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Tree Size Control and Dwarfing Rootstocks[1]

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The economics of modern day citrus production strongly suggest the need for wise use of resources and increased yields in order to insure the continuance of acceptable profits. The need to improve yield is bringing about a change in the manner by which grove performance is evaluated. Yield has generally been evaluated on an individual tree basis in the past; however, now it is considered in terms of land area, reflecting a more efficient means of utilizing this basic resource. The productive potential for a given land area then, is related directly to fruit bearing foliage. This concept has manifested itself in the form of higher density plantings. Field trials of closely-spaced trees have demonstrated the capability of such plantings to increase productivity. The advantages and disadvantages associated with higher density plantings have been reported. One consistent observation has been the need for tree-size-control to ameliorate or perhaps eliminate those factors which may cause a decline in yield soon after the planting is established. Furthermore, and equally important, is the desire to have smaller trees which may be more economically managed and harvested.

Tree size control in citrus can be achieved by four general techniques - environmental, genetic, viral and mechanical. An example of the former is trees on trifoliate orange which are often smaller-sized when grown in deep, sandy soils even with irrigation. Elsewhere, on better soils, they are slower-growing but reach standard size. Various combinations of plant material (genetic approach) may also favorably affect tree size and vigor. Suitable germplasm has, unfortunately, been difficult to find and only limited evaluation of this material has occurred so far. The use of plant pathogens has been explored especially citrus exocortis viroid. It is a promising technique. The easiest and most reliable method of size control is mechanical, i.e., hedging and topping.

THE CONCEPT OF TREE SIZE CONTROL VERSES DWARFING

In classifying trees according to size, dwarf trees are those approximately 8 ft or less in height when mature. Trees of this size have many advantages as compared to larger, vigorous ones. They can be spaced closer together without suffering from excess crowding or the need for frequent, severe pruning. Moreover, they generally produce fruit in a more efficient manner. Smaller trees have a more favorable ratio of fruit bearing foliage to non-producing woody framework than larger trees.

Despite its advantages, small tree size is not an end in itself nor necessarily desirable if pursued to its limits. Small trees must be horticulturally satisfactory in other aspects. Also, if extremely dwarfed, trees will have inadequate volume to allow maximum productivity/land area because yield is function of canopy bearing volume among other factors. Therefore, small trees are useful for certain practical

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and economic reasons, but their reduced volume may not be ideal or optimum for best grove performance.

It is important to compare "dwarf" or "dwarfing" and "tree-size-control." The term "dwarf" when used to describe a fruit tree ordinarily evokes an image with which reasonably specific dimensions are associated. "Dwarf" then is applicable only to trees of a certain stature within the full range of potential sizes resulting from the ability to control tree size. The use of rootstocks and viruses should be viewed as a means of controlling tree size, not just dwarfing citrus.

Tree-size-control is a concept, with well-defined objectives, that has two important implications. First, this approach recognizes and encompasses the desirability and need for an array of plant materials, as well as techniques, to create a whole spectrum of tree sizes, not just dwarf ones; and second, it implies the ability to regulate tree size through the proper combination of these materials and techniques. Thus, rootstocks and/or viruses represent two ways of controlling tree size, because trees in a variety of sizes result from their use.

DEFINITION OF A DWARFING ROOTSTOCK

A dwarfing rootstock may be defined as simply one which in combination with other plant parts, and independent of viral, environmental or other influences, results in a mature tree no larger than 8 ft (2.5 m) in height. Tree size in citrus, however, represents some form of physiological balance between each respective component. It is possible that two sources of propagation material may exhibit a growth pattern in combination that is entirely different from either of them individually. Some success in tree size control has been achieved, for example, with citrus relatives and species of *Citrus* even though the rootstock itself is not a true dwarf.

A dwarfing rootstock may also be a true genetic dwarf itself and impart this characteristic to scions budded upon it. This type of rootstock may have greater potential because it is one that is likely to produce more consistent results, and be less affected by variations in environmental and cultural factors; however, their slower growth and shorter internodes would complicate present commercial nursery operations and probably increase the time required to produce a saleable plant.

IDENTIFYING DWARFING ROOTSTOCKS

Genetic or inherent dwarfism often manifests itself in distinctive morphological forms which are easily identified and obvious to even the casual observer. Typical variations involve changes in internode length, leaf size, shape and color, growth rate, and foliage density and branching. These variants are commonly referred to as "off-types" and are usually discarded. Evidence is accumulating from studies with apple rootstocks that dwarfism is related to growth hormones. Very little is known about the hormone physiology of citrus as it controls growth but as a more complete understanding is achieved, it is reasonable to assume that this information will help identify dwarfing rootstocks.

There are no reports describing a true citrus dwarfing rootstock. Some stocks such as trifoliate orange (*Poncirus trifoliata* Raf.) were considered dwarfing in the past, but now are recognized as size controlling rootstocks or "rootstocks with dwarfing effect." Trees on these stocks do not generally fit the definition of "dwarf." Moreover, in those instances where tree-size was reportedly reduced, dwarfing may have been caused by other factors.

