Some Disease Problems of Citrus Rootstocks

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Introduction

Except for certain disease problems, many citrus trees would be grown on their own roots or on seedling stocks of the same variety, thus eliminating many bud-union problems which are currently important as causes of decline and tree loss. Also, sweet orange and mandarin trees on their own roots are very tolerant of most forms of tristeza. There are several other diseases that are rootstock-related which is to say that rootstocks tolerant to these diseases usually exist. Two of the very worst diseases, stubborn and greening can effect all kinds of commercial scions so severely that they cannot be controlled by using disease-resistant rootstocks.

Let us take a look at some of the rootstock-related citrus disease problems in various parts of the world. We will concentrate on virus and mycoplasmalike diseases and their symptoms. We will also discuss some very severe disease problems unrelated to rootstock varieties. Symptoms of the diseases and varieties affected are shown in the Table 1 which follows this text.

Virus and Virus-Like Diseases

Tristeza. Tristeza probably has killed more trees than any other disease in the past 35 years, probably more than 30 million. Most of the losses occurred in Argentina, Brazil, Spain, and the United States. Some countries have not yet experienced extensive losses from tristeza. Australia, Japan, India, Indonesia, Philippines, Rhodesia, South Africa, and Taiwan are heavily infested with tristeza virus and have long used tristeza-resistant rootstocks such as rough lemon (India, Rhodesia, and South Africa), mandarin (Taiwan and Philippines) and trifoliate orange (Japan). Other countries, including those surrounding the Mediterranean (except Spain), Mexico and Central America, Chile, and part of the United States (Arizona, Texas, and parts of California) still have little or no tristeza present and still have millions of trees of the highly sensitive sweet orange/sour orange. Tristeza, if established in these areas, will eventually damage or destroy the trees of sweet orange/sour orange. Tristeza is known to be spreading now in Peru, Spain, Israel and the United States. It probably is spreading in Turkey. The disease has not yet killed half of the world's highly tristeza-sensitive trees.

Symptoms of tristeza are varied, depending on the strain of virus, the variety of host and the environment. Usually the sour orange phloem is damaged near the bud union producing a girdling effect which results in starvation of the roots and gradual decline of the top. Pinholing often occurs in the sour orange bark just below the union. Sometimes the quick decline effect with sudden wilting, occurs when a sudden and severe water stress develops. Starch disappears in the rootstock before it does in the top. All known forms of tristeza cause some vein clearing and stem pitting of Mexican lime at cool to moderate temperatures. There are some mild isolates of tristeza virus that cause little damage to trees on sour orange rootstock. Some other rather severe forms of tristeza are called seedling yellows, stem pitting, and 'Hassaku' dwarf.

Seedling yellows causes yellowing and stunting of lemon, sour orange and grapefruit seedlings and usually some vein corking of Mexican lime. It can damage mature trees of these varieties. Seedling yellows appears to be abundant in Brazil, Argentina, South Africa, Japan, India, Southeast Asia, Philippines, Australia, Hawaii, and Taiwan.

Stem pitting tristeza occurs on grapefruit and its close relatives, such as 'Hassaku', causing severe stem pitting, dwarfing of the plant, and small fruit size. Tristeza also causes extensive stem pitting of sweet lime and 'Alemow' rootstocks, badly damaging trees planted on these rootstocks. Stem pitting is most common in areas where *Toxoptera citricidus* (black citrus aphid) is the principal tristeza vector. In some localities stem pitting causes considerable damage to sweet orange as well as to grapefruit. Tristeza stem pitting of grapefruit and sweet orange is extremely rare in California and Florida but tristeza is now killing grapefruit trees on sour orange rootstock in both states. Where severe stem pitting of grapefruit or of limes is common it appears advisable to use a mild strain of tristeza for protection against stem pitting, as has been reported from Brazil. It is possible to obtain tristeza-free young trees by using tristeza-free buds propagated on clean stocks. However, in heavily infested areas the young trees soon become infected with whatever isolates are being moved by vectors. In such situations inoculation with one or more isolates of tristeza virus may be desirable.

