the publication of any material which is not of a scientific nature, in the deepest sense of the word.

In its endeavor to make the American Breeders Association advance the interests of science, the council hopes for the co-operation of everyone interested in the most important branch of science—that which deals with the production of better plants, animals and men.

New Citrous Fruits

Successful Hybrids—The Citrange, Tangelo and Limquat—Cold-Resistant Substitutes for the Lemon and Lime—Future Possibilities*

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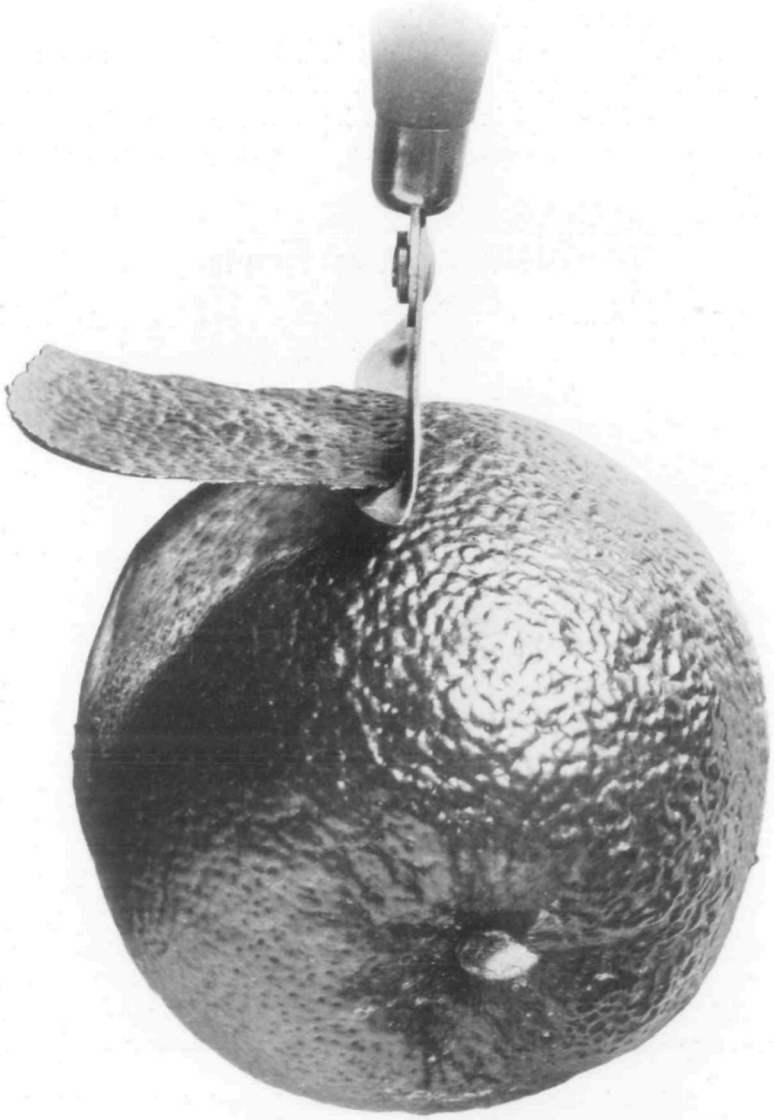
In the spring of 1910, I presented to the horticultural societies of Alabama and Florida, two papers on the breeding of new types of citrous fruits. As these papers were published in the proceedings of those horticultural societies[1] [2] it is not necessary for me to rehearse here the accounts published there in full. For the benefit of those who have not followed the work I may state that citrous breeding work was begun by me in Florida in 1893, but that the hybrids made at that time were for the most part lost during the great freeze of the winter of 1895-6; that the most important work was that carried on in the spring of 1897 when I made a determined effort to originate hardy citrous fruits by crossing the common oranges with the hardy Chinese *Citrus trifoliata.* In all 212 crosses were made, of which one parent was *Citrus trifoliata.* Three fruits were secured which yielded altogether 13 true hybrids. When these fruited they turned out to be a new type of citrous fruit, so different from any then existing as to require a new name and they were

* Read before the American Breeders Association, Ninth Annual Meeting, Columbia, South Carolina, Jan. 25, 1913.

