Bud Variation in Citrus*

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Bud variation in citrus is a two-faced problem. On the positive side bud variation has provided some of the best horticultural citrus varieties throughout the world. On the negative side bud variations with undesirable characteristics are continually produced and must be eliminated. Therefore, while the horticulturist is looking for bud variations which will be superior to existing horticultural varieties, he must also be careful to avoid inferior variations in order to maintain the standard of the variety which he is propagating.

The highly heterozygous condition of most citrus forms favors the production of detectable bud variations, whether they are caused by gene mutation or somatic segregation. The probability of finding variations is thus higher than in more homozygous plants. The apparent absence of bud variations in the pummelos *(Citrus grandis)* may be because the lack of nucellar (asexual) embryony removes the mechanism whereby the high degree of heterozygosity is accumulated and maintained in other citrus species which have a high degree of nucellar embryony.

The seedless Washington navel orange, one of the two main orange varieties grown in California most likely arose as a bud variation of the Brazilian variety "Laranja selecta". It would be hard to overestimate the importance of this variety to the citrus industry of California. The Shamouti, the principal orange variety of Israel, probably had its origin as a bud variation of the Belladi, the common orange of Israel. Limbs of Shamouti sport back to the Belladi rather frequently, and bud variations similar to the Shamouti are occasionally found on the Belladi. The seedless Italian variety Ovale probably originated as a bud variation from the common seedy variety of Italy. It rather frequently reverts to this type, known as Allapatura, and the Italian growers practice a selective pruning program to keep the trees free of the branches of this less desirable type.

Several pink or red-fleshed grapefruit varieties have arisen from white-fleshed varieties. The pink-fleshed Foster variety originated on a tree of the Walters variety. The pink-fleshed Thompson originated as a bud variation from the Marsh variety. The red-fleshed Ruby and Webb variations originated from the pink-fleshed Thompson. Fruits of these pink and red-fleshed sports, particularly the deeper colored, seedless types like the Ruby and the Webb (Redblush) have brought premium prices, so that a large portion of the newer plantings of grapefruit in Texas and California have been of these bud variations.

The importance of bud variation to the Satsuma orange industry of Japan

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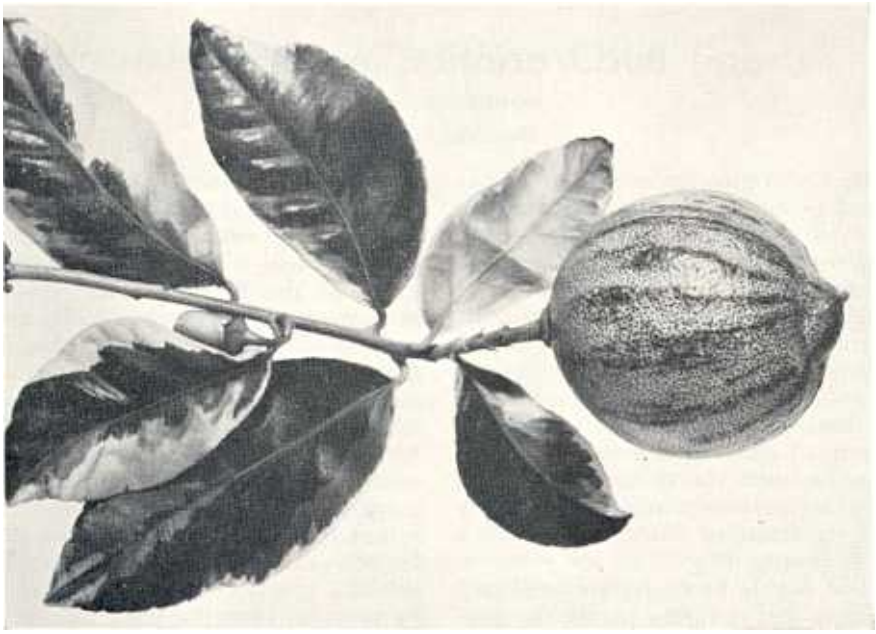