Psorosis. The name psorosis is applied to a group of diseases that are believed to be related to each other; in addition to common psorosis there are blind pocket, crinkly leaf and infectious variegation, Satsuma dwarf, concave gum, eruptive gummosis and ringspot. Of these, crinkly leaf, infectious variegation and Satsuma dwarf are known to be caused by viruses.

Common psorosis causes pimpling and scaling of the bark of mature trees of sweet orange, grapefruit, mandarin, and tangelo. Lemon, trifoliate orange, citranges, and limes may become infected but do not scale. In advanced stages the wood beneath lesions dies and discolors to develop the "woodform" of psorosis. Psorosis was once the most important citrus virus disease in Florida and California. Thanks to budwood programs it is becoming a minor disease except in old orchards.

Infectious variegation causes crinkled and puckered leaves and some leaf variegation but is less common than the very similar disease crinkly leaf. Lemons as well as oranges may be affected. Infected lemon fruits tend to be rougher than normal. Occasionally these viruses are seed transmitted.

Blind pocket causes abrupt depressions in trunks of affected trees and affects some trees of various varieties in California and Florida, but is easily avoided by using registered budwood.

Concave gum causes some stunting and results in formation of broad concavities on the trunk and large branches. An oakleaf pattern is normally associated with this disease.

Relatively little is known of eruptive gummosis and ringspot. Eruptive gummosis and perhaps ringspot may be spread by an unknown vector. Their geographical distribution is incompletely determined but they appear to be present in South and North America.

Impietratura causes gumming in the peel of grapefruit and some other varieties in countries around the Mediterranean basin. A leaf symptom similar to that of psorosis is associated with it. There is proof of graft transmissibility but no proof of natural spread.

Satsuma dwarf has a leaf symptom similar to psorosis and causes downward bending of leaf margins on Satsuma trees in Japan and Turkey.

Fortunately most psorosis diseases can be completely avoided by using only registered psorosis-free seed and budwood materials.

Cachexia (Xyloporosis). Cachexia is important mostly on certain mandarin, mandarin lime, tangelo, 'Alemow', and sweet lime varieties when these varieties are used either as scions or as rootstocks. The virus can infect sweet orange, sour orange and grapefruit but causes little or no damage nor symptoms on these species. Cachexia infection is widespread in most of the citrus world in old budlines but, since it has apparently no means of natural spread, it usually is found in seedling lines only as a result of graft transmission. It is easily prevented by using cachexia-free stock but the most rapid indexing method requires about 6 months to a year.

Symptoms of cachexia are lens-shaped pits in the wood, especially on the trunk and rootstock, usually with gum impregnated irregularly in the bark, and pegs on the innerface of the bark. Severely affected trees usually have chlorotic foliage and are stunted. In stocks or trees such as 'Alemow' and 'Palestine Sweet lime' the symptoms closely resemble those of tristeza but cachexia pits are broader and the bark contains more gum than with tristeza infection.

Cachexia is relatively unimportant in California because most popular budlines are of seedling origin. However, 'Alemow', the principal rootstock for lemons, reacts severely when budded with cachexia-infected lemon buds. If there were an efficient vector present many lemon orchards would be ruined by cachexia. Budwood programs in Florida and California have done much to control cachexia.

Cristacortis symptoms are similar to those of cachexia but occur on sweet and sour orange scions and rootstocks. Pits are usually larger than for cachexia and gum deposits are present in the wood. Cristacortis has not been reported in the United States nor in most other citrus producing countries but is common in the Mediterranean area. No natural spread is known for cristacortis

Woody gall or vein enation. This virus disease causes rough woody galls on *Citrus volkameriana* rough lemon and on some other lemon and lime trees and rootstocks. Galls form especially at wounds on infected plants. Woody galls at the bud union are very common on rough lemon rootstocks in Peru but damage to the tree appears to be minor in most cases. Vein enations on the leaves are found mostly on young, vigorous trees and are rarely seen in the orchard. The woody gall virus is transmitted by aphids, including *Toxoptera citricidus, Aphis gossypii,* and *Myzus persicae.* The use of vein enation-free budwood in clean areas is advisable. In infested areas the use of clean budwood helps to improve the appearance of young trees on rough lemon rootstock but the trees soon become infected with the virus.