DEVELOPING DWARFING ROOTSTOCKS

New rootstocks being evaluated at the Citrus Research and Education Center, Lake Alfred suggest that favorable tree size is obtainable despite the apparent absence of genetic dwarfing. If true dwarfs are preferred, however, one very promising source has been virtually ignored.

H.J. Webber, in 1932, published his classic study of variations in citrus seedlings. He stated that:

> "The seedlings of variable types which are present in small numbers in all lots of citrus seedlings... are here termed variants...The seedlings of variant types are usually small and lacking in vigor, and when used as stocks are found almost invariably to produce orchard trees exhibiting some degree of dwarfing."

The sour orange *(Citrus aurantium* L.) variants (off-types) he selected ranged from weak, spindly individuals to other healthier types of different sizes, but all were smaller than his "standard." These

variants also maintained their characteristics even through subsequent propagations on rough lemon *(Citrus jambhiri* Lush.) and sour orange rootstocks. This stability is a good indication that the variants are an expression of genetic change. Off-type seedlings could be a rewarding source of dwarfing material that should not be overlooked. Furthermore, previous concerns regarding the vegetative propagation of such seedlings and other rootstock materials have been greatly reduced considering recent advances in tissue culture techniques.

Perhaps more progress in dwarfing citrus trees has been made in recent years through the work of W.P. Bitters with the citrus relatives. Representatives from genera within the subfamily Aurantioideae excluding *Citrus* and *Poncirus* were tried as interstocks or rootstocks primarily with a lemon scion. Results were encouraging with species of *Citropsis*, *Eremocitrus*, *Clymenia* and *Microcitrus*. Tree-size was frequently reduced to 50% and, in some instances, 75% of the standard commercial tree. The mechanism of dwarfing is unknown but it is apparent that bud union compatibility is involved. Certain relatives, e.g. *Hesperethusa*, were successfully propagated with one species of *Citrus* but not another.

All possibilities involving the citrus relatives have not been explored. The variation mentioned above precludes any generalizations about a particular genus. Additional investigations underway in Florida are designed to evaluate specific rootstock/interstock/scion combinations.

Presently, advanced techniques are being used to map the genetic material of *Citrus* in order to identify genes or groups of genes that control specific traits such as juice acidity and tree vigor. When sufficient information is accumulated then very efficient and focussed breeding will be possible. Meanwhile, new rootstocks are being created at the CREC by somatic hybridization (protoplast fusion). The parents for these new hybrids include germplasm from selections of trifoliate orange, e.g., Flying Dragon, and other species thought to have potential for tree size control.

VIRUSES AND VIROIDS FOR TREE SIZE CONTROL

Potential risks

Dwarfing trees with citrus exocortis viroid is practiced in Australia on a limited basis; however, commercial implementation is hindered by several risks and uncertainties concerning exocortis and its interaction with the host. Virus infected trees are purportedly unappealing to many individuals because of fears associated with virus mutation and unwanted transmission to adjacent healthy trees. Although these risks do exist, they will probably always be present and are not necessarily completely discouraging. If exocortis is considered a hazard, what role would hedging or topping play? Theoretically, the proper combination of tree and exocortis would negate the need for these operations. If nearby trees are not budded on a susceptible rootstock, contamination is unlikely to have an effect. Furthermore, tree age is a factor. Mature trees, even on susceptible rootstocks, may show no, or slight, effects from mechanical inoculation. It seems that exocortis influence on tree growth is greatest when trees are inoculated as young plants.

Exocortis spread is also influenced by the scion variety. Grapefruit and mandarin cultivars appear to be relatively resistant to mechanical inoculation. Another risk not commonly mentioned is the spread in groves of those cultivars where clippers are used to harvest the fruit. This possibility is low however, because generally the largest amounts of viroid particles are found in the below-ground parts of the citrus tree.

Mutation and Variation

Citrus exocortis does not apparently mutate readily to forms that are more detrimental than the original one. Millions of exocortis infected trees exist around the world without any apparent hazards from mutation. Inoculated trees in field trials have remained stable in appearance. If an undesired mutation did occur, it is not likely to be a problem even if deleterious because it could be restricted to a single tree; and, exocortis is not insect transmitted.

Variation in the visual symptoms of apparently infected trees, supported by experimental work, has generally been interpreted as evidence for the existence of exocortis strains. Some strains may cause extreme dwarfing and ill health while others are much milder in their effects. Strain mixtures may exist in individual plants. Also, it has been suggested that another transmissible factor other than, or in addition to, exocortis is associated with the dwarfing.

Recent research has shown that citrus trees may harbor a host of viroids which have yet to be fully characterized regarding their effects, if any, on citrus.

It is now known, e.g., that xyloporosis is a viroid disease. Some of these previously unknown viroids may be responsible, either alone or in various combinations, for behavior thought to be caused by exocortis viroid.