[1] Swingle, Walter T., 1910, New types of Citrus Fruits for Florida (read May 18, 1910), in Proceed. 23 Ann. Meet. Florida State Hort. Soc., Ormond, Fla., pp. 36-41, pls. 1-8.

[2] Swingle, Walter T., 1910, New Methods of Breeding and Testing Hardy Citrous Fruits (read Jan. 28, 1910), in Rept. 7 Ann. Meet. Alabama State Hort. Soc., Bessemer, Ala., in Bull. State Dept. Agric., Serial No. 36, pp. 190-200.



MORTON CITRANGE, NATURAL SIZE.

A remarkable hybrid between the Japanese orange, hardy as far north as Washington, and the ordinary orange. To avoid the strong oil in its glands, the skin should be peeled before cutting the fruit. (Plate 1.)

accordingly called "Citranges" by Dr. H. J. Webber and myself.* Citranges vary greatly in size, shape and color, but are all alike in having very abundant acid juice of an aromatic and slightly bitterish taste. A very good substitute for lemonade can be made from them and they can also be used for culinary purposes. Citranges are admirably adapted for home use throughout most portions of the Cotton Belt, where the climate is far too cold for growing ordinary citrous fruits.

The best citranges thus far produced are undoubtedly the Morton, Colman, Savage, Rusk and Cunningham. The first three named are large fruits, the largest being the Morton, which frequently exceeds a pound in weight (Pl. I). It is nearly round and closely resembles a large orange. It may be served as a breakfast fruit if plentifully sprinkled with sugar. The Colman, on the contrary, is somewhat flattened and can be distinguished at once by its mottled yellow skin which is covered with a fine fuzz. The peel of this citrange does not contain the disagreeable oil common to the others (Pl. II). The only other citrange having fuzzy skin is the Cunningham, which is a small fruit resembling a miniature Colman. The Savage has the external appearance of an orange except that it is slightly flattened and exhibits a tendency to ribbing. It is considerably smaller than the Morton. The Rusk is the smallest of the citranges, eight average size fruits going into a quart measure. The tree itself is an ornament, being loaded with white blooms in Spring and with brilliant red fruits in Fall (Pl. V). It is the most prolific of all and the most precocious, frequently bearing the third year after budding.

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* These citranges have been described in the following papers:

Swingle, Walter T., and Webber, Herbert J., 1898, Hybrids and Their Utilization in Plant Breeding, in Yearbook Dept. Agric. for 1897, p. 415, fig. 13.

Webber, Herbert J., 1900, Work of the United States Department of Agriculture on Plant Hybridization, in Journal Royal Hort. Soc., London, 24: 128-138, 144, figs. 42-47. Also reprinted separately, pp. 1-11, 17, figs. 1-6.