Stubborn. Stubborn is widespread in most arid and semiarid citrus areas of the world and has ruined several million trees during the past 40 years; it rarely kills trees but it lowers the quality and quantity of fruits. Stubborn is especially destructive in California and Arizona, in the warmer portions of Mediterranean countries, and in Peru.

The symptoms of stubborn are somewhat variable but include low yield, stunting, eccentric or acorn-shaped fruits, stylar-end greening, blue albedo, seed abortion, stiff, upright growth of leaves and stems, small and sometimes mottled leaves, premature defoliation and drop of fruit in hot areas, and dieback in severely affected trees.

There are about 2 million stubborn-infected trees in California and probably at least that many in the Mediterranean. The disease spreads readily by vectors, as yet unidentified, in some California locations. The vectors are believed to be leafhoppers.

All commercial varieties of citrus appear to be susceptible to stubborn regardless of the rootstock used, but sweet orange, grapefruit, and tangelo are the species most frequently attacked. Lemon and lime trees are rarely attacked by the stubborn pathogen.

The apparent pathogen of stubborn, *Spiroplasma citri,* is unique in that it is mycoplasmalike, has many forms, and can be cultured from diseased plants and from insects suspected of being vectors. The suspected pathogen is sensitive to tetracycline and to some other antibiotics. Thus far, attempts to control stubborn by antibiotic treatments have succeeded only with small plants grown in hydroponic solutions containing tetracycline.

Most stubborn infections of importance occur in young trees less than 4 years of age or from infected budwood. In areas where natural spread is relatively slow stubborn can be controlled by planting clean trees and destroying visibly stubborn-diseased ones. It is not known whether plants other than citrus are hosts of stubborn.

Spiroplasma citri is smaller than most bacteria, motile at certain stages in citrus and insect hosts, and has a characteristic spiral form of very slender filaments at one stage of its development. In citrus this organism seems to be confined to the sieve tubes.

Greening. Greening is by far the most dangerous and destructive citrus disease in the world. Greening is called by various names including blotchy mottle in South Africa, leaf mottling or leaf mottle yellows in the Philippines, citrus decline in India, likubin in Taiwan, and yellow shoot in China. The symptoms resemble stubborn but greening is far more detrimental than stubborn to citrus trees. Greening is vectored by the psyllids *Trioza erytreae* in South Africa and nearby countries and by *Diaphorina citri* in southern, eastern and southeastern Asia, the Philippines and Indonesia. Greening is present in most of the tropical and warm subtropical citrus areas in the eastern hemisphere but has not been reported from the western hemisphere. In the western hemisphere, only Brazil has reported having either of the psyllid vectors. Climatewise greening should do well if established in the western hemisphere, especially in Florida, Mexico and the Caribbean area.

Greening has completely ruined many millions of trees in the Orient and in South Africa during the past 20 years and continues to ruin millions more. The apparent pathogen of greening is mycoplasmalike but it has a thicker covering around each cell, making it resemble bacteria in this respect. The greening organism apparently is more difficult to culture than is the stubborn organism.

Greening attacks all important varieties of citrus regardless of the rootstock variety on which they are propagated.

No control has been developed for greening but injections of tetracycline-HC1 appear to have improved tree condition and production of some greening-affected trees in South Africa. Reports from the Philippines indicate inactivation of the greening pathogen in mandarin orange budwood dipped in tetracycline solutions. In India promising results have been obtained by spraying tetracycline antibiotics on greening-infected citrus trees.

Miscellaneous virus or virus-like diseases are listed in Table 1

Bud-union Disorders

Disorders at the bud union may severely damage or kill citrus trees. Some such disorders are due to transmissible pathogens; others for want of a better term are called incompatibilities and are apparently not transmissible.

Among the transmissible diseases causing bud-union disorders are tristeza and citrange stunt. The latter is rare, except that it is usually present in old budlines of 'Meyer' lemon and can cause a brown stain and crease at the bud unions of sweet orange or mandarin scions on citrange or trifoliate orange rootstocks.

Many scion-rootstock combinations are sometimes or always incompatible. Among the most common of these is sweet orange (especially blood orange) on rough lemon. This combination is rather variable in its performance, certain budlines on certain rough lemon seedlings are apparently fully compatible while others are slightly to severely affected.

