INTERNATIONAL CITRUS NURSERY PRODUCTION AS IT RELATES TO *PHYTOPHTHORA*, VIRUSES, AND GROWING MEDIA

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Several important factors must be considered before growing citrus nursery stock in the world. Climate and available useable irrigation water are critical. Most citrus is grown between 20° and 45° latitude N, and 20° and 40° latitude S. To propagate and grow citrus, two of the most significant challenges have been *Phytophthora* diseases and citrus viruses. The threat of *Phytophthora* can be reduced by using tolerant rootstocks when possible, and practicing preventative sanitation.

Phytophthora diseases of citrus (gummosis, root rot) attack the root system and/or the trunk. Depending on soil, moisture conditions, and treatment, the affected tree may die quickly, or make periodic attempts at regrowth. Contaminated citrus seed can be a source of *Phytophthora* infection. The extracted seed needs to be heat-treated in agitated water at 52° C (127° F) for 10 min. The seed is then dusted with a protective fungicide and stored in poly bags at 3° to 7° C (35° to 45° F).

Growing media used in the nursery must be free of *Phytophthora* organisms harmful to citrus. It has been proven that decomposed pine bark affords some antagonistic effects on the development of various plant pathogenic fungi, including *Phytophthora* species (3). Media can be fumigated under plastic tarps with methyl bromide to kill fungal organisms. Aerated steam could also be applied.

Contaminated river water used for irrigation of nursery stock must be decontaminated of plant pathogenic fungi and nematodes by extensive filtration and chlorination (3).

Copper-containing footbaths at the entrances of various sections of the nursery and greenhouses can limit spread of *Phytophthora*. Vehicle-tire-drive-thru-copper-containing troughs can limit outside contamination.

Citrus rootstocks selected for their high degree of tolerance to *Phytophthora* continue to play an important role. 'Carrizo' and 'Troyer' citrange, *Citrus* × *macrophylla*, and trifoliate orange have shown high tolerance to *Phytophthora*.

Use of the systemic fungicides, methalaxyl (Ridomil) and efasite aluminum (Aliette), have been proven to be effective at controlling gummosis and root rot of citrus caused by *Phytophthora*. Neither chemical should be used as a substitute for soil fumigation in the

nursery. Using systemic fungicides in nursery stock known to be heavily infected with *Phytophthora* will probably result in healthy-appearing nursery stock, but will only serve to distribute *Phytophthora*-infected plants to growers (5).

California has a long-standing concern for the protection of citrus. It was the State of California that enacted in 1881 the first law establishing a plant quarantine. The first registration program for citrus, by the California Department of Food and Agriculture (CDFA) was started in 1937 for trees inspected and found free of psorosis. Prior to this time, very little was known about citrus virus diseases (1).

The discovery in 1939, of a quick-decline disease of sweet orange on sour orange rootstock in southern California, ushered in an era of concentrated attention and research on citrus viruses. Quick-decline has its most serious effect on sweet budded to sour orange. Young trees may wilt and die within a few months after infection (quick-decline) when tristeza-infected budwood is used—or will linger for a number of years, making poor growth before death. Extensive indexing by the CDFA in the 1950s revealed that tristeza (quick-decline) had been spread by vector and transported by budwood or nursery stock to most commercial citrus areas in the Los Angeles area. As a result, the psorosis program was amended to include indexing for tristeza and another virus disease, veinenation.

Recognizing the fact that citrus was highly vulnerable to several diseases spread by budwood and insects, the Citrus Advisory Committee asked the University of California to assume responsibility for developing and maintaining a foundation-variety planting of scion and rootstock cultivars that would be virus-free and true-to-type. The University accepted this challenge, and in 1957 inaugurated the Citrus Variety Improvement Program (CVIP). In 1977 the program was renamed The Citrus Clonal Protection Program (CCPP), to more accurately reflect the activities of the project.

Citrus selections to be placed in the program, are very extensively tested or indexed for all known citrus viruses before they are cleared for planting in a Foundation Block at the U.C. Lindcove Field Station near Visalia, California. If the desired selections are found by indexing to be virus-infected, they are subject to either shoot-tip grafting or heat treatment, to obtain virus-free plants. Following 2 to 3 years of fruiting by the newly-propagated trees, usually at about 5 to 6 years of age, the individual trees are registered and can serve as source of scionwood for propagation of nursery-increase blocks, mother-block trees, or propagating certified nursery stock directly. Figure 1 shows the flow of a citrus selection through the CCPP to the nursery and to the grove.