FIG. 1. Variegated pink lemon—a periclinal and sectorial chimera.

is indicated by the extensive work of Tanaka on the bud variation of this variety. According to Tanaka, the quality of the Satsuma fruit has improved by means of bud variation from the more primitive Zairai strain to the Miyagawa Wase strain. The Zairai was displaced by the Owari strain which is a bud variation from the Zairai. A bud variation of the Owari, the Kawano Wase, displaced it. The Miyagawa Wase is a separate bud variation from the Zairai and today is the principal Satsuma orange strain grown in Japan. Many other bud variations in the Satsuma orange have been described by Tanaka.

An intensive study of bud variation in the main citrus varieties of California was carried on for over twenty years by Dr. A. D. Shamel of the U.S.D.A. and his co-workers. Their early surveys of citrus groves indicated that groves had as many as 75 per cent "off-type" trees. This high percentage was undoubtedly due to unknowingly propagating from bud variation trees or limbs on otherwise normal trees. In progeny studies of limb variations, a wide range of bud variations affecting production and fruit and tree characters were found. In both the Washington navel orange and the Valencia orange many variations producing changes in rind characteristics, including color, were isolated and given descriptive names such as Corrugated, Fluted, Ridged, and Golden Buckeye. Other variations affected fruit shape or dryness of the pulp. Some of the variations produced changes in tree growth habit or leaf type, such as Willow Leaf and Rolled Leaf. Among bud variations found in Eureka Lemon, one is a pink-fleshed variation and with variegated foliage and rind color (Fig. 1). A pink-fleshed variation and several seedy variations of the seedless Marsh grapefruit were isolated.

This work on bud variations demonstrated that while the initial occurrence of bud variation was relatively low, the number of "off-type" trees could reach a high percentage in groves, if budwood was unknowingly taken from trees having variations. Careful checking of budwood source trees and their progeny is necessary to avoid propagation of undesirable variations.

Several of the bud variations in citrus have been identified as chimeras. Among these are several white-over-green periclinal chimeras from the Eureka lemon and Valencia orange, and green-over-white periclinals from the Lisbon lemon, Valencia orange and sour orange. All are characterized by extremely irregular arrangement of the two kinds of tissue in the leaves. The pink-fleshed lemon variation mentioned above, and pictured in Fig. 1, is an example of a white over green type. A number of the different types arising as bud variations are probably also periclinal chimeras. Such variations as the Golden Buckeye, Corrugated, and Seamed strains of navel oranges behave as if there is a repeated emergence of the parent type from the inner cell layers. Fig. 2 shows fruit from a sour orange tree which usually has normal foliage and fruit but occasionally has variegated leaves and fruits with sectors of thinner, smoother, yellow rind; rarely a fruit is mainly yellow. This may be a green over white chimera or perhaps an unstable green type.

Because of the possibility of the chimeral condition, a tree with a bud variation branch, or occasional variant fruits, is to be considered an unsafe source of budwood for propagation. Shamel and his co-workers demonstrated in several cases when budwood was taken from branches bearing normal fruits on trees also bearing variant fruits, that some of

