CITRUS ROOT-STOCKS*

THE question is frequently asked. "Why not grow fruit trees from Seeds?" The answer is that where improvements have been made these qualities are usually not transmitted through seed, but are perpetuated through the buds. Hence the necessity for using parts of the vegetative portion of the plant for the purposes of propagation. The Mendelian discovery has only comparatively recently explained this phenomenon, but practical attainment preceded the theoretical explanation by centuries, and the arts of budding and grafting have preserved the desired fruit varieties throughout succeeding generations.

The extreme antiquity of the practices of budding and grafting are illustrated by the writings of Columella, a celebrated Roman authority on all matters connected with agriculture and horticulture in or about the year A.D. 55. He wrote: "The ancients have taught us three kinds of engraftments, one which after the tree is cut and cloven receives the scions which are inserted into it, another which admits the graft between the bark and the wood, both which kinds are proper for the spring season. The third, which the husbandman calls "emplastration", receives the buds themselves, with a little bark into a part of itself, from which the bark is pulled off."

This "emplastration" to which Columella refers is clearly budding, as we understand it today.

The use of such asexual methods of propagation introduced into horticulture the scientific problem of the relation and interaction of stock and scion. Much attention has been given by horticulturists to these reciprocal influences, and after many years of research, the problem is more clearly, though by no means, perfectly understood.

Citrus growers throughout the world have observed great variations in the yield of different trees in the same orchard, under the same conditions, and this variation is now understood to be due to one of the following factors:

1 Variations inherent in the buds from different parent trees.

2 Different kinds and character of stocks used.

3 The character of the union obtained at budding.

4 Differences in individual environment, especially as to soil and climatic conditions under which the trees are growing.

5 Accidental and unavoidable differences in treatment given to different trees.

Of these factors, the influence of the character of the stock is probably of the greatest importance, and the purpose of this article is briefly to consider the question.

The experience of citrus growers in various countries of the world has clearly demonstrated that no one stock is satisfactory for use in all locations and under all conditions. In California, the bulk of citrus trees are budded on the Seville or sour orange, *Citrus Aurantium,* whilst a few are worked on the sweet orange *C. Sinensis,* pomelo *C. Paradisi* and the trifoliate orange, *C. Trifoliata.* In Florida, the Seville orange is probably most extensively

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used, but the rough lemon, *C. Limonia,* and sweet orange stocks are also used to a considerable extent, as is also *Trifoliata*; the latter stock chiefly for the mandarin type of orange. The sweet oranges stock is rather indiscriminately used on all types of soils, but is more or less avoided in most countries because of its susceptibility to root diseases. In South Africa, extensive experience definitely shows that the rough lemon stock is the only one that can at present be recommended for general use, being the only stock fully tested that has given uniformly good results. In Palestine and Cyprus the chief stocks for citrus are the "Sour" or "Bitter" orange, *C. Aurantium,* and the sweet lime (or sweet lemon, as it is often erroneously called) *C. Aurantifolia.*

Dr. Webber, one of the world's authorities on this subject states: "If a critical examination of the evidence relative to citrus stock is made, it will be admitted that in no country is the evidence sufficiently exact and extensive to justify an assertion that a certain stock is the best and only one to use. All that we can say is that certain stocks have proved to be successful and are the best available".

The Sour, Bitter, or Seville Orange (C. Aurantium)—This stock has proved generally satisfactory in California and is now commonly employed in Palestine and Cyprus, where experience has proved it to be superior to any other, in the long run. It is characterized by a well developed root system which spreads and penetrates deeply into the soil; it is resistant to the various root diseases and next to *C. Trifoliata* is the hardiest of citrus stocks in common use. According to the experience of growers in several countries, the quality of fruit produced on this stock is of high grade from the time the tree begins to bear.

As an instance of the effect of environment on stocks the following case is worthy of note. Some years ago *C. Aurantium* was recommended for trial in South Africa, on the basis of its almost universal success in other countries. It was extensively used but was found to be a complete failure. Its failure, as a stock in South Africa, is difficult to understand and the case is rendered more perplexing by the fact that the Seville orange grown there as a seedling, does well and appears to be vigorous, healthy and of normal size. A number of problems at present besetting the citrus industry of South Africa would be largely obviated if *C. Aurantium* could be successfully used there as a stock. Fortunately, it grows naturally and well in Cyprus under the common name of "Bitter" orange and it is unquestionably the stock to be recommended, at present, for future citrus plantings in Cyprus. It is now being widely used in Palestine, and a concrete instance of its superiority over the sweet lime stock in that country, where conditions are to all intents and purposes similar to Cyprus, is given below:

"There were two plantings alongside each other, one consisting of Jaffa oranges on sweet lime stock and the other of Jaffa oranges on sour or bitter orange stock. The trees on sweet lime stock were 17 years old and the ones on sour stock 15 years. The planting distance was about 20 feet in both cases, the square system being employed. The trees on sweet lime were showing considerable "die-back", many of them were infected with gummosis, they were not uniform, they were carrying only a fair crop, and the fruit was of inferior flavour, whilst the trees on the sour or bitter orange stock, although two years younger, were very much bigger, viz. had a larger potential bearing surface, free from disease, very uniform and well formed, and were carrying a heavy crop of the highest quality fruit".

