS CROSS POLLINATION ISSUES SUCH AS CROSSING RELATIONSHIPS BETWEEN VARIETIES, ISOLATION DISTANCES, AND STRATEGIES THAT HELP PREVENT CROSS POLLINATION OF SELF-INCOMPATIBLE VARIETIES.

Topics in Subtropics



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