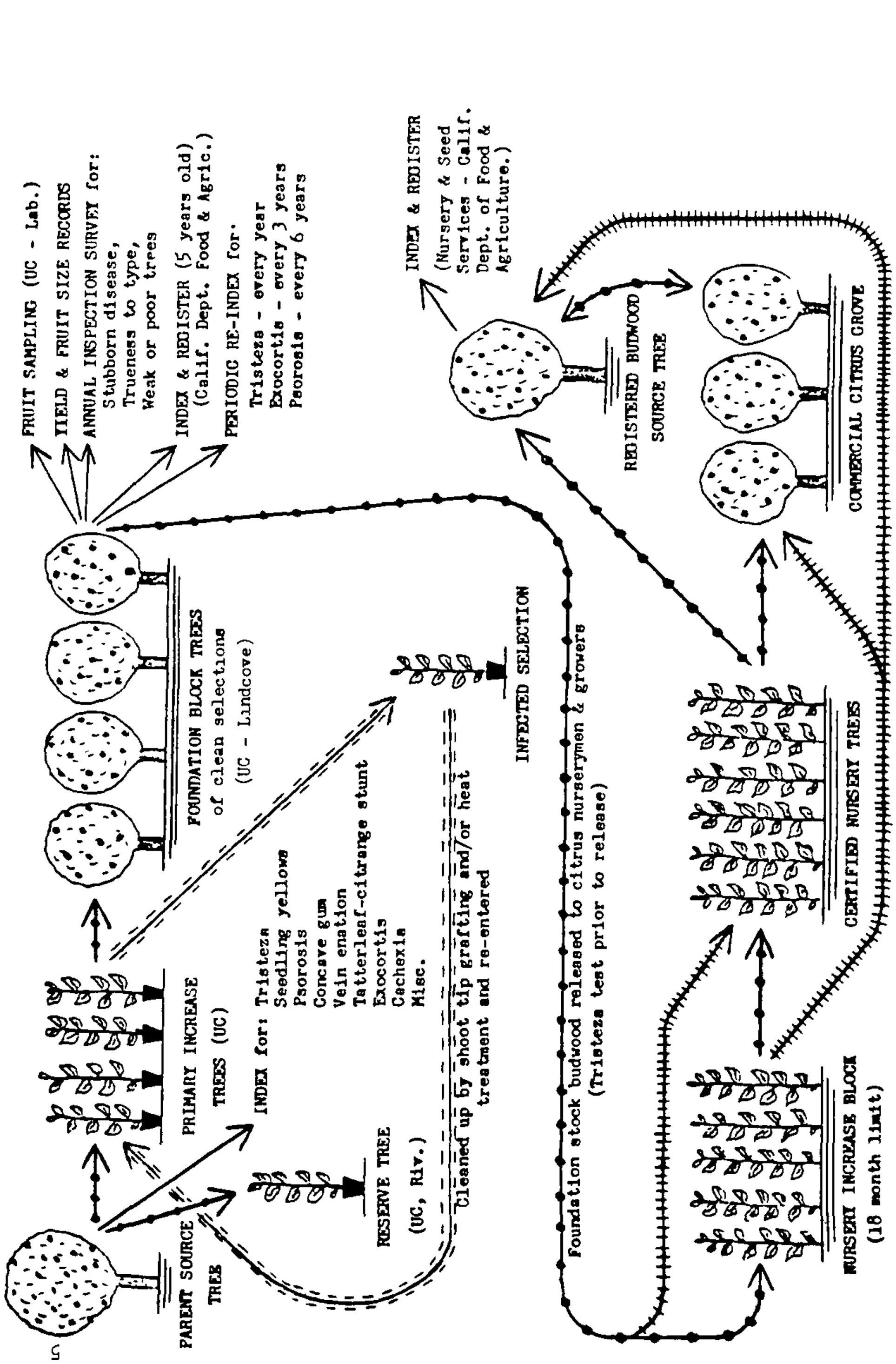

Figure 1. The California citrus clonal protection program. Diagram of Steps and Procedures

As a direct result of this integrated program of research and services, psorosis has been virtually eliminated from California. Exocortis is declining rapidly, especially in new plantings, and one of the major tristeza-free areas of the world has been maintained in the Central Valley of California.