The Sweet Lime (*C. Aurantifolia*).—This stock is very early maturing, but its extreme susceptibility to the various root diseases, especially gummosis, renders it unfit for use except on the very lightest soils. Trees worked on this stock invariably start to deteriorate at an early age, whilst a normal citrus tree should increase in production, according to recent investigation, at any rate up to 40 years old. The use of this stock should be avoided wherever possible.

Importance of Root-Stock Selection.—It is a common observation that some orchards grow and develop satisfactorily from the time of planting, while others on similar land, receiving similar treatment are always lagging behind. Such differences, when a standard variety has been used have commonly been ascribed to differences in local environment and different care, but it has become evident that all the variation exhibited cannot be thus explained.

The differences in the stocks used are undoubtedly one of the chief causes of this variation, as the stocks are seedlings from many different parents of unknown character and thus no single one is ever just like any other one.

In Cyprus, practically all our citrus trees are budded either on sweet lime stocks or bitter orange stocks, not of any particular strain, but just any sort of stock as long as it is a sweet lime or a bitter orange.

To illustrate the far-reaching effects of this lack of selection, the following experiment is quoted. In preparation for an extensive fertilizer experiment in California, a nursery of some 16,000 trees was grown of Washington Navels, Valencias and Marsh grapefruit. Good seeded stock was selected from the nursery and buds were used from the best selected trees of known standard type. Planting and all other cultural operations was performed with the utmost care to secure uniformity of treatment, and an excellent and apparently very uniform nursery was produced.

Later, upon inspection, it was found that there was a big variation in the size of the trees, some having trunks $\frac{3}{8}$ inches in diameter and others $1\frac{1}{4}$ inches in diameter. Dr. Webber, who was in charge of the experiment, now decided to lay out a small experimenal orchard with the trees thus varying in size. Rows were planted with large, medium and small trees and the treatment given was as uniform as possible. After a lapse of seven years, there was still the same marked difference in size between the rows, and the consequent difference in the productive capacity of the trees was also noticed. In ordinary practice, *all* these trees would ultimately have been planted in commercial groves.

The variation in size of nursery trees may be influenced by factors such as variation in environment, nature of stock and natue of bud used, but investigations have clearly revealed that the most variable element and probably the one responsible for the greatest part of the variation is the variability in the stocks used.

It is clearly evident that if we desire to produce uniform orchards, where every tree is to be a producer of revenue, it will be necessary to pay more attention to the selection of stock strains. Not merely any sweet lime or bitter orange, or whatever seedling we are going to use is going to be suitable, but a certain strain of a particular type, which by trial is known to produce batches of seedlings of uniform size and character.

In making a stock selection the following points should be considered:

1 *Seed.*—The seeds should be obtained from parent trees of known character. They should be sorted, and all weak and unhealthy seeds should be removed. Further, it is no use of selecting all the largest seeds, as citrus seeds are polyembryonic and it may thus occur that one big seed will give rise to two or more weakly seedlings, whereas a medium-sized healthy seed with only one embryo will usually give rise to one vigorous seedling.

2 *Transplanting from the Seedbed.*—At this stage only those seedlings with perfect root systems, and those which are most vigorous, viz. the largest, should be used. All seedlings with "bench" roots, and those with twisted tap roots should be discarded. Fully 60 per cent. of the seedlings from the original seedbed usually have to be discarded at this stage.

3 *Budding.*—Only seedlings which are true to type and show no signs of variation should be budded. A further weeding out of the weaker stocks should be made at this stage. It is a grave mistake to leave undersized stocks for an extra few months, in order that they may attain budding size. Their growth rate is slower than that of the large vigorous seedlings, and this difference in size will always be maintained.

4 *Transplanting into the Grove.*—When the young trees are transplanted into their permanent positions, only those true to type should be used. All "wild" ones, and those stunted in growth should be discarded.

It will be observed that the above system of stock selection gives four checks on variation, and if stock selection is thus followed carefully at each stage in the growth of the young tree, the grower can be assured of a fairly uniform batch of trees. Trees (budded) and stocks of different ages should never be planted in the same block in the nursery. Nursery trees should invariably be grown in blocks; stocks just transplanted from the seedbed; one year old stocks; stocks ready for budding; and budded trees. At the end of the planting season, all budded trees not sold should be cleared off the land, and after a deep and thorough cultivation and perhaps a dressing of manure, the block should be replanted to young stocks straight from the seedbed.