Calamondins and kumquats are incompatible with most other citrus varieties and form a bud-union crease with highly abnormal xylem and phloem at the union. This disorder does not appear to be transmissible.

Some citranges and trifoliate oranges are highly incompatible with certain budlines of lemon, especially 'Eureka' and 'Villafranca' selections. There also seems to be considerable incompatibility between sour orange and some citranges. No scion rootstock combination can be considered fully compatible in any situation until it has been tested for 10 years or more in a given situation.

Maintenance of a strong, viable citrus industry in any country requires the prevention and/or control of severe diseases. Fungal and bacterial diseases may be controlled by cultural and pesticidal measures but graft-transmissible and bud-perpetuated diseases can best be controlled by the use of clean propagating materials, resistant or tolerant varieties and combinations, and by the replacement of worthless diseased trees with healthy ones. In some areas severe diseases such as stubborn and greening cannot be controlled by any practical measures available at this time. Under such hopeless circumstances it is advisable to change to another crop.

Table 1

Symptoms, distribution and control of some virus and mycoplasmalike diseases of citrus

Disease	Symptoms	Distribution	Varieties affected	Control
CACHEXIA	Pits in trunk wood; gum in bark and pegs on inner surface of bark; stunting.	Most citrus areas.	'Alemow', mandarins, mandarin limes, tangelos.	Avoid susceptible rootstocks, Use disease-free budwood and seed.
CRISTACORTIS	Pits in trunk and branch wood; crested pegs on inner bark surface; gum in bark.	Mediterranean countries.	Grapefruit, mandarins, sour and sweet oranges, tangelos.	Use disease-free propagative materials.
EXOCORTIS	Cracking and scaling of bark of citranges, trifoliate orange, and 'Rangpur' lime; epinasty, cracking and browning of the lower side of midveins of citron; yellow blotches on shoots of trifoliate, citrange, 'Rangpur' lime and citron; stunting.	Worldwide.	Citranges, citrons, 'Rangpur' and other mandarin limes, sweet limes, some lemon, trifoliates.	Use tolerant rootstocks and clean propagative materials. Sterilize cutting tools chemically to prevent mechanical transmission.
LEAF CURL	Excessive flowering and dieback, curling of leaves, gum and grooves in wood, few fruits.	Brazil (rare).	Sweet oranges.	Destroy infected trees.
PSOROSIS Common	Clear flecks on some veinlets, local or general bark lesions in mature trees.	Worldwide, or nearly so.	Bark and leaf symptoms, sweet oranges, mandarins, tangelos, grapefruit; leaf symptoms only, most other varieties.	Use disease-free propagative material; scrape small lesions and remove bad branches.
Blind pocket	Abrupt longitudinal depressions on trunk; occasionally scaling lesions.	Nearly worldwide.	Lemons, sweet oranges, mandarins.	Use disease-free propagative material.
Concave gum	Broad concavities on trunk and major branches; flecks and oak-leaf pattern in young leaves.	Worldwide.	Lemons, limes, mandarins, sour and sweet oranges and some others.	Use disease-free propagative materials.
Crinkly leaf	Crinkled distorted leaves; flecking and stippling of young leaves.	Worldwide.	Lemons, limes, sour and sweet oranges.	Use disease-free propagative materials.
Dweet mottle	Psorosislike mottle in young leaves.	California (rare).	'Dweet' tangor.	Use disease-free propagative materials.
Impietratura	Gummy deposits in rind, center, and vascular bundles of fruit. Psorosislike markings in some young leaves.	Mediterranean area.	Grapefruit mostly.	Use disease-free propagative materials.