World-wide, citrus nursery stock has historically been field-grown and either bare-rooted or field-dug with soil attached to root ball. The past 10 years have shown a trend from field to container growing.

Since container-growing is a trend, and since we are exclusively growing citrus in containers at our nursery, my focus will be on that challenge.

An ideal growing medium should fulfill certain physical and chemical requirements. Most California nurseries use a mixture of pine or fir bark with coarse sand or decomposed granite. Bark fulfills the majority of good growing medium components. In addition, it can be milled to the required particle size distribution and is extremely light. The main disadvantage of bark is that if it is not correctly composted, toxicities due to water-soluble tannins or organic acids can occur, resulting in growth stunting and, in severe cases, even tree dieback (4).

Composting causes these tannins to be bound in forms not soluble in water For composting to take place water, nitrogen, and air are required. The media should be turned at 4 to 6 weeks, and ready for use in 2 to 3 months Composted media at least half bark (by volume) has moderate (desirable) cation exchange.

The moist, hot, oxygenated conditions in an active compost pile are just right for killing plant pathogens. They are either killed outright by the heat, or they become food for other microbes. Most weed seeds are also killed if the temperature is high enough (2). The pH should be between 5.5 and 7.0.

The air-filled porosity (AFP) of a growing medium is the percentage of its volume that contains air after it has been saturated with water and allowed to drain. AFP is a measure of how much air is available to the roots and is, therefore, an excellent means of determining the suitability of the physical properties of a growing medium. Citrus, when grown in coarse sand, reacts favorably to AFP ranging from 12% to 20%, while lower values are more suitable to early seedling growth.

The water-holding capacity (WHC) of a growing medium is the volume of water retained just after it has been saturated with water and allowed to drain. WHC should range between 150 and 250 ml/l of media.

A growing medium should have a good balance between AFP and WHC. This ensures sufficient oxygen for root respiration without

dieback due to desiccation. If drainage is impaired, not only will an environment be created which is conducive to *Phytophthora* and *Fusarium* root rots, but root growth will also deteriorate (4).

World citrus growing currently covers 3.2 million hectares. With an expanding output of 60 million metric tons, citrus ranks second only to grapes (64 million tons) in world fruit production. While citriculture is carried out in more than 70 countries, only 20 account for 90% of total yield. Only about 10 countries have a budwood program, controlled with virus-free buds available.

Brazil has recently taken over top ranking in citrus production from the USA, whose industry has dropped to second place due to diseases, freezes, and ever-increasing urbanization; these have brought American citrus growing to a standstill.

Brazil (650,000 hectares of citrus; 12.2 million tons produced) mainly exports concentrated orange juice. Nurseries are growing some 18 million trees annually, at about $1.50 per tree. Government control of budwood sources started with the revival of the citrus industry after tristeza rampaged through orchards in the late 1930's. The time had come to recognize nucellar selections. Recently, the disease, "declino" is killing 8 to 10 million trees per year in Brazil at age 15 or 16 years. Rootstocks have changed from Rangpur lime (resistant to drought; high-quality fruit) to Sweet orange and Cleo mandarin.

Brazil has maintained research stations that produce clean budwood to satisfy the tremendous requirements for their expansion of citrus growing.

The major citrus-producing states in the USA are California, Arizona, Texas, and Florida. Each state has a good program of maintaining blocks of virus-free budwood (except tristeza in Florida, which is wide-spread). Strict quarantines regulate movement of budwood between states.

Florida is losing about 3% of its citrus each year due to blight (this disease is not well understood).

Spain, 3rd in world production, (254,000 hectares, 5 million tons) exports 80% of its production of fresh fruit. Because of tristeza, sour orange as a rootstock has been restricted since 1972, except as a stock for lemon. To date, approximately 10 million trees have been killed by this virus, now controlled in new plantings with resistant rootstocks.

Spain conducts one of the world's model programs AVASA, the Association of Nurserymen, produces clean budwood at a farm outside the regular citrus area, where it is free from tristeza. The new disease-free orchards in Spain contrast with the poor old groves. Since 1983, a quarantine program based on *in vitro* studies exists.

Because of severe strains of tristeza and good vectors Africa and Australia pre-immunize their bud source trees with a mild strain of tristez. The severe strain, known as stem pitting in South Africa, when attacking grapefruit shortens the tree's life by 20 years (total tree life 12 to 15 years). Both countries have government-indexed budwood sources, optionally available to nurserymen.

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