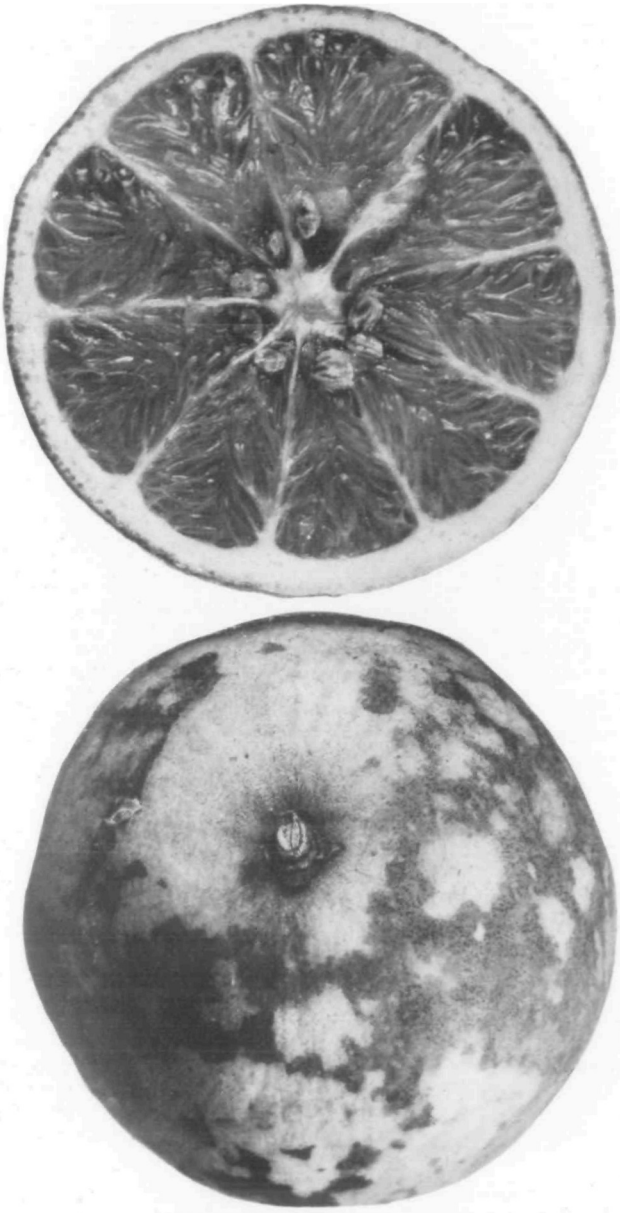
Webber, Herbert J., and Swingle, Walter T., 1905, New Citrus Creations of the Department of Agriculture, in Yearbook Dept. Agric. for 1904, pp. 221-235, figs. 12-13, pls. 10-16.

Webber, Herbert J., 1906, New Fruit Productions of the Department of Agriculture, in Yearbook Dept. Agric. for 1906, pp. 275-278, fig. 80, pls. 17-19.

Webber, Herbert J., 1907, New Citrus and Pineapple Productions of the Department of Agriculture, in Yearbook Dept. Agric. for 1906, pp. 329-336, fig. 10, pls. 17-20.

Webber, Herbert J., 1912. Citrus-Arten, in Fruhwirt, D. C., Die Züchtung der landwirtschaftlichen Kulturpflanzen, 5: 107-121, figs. 18-24.

Swingle, Walter T., 1910-1913. See the articles cited elsewhere in this paper.



COLMAN CITRANGE.