Disease	Symptoms	Distribution	Varieties affected	Control
Infectious variegation	Variegation in leaves plus symptoms of crinkly leaf.	Worldwide.	Lemons and sour orange mostly.	Use disease-free propagative materials.
Ringspot	Yellow rings on some leaves, sometimes vein clearing and stem lesions.	Probably nearly worldwide.	Grapefruit, lemons, mandarins, sweet oranges.	Destroy infected trees. Use disease-free propagative materials.
Satsuma dwarf	Downward bent leaves, psorosislike leaf symptoms.	Japan, Turkey.	Satsuma mandarin.	Use disease-free propagative materials.
TATTERLEAF	Distortion and blotching of young leaves and twigs; stunting.	Wherever Meyer lemon is grown.	*Citrus excelsa;* 'Meyer' lemons are symptomless carriers.	Use disease-free budwood. Destroy infected trees.
Citrange stunt	Deep pits and grooves in wood; blotched distorted leaves; stunting; bud union disorder.	See tatterleaf.	Citranges, trifoliates and various trifoliate hybrids.	Destroy infected trees. Use clean propagative materials.
*TRISTEZA (Quick decline)	Veinlet clearing in young leaves of some varieties; necrotic sieve tubes at bud union; pits in wood of sour lime and some other varieties; decline of top; chromatic cells in some varieties.	Nearly worldwide except for some districts around Mediterranean and in south-western North America.	Mandarin, sweet orange, etc. on sour orange, grapefruit and some other rootstocks; lime and 'Alemow'.	In disease-free areas use quarantine and eradication, also disease-free propagative materials. Elsewhere use tolerant combinations with rootstocks such as trifoliate, 'Troyer' citrange, sweet orange, 'Rangpur' lime or 'Cleopatra' mandarin.
*Hassaku dwarf	Small, pale, upward folded leaves; stem pitting and furrows on trunk.	Japan.	*Citrus hassaku, C. obovoidea,* and 'King' mandarin.	Use propagative material infected with a mild strain of tristeza virus in infested areas.
*Seedling yellows	Stunting and yellowing of leaves of highly susceptible varieties; stem pitting and usually vein corking of Mexican lime.	In most citrus areas but rare in U.S.A. and Mediterranean area.	Citrons, grapefruit, lemons and sour orange.	Use propagative material free of seedling yellows. Cross protection may be useful in areas where seedling yellows is prevalent. Eradication is desirable if only a few infected trees are present in an area.
*Stem pitting	Pits and grooves in wood; stunting, small chlorotic mottled leaves; low production and small acid fruit.	See seedling yellows.	Grapefruit and closely related varieties. 'Alemow', and in some areas sweet orange.	Use propagative material free of stem pitting. See seedling yellows.

Disease	Symptoms	Distribution	Varieties affected	Control
*WOODY GALL (Vein enation)	Small projections on underside of leaves; rough woody galls on trunk, branches, and roots.	Australia, Japan, Peru, S. Africa, U.S.A.	*Citrus volkameriana* lemon, rough lemon, limes, sweet and sour oranges.	Avoid *C. volkameriana*, rough lemon and sour lime rootstocks. Use clean propagative materials.
YELLOW VEIN	Bright yellow veins.	California (rare).	Calamondin, kumquat, limequat, lemon, 'Mexican' lime, citron, 'Orlando' tangelo, 'Troyer' citrange.	Destroy infected trees. Use clean propagative material.
*GREENING (also called blotchy mottle, citrus decline, leaf mottling, likubin, and yellow shoot).	Trees chlorotic and stunted with low yield; misshapen fruits; small leaves; considerable dieback and severe general decline; blotchy mottle of leaves; seed abortion.	South Africa and several nearby countries, India, Indonesia, Thailand, Philippines, China and Taiwan.	All important varieties regardless of rootstock.	Use disease-free propagative materials and propagate in an area where greening is not naturally spread. Avoid planting in heavily infested areas.
*STUBBORN	Stunting; distorted eccentric, or acorn-shaped fruits; sometimes inverse coloration of fruits (stylar-end greening) and blue albedo; seed abortion; stiff upright multiple twigs; small chlorotic or mottled leaves with short internodal space; brushy growth; low yield.	Probably nearly worldwide. Important in Arizona, California, Mexico, Peru, and the Mediterranean area.	Grapefruit, sour and sweet oranges, tangelos, citrons and most other varieties regardless of rootstock.	Use disease-free propagative materials. Propagate indoors or in an area where stubborn is not spreading. Avoid planting highly susceptible varieties in heavily infested areas.

*Transmitted by insect vectors.