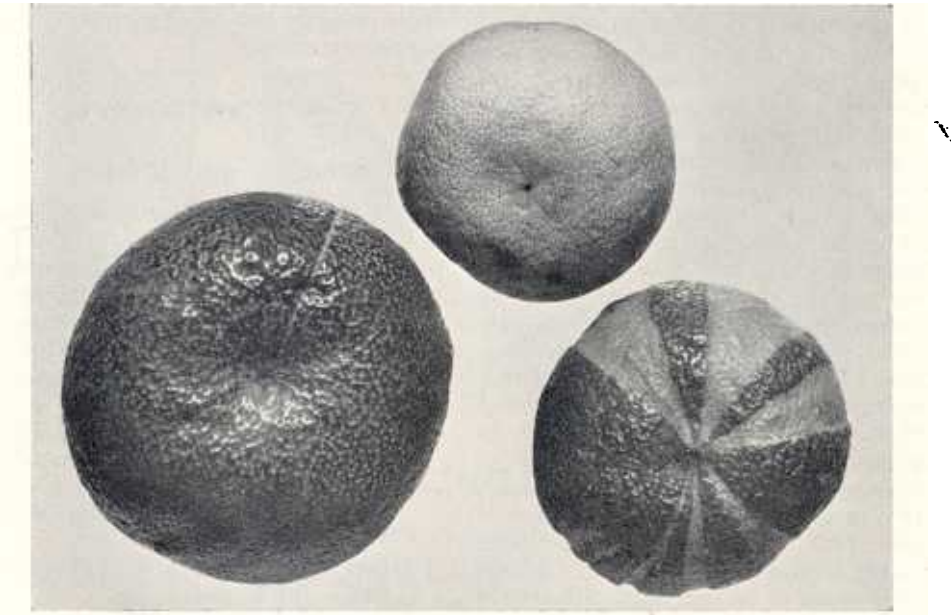

FIG. 2. Fruits of sour orange showing normal rough, green rind (left) and variants—smooth, yellow (center), and sectorial chimera (right).

the bud progeny from the normal branches were variants.

The presence of nucellar embryony in citrus provides a method of recovering or separating one or more types occurring in a chimera. Since the nucellar embryo arises from a single maternal cell without union with a male cell, only one type of tissue will be included in any one nucellar seedling. Such a technique is now being employed with such important but ever-sporting varieties as the Ovale of Italy, in an attempt to isolate the desired Ovale type.

Three strains of Satsuma orange which differ in several characteristics were established by Dr. H. B. Frost from nucellar seedlings from a single parent, indicating that the parent may have been a chimera. Or possibly the bud variations might have occurred just prior to the formation or at the time of formation of the nucellar embryos. However, this latter possibility would necessitate a rather high rate of production of variation.

Nucellar progeny from some citrus also indicate that some bud variations are due to genetic instability of some kind. Six nucellar offspring of one Valencia orange tree bear fruits that are partly "solid-dry". The fruits of these trees vary from a condition of abnormal firmness to complete absence of juice. Not only do the fruits on each tree differ greatly among themselves but the trees affected differ greatly in the average amount of dryness. Nucellar progeny of the Ruby orange, a variety with red pulp and rind, behaves in this same manner in regard to the red coloration.

Even if the variation within each tree in such cases can be explained as the result of a chimeral condition, rather frequent genetic changes within cells seems to be indicated. Since each nucellar embryo originates from a single cell, each variant embryo probably has undergone at least one change of genetic type in order to become a chimera.

The possibility of virus diseases producing changes that will be mistaken for bud variations should be considered. Some viruses have been demonstrated to produce changes in fruit shape. Other virus diseases such as Triztesa will produce tree stunting when the scion is grown on certain rootstocks.

Reported variations must be constantly screened to determine if they are advantageous and if they are heritable changes. It is particularly difficult to detect bud variations affecting such characters as yield or quality. Such variations usually cannot be expected to be detected until they exist as entire trees as the result of propagation. It is then difficult to determine if the differences observed are the result of particularly favorable environmental conditions the tree has enjoyed or if it is the result of bud variation. Only progeny testing of such trees can supply the answer.

Breeders and Testers

We shall periodically add to the list of fruit breeders and testers originally published in Vol. 9, No. 1 and supplemented in Vol. 9, No. 3 of FRUIT VARIETIES and HORTICULTURAL DIGEST. Our current additions are as follows:

Barker, G. N., Littleton, Mass.—grape, plum.

Isbet, A., U.S.D.A., King's Hall, U.S. Virgin Islands—Annona, avacado, citrus, guava, lime, mango, papaya, passiflora, sapodilla, West Indian cherry.

Janick, J., Purdue Univ., Lafayette, Ind.—apple, pear.

Tukey, R. B., Purdue Univ., Lafayette, Ind.—apple, pear, peach.