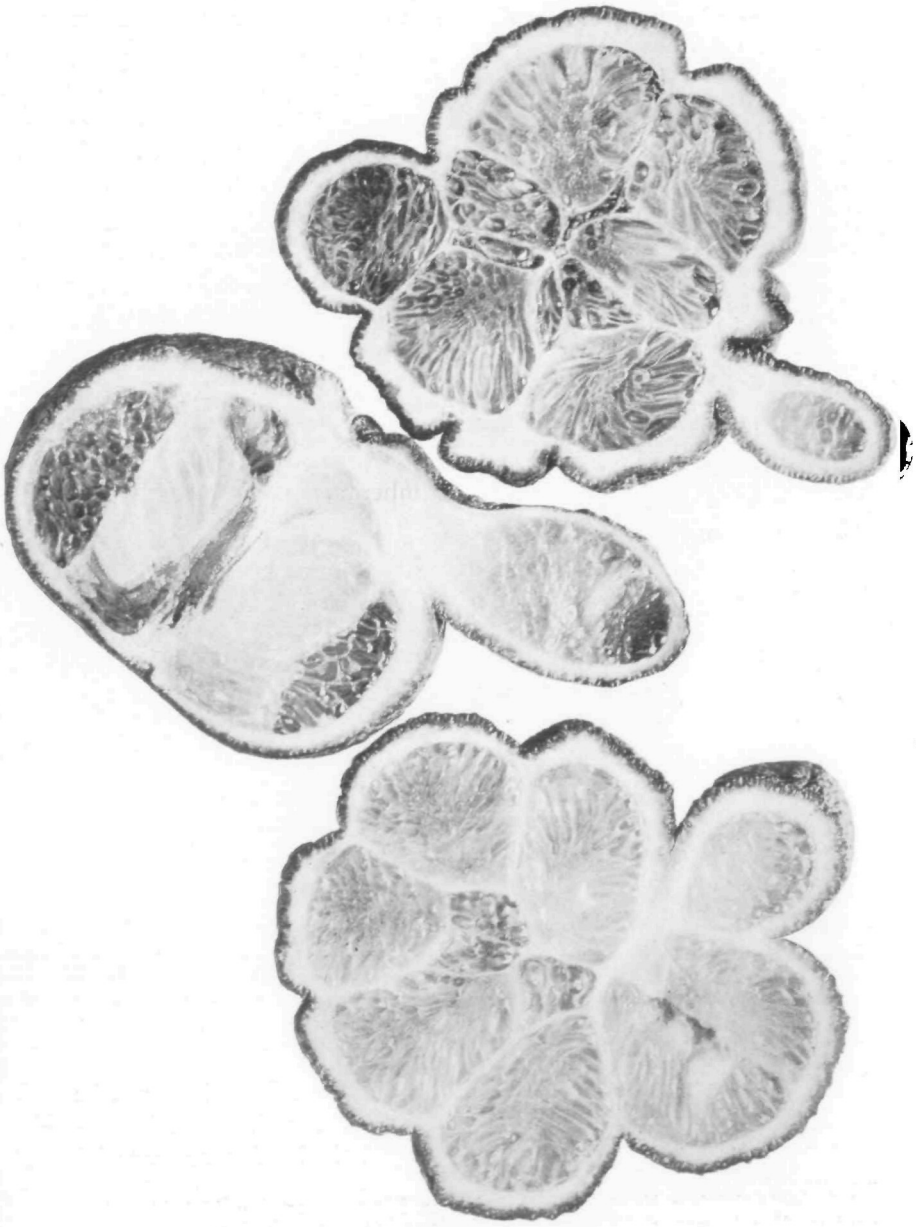
This variety, shown natural size, is conspicuous by the dark blotches which are always present, and due to fungus growth among the fuzzy hairs covering the skin. Oil glands small and few. (Plate 2.)

The fruits of the Willits citrange exhibit a tendency to freakishness in shape, becoming sometime a mass of finger-like segments (Pl. III, IV). When of normal shape the fruits of this variety yield an abundance of juice of excellent quality. The Saunders citrange, though small in size and having a very rough thick skin, is of interest because of its good keeping quality (Pl. V).

The surprising variations exhibited by these citranges led to a renewed study of the phenomena of inheritance they manifest and in the autumn of 1911 I read a paper at the Fourth International Conference on Genetics at Paris, calling attention to the impossibility of accounting for observed variations by the ordinary laws of heredity and suggesting a new principle, Zygotaxis,* presumably of wide application in the explanation of these facts. I need not discuss this phase of the matter here. Suffice it to say that the wide variations exhibited by sister citranges of identical parentage showed the desirability of producing these hybrids in large numbers in the hope of occasionally securing an exceptionally valuable combination of characters. Accordingly, beginning in 1909, I again undertook the breeding of hardy citrous fruits on a very large scale and as a result some thousands of hybrids, containing more or less blood of the *Citrus trifoliata,* are now growing in various parts of the South.

At the same time that the original citranges were made in the spring of 1897 another hybrid was made between the tangerine orange and the grapefruit. The resulting fruit was also of a new type and was named "Tangelo." The first of these tangelos, which received the varietal name of "Sampson," has since come to be cultivated commercially on a small scale in several parts of Florida. It has developed in the course of this work that the tangelos show amost as much variation as do citranges and are almost as much unlike the parent species. Tangelos show little of the grapefruit and almost nothing of the tangerine, but are in effect new types of oranges showing a greater variability as to size and color and having, as a rule, a more sprightly flavor, in this respect approaching somewhat to the grapefruit. There can be no doubt that these hybrids called tangelos constitute an important source of new and improved citrous fruits for commercial

* Swingle, Walter T., 1913. Variation in First Generation Hybrids (Imperfect Dominance); its Possible Explanation through Zygotaxis, read Sep. 23, 1911, in Comptes Rendus de la 4ième Conférence Internationale de Génétique, Paris. p. 381-394.



ABNORMAL WILLITS CITRANGES.

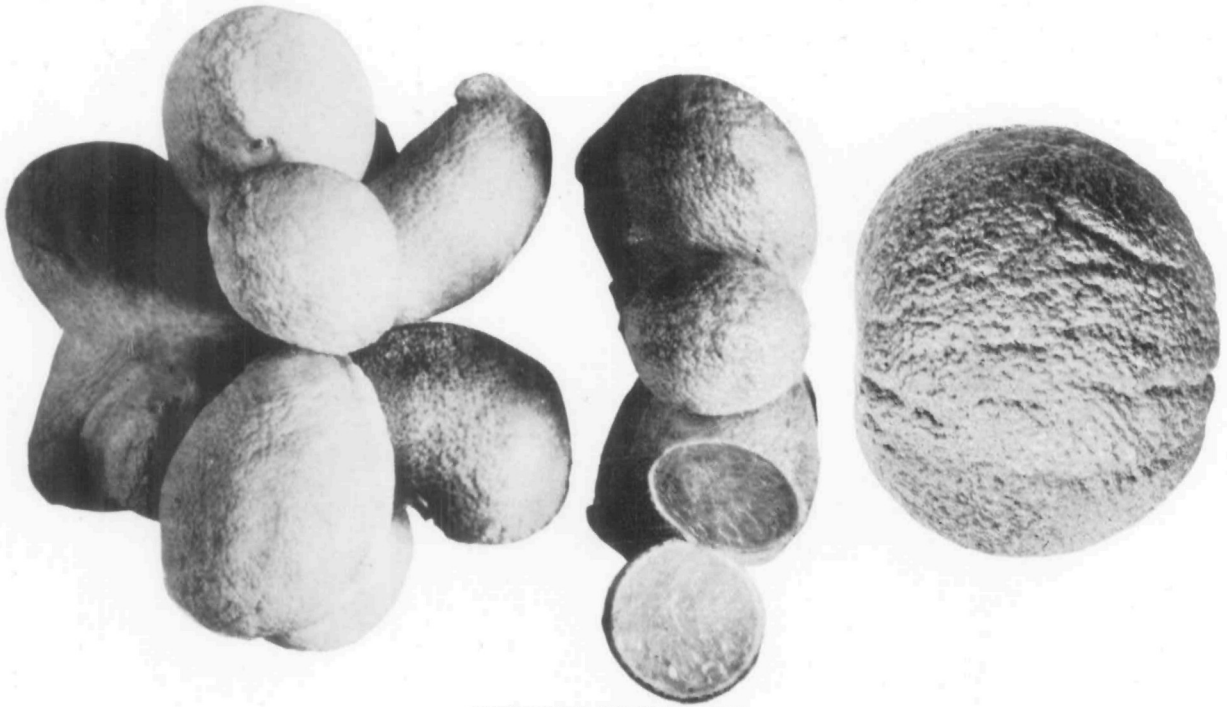
Cross sections, slightly less than natural size, of some of the abnormal types, which are of good flavor although of fantastic appearance. Produced particularly while the tree is young. (Plate 3.)

culture. Realizing this fact, I have for the past three years carried on extensive hybridization work in Florida with the help of F. W. Savage, and some thousands of new types of tangelos are now being propagated.

Another new type of citrous fruit is the limequat, which I originated in 1909 by crossing the common West Indian lime with the kumquat orange. I do not need to explain to those familiar with citrous fruits that the lime is the tenderest of all the commonly grown plants of this group. It is frequently frozen to the ground even in southern Florida and is often injured by frosts which have scarcely any effect on other citrous trees. The kumquat, on the other hand, is one of the hardiest of the evergreen citrous fruit trees. This is without doubt due not so much to its direct powers of cold resistance as to its remarkable dormancy. The kumquat is able to pass unaffected through long spells of hot weather which force other citrous trees into a tender and succulent growth that is liable to be injured by even a slight frost. Some measure of its dormancy is indicated by the fact that it flowers from two to three months later than other citrous trees. Fortunately the pulp of the kumquat, although small in amount, is mildly acid and, as might be expected, the hybrids between the lime and the kumquat prove to be of a very desirable character. The limequats vary in size from that of a large kumquat to that of a small lime. The skin is thin and of agreeable aroma and flavor, the pulp juicy and of varying degrees of acidity, some of the hybrids being almost as acid as the sourest lime, others being scarcely more acid than the kumquat itself. Here again we have great variation in first generation hybrids, due probably to zygotaxis, as in the cases of citranges and tangelos.

With this brief summary of the accomplished results I beg leave to direct your attention to what I consider some of the more important lessons of this work, one of the first of the lines of plant breeding work to be established in this country and one which is now being carried out perhaps on the largest scale and with the most complete record of any fruit breeding work. Nevertheless I consider that the work done hitherto is merely of a preliminary order and of comparatively little importance.

As long ago as April, 1893, I read at the Pensacola meeting of the Florida Horticultural Society an account of some citrous fruits which were being introduced into Florida, and emphasized the value of these wild relatives of our cultivated citrous fruits for



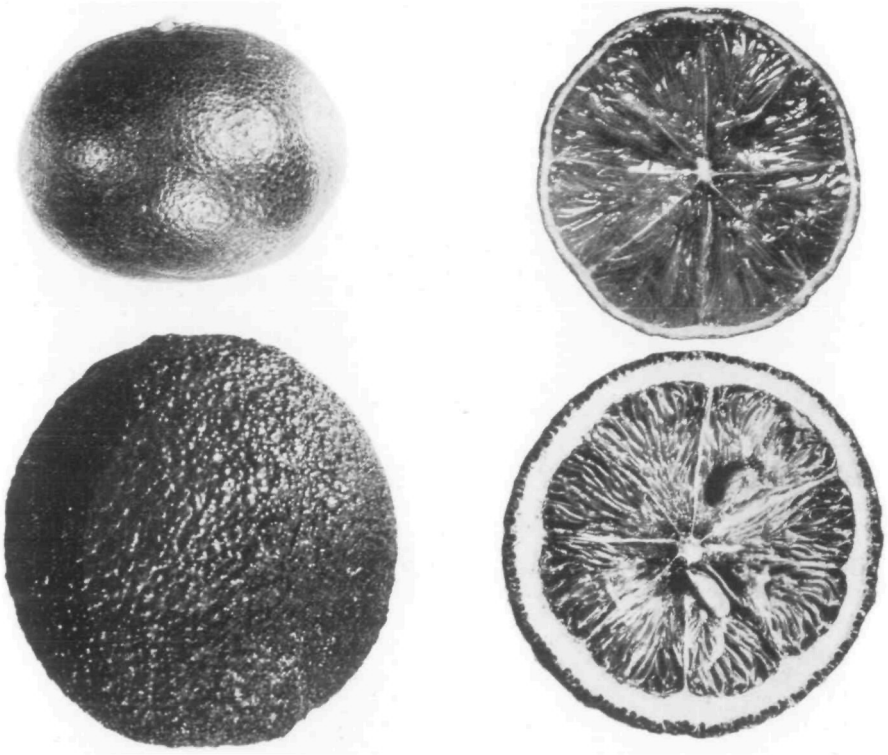
WILLITS CITRANGES.

At the right is the normal type, of excellent quality, while at the left is shown the fingered type, natural size. This abnormal type is uncommon in first generation hybrids, a fact that is not in accord with the ordinary ideas of Mendelism. (Plate 4.)

use in hybridizing.* It was not until some three years ago that I was finally in a position to take up this work planned twenty years ago, but these recent investigations have brought to light a large number of wild relatives of our citrous fruits, undoubtedly closely related to the commonly cultivated species. Many of these plants have been entirely neglected by horticulturists and their relationships misunderstood by botanists. A few examples will prove the truth of this statement. In the deserts of Australia there is found a small acid fruit edible in its wild state, and called by the settlers "desert lime" or "desert lemon" (*Atalantia glauca* (Lindl) Benth). It was first found growing in a region where such thick ice had formed that it had to be broken with an ax before the horses of the exploring expedition could get water to drink. Undoubtedly this desert kumquat has occasionally been subjected to temperatures almost as low as zero Fahrenheit. Here, then, is the hardiest of all the evergreen citrous trees producing in the wild state edible fruit which has, nevertheless, so far as I know, entirely failed to attract the attention of plant breeders in any part of the world. Certainly our correspondence seems to show that the desert lemon is not grown even in the botanic gardens of Australia, to say nothing of those of other countries. After considerable difficulty I succeeded, through the co-operation of the Office of Foreign Seed and Plant Introduction, in securing a quantity of seed of this species, and young plants are now growing in our greenhouses and in the southern and southwestern states. How much more promising is this species for use in breeding hardy citrous hybrids than is, for instance, the trifoliate orange, with its seedy fruit, acrid skin and scanty juice!

Throughout Central Africa there occur a number of species of *Limonia* (*L. Preussii* Engl., and related species) which upon study are found to be very closely related to *Citrus*. They bear large numbers of small, highly-colored, aromatic, delicious-flavored oranges clustered like cherries at the nodes of the branches. After some delay I succeeded in securing from Africa seeds of one of the species of this new group of citrous fruits, which we have been calling "cherry oranges." They grow rapidly and can be grafted readily on all the common citrous stocks. Unlike the species of

* Swingle, W. T., 1893. Some Citrus Fruits That Should be Introduced Into Florida, in Proceedings of the 6th Annual Meeting of the Florida State Horticultural Society, Pensacola, Fla. Pages 111-121. (Read April 13, 1893.) Tallahassee, Fla.



RUSK AND SAUNDERS CITRANGES.

Rusk (above) has a smooth, thin skin of bright orange-red color, while the Saunders (below) has a thick skin and very large, prominent oil glands, making it a good keeper. Both natural size. (Plate 5.)

Citrus, these African cherry oranges have compound leaves composed of from three to seven very large leaflets. It is not uncommon for a single compound leaf of an African cherry orange to have a surface ten times as large as that of a common orange leaf. When we reflect that the sugar that sweetens the fruit and the aromatic substances that give it flavor and perfume are formed in the leaves we realize how important it is to secure large-leaved forms of our cultivated plants.

Through a new system of grafting it has been possible to force some of these African cherry oranges to flower when they were less than two years old. In this way it has been possible to make a few

hybrids with species of Citrus. It can be imagined with what interest we await the result of these first experiments.

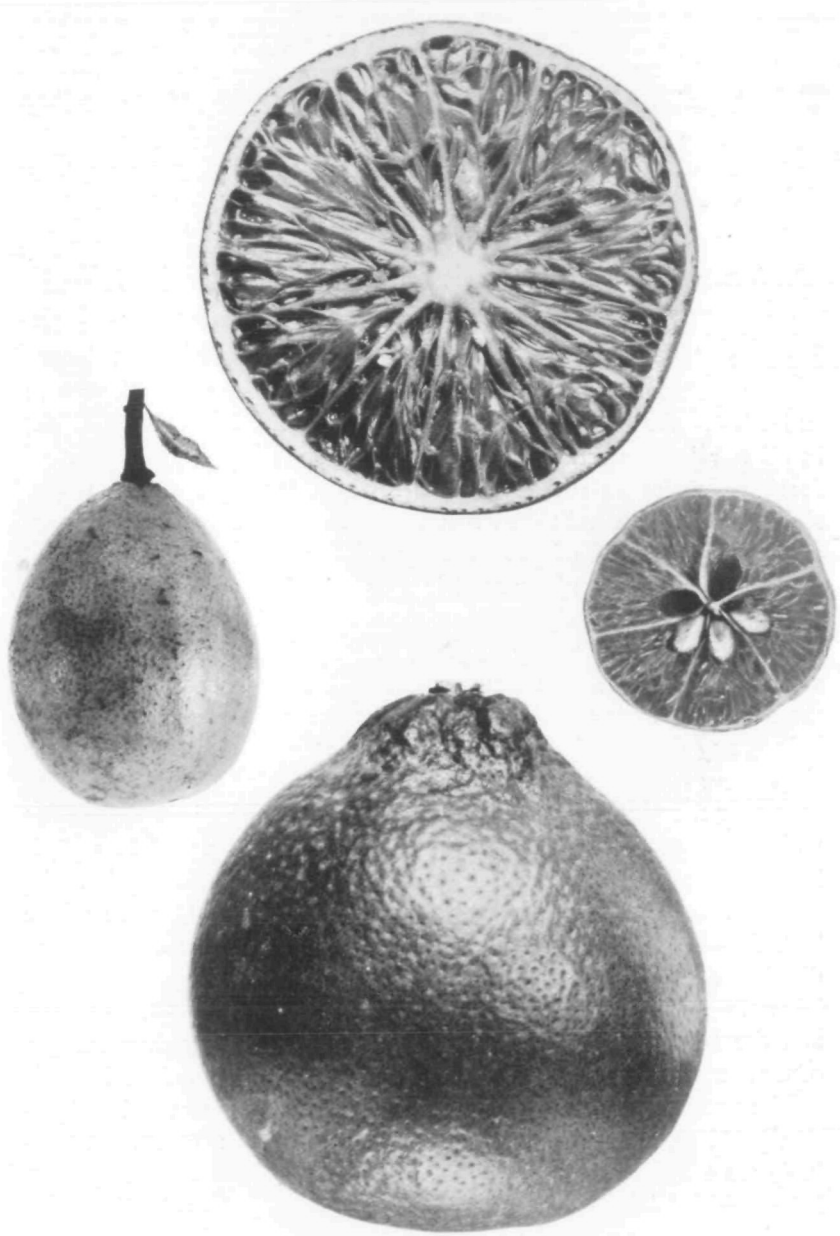
Other examples almost equally striking could be given to show what valuable material awaits the attention of the plant breeder. I think I am justified in stating that almost all of the plant breeding work done in this country, or any other country for that matter, has been very seriously handicapped by a lack of accurate knowledge as to the material available for use in hybridizing. I consider it the duty of plant breeders to inform themselves concerning the wild relatives of the groups they are breeding. To do this properly a thorough study of the group is necessary in order to discover the relationships of the different species and to suggest the most promising lines of hybridizing work. When we think of the hundreds of millions of dollars invested in the culture of our fruit and other crop plants and consider how frequently the varieties now cultivated suffer injury or death through lack of proper adaptation to the climate or soil, we realize how great is our responsibility to the people of this country and how imperative it is that we as plant breeders should inform ourselves as to the material at our disposal before spending public or private money in experiments carried on in an inadequate way. I am glad to say that we are now securing for our breeding work on the citrous group the wild relatives of the orange which I was so anxious to get twenty years ago. I think I can assure you that when this breeding work shall have progressed another ten years we shall have been able to demonstrate beyond any possible doubt the fundamental importance of securing a proper equipment of wild species with which to carry on the work.

I have looked into other groups in a preliminary way and am convinced that what I have said of citrous breeding applies with almost equal force to the improvement of nearly all other perennial fruits, berries and vegetables to which breeders are now giving their attention.

The new botany which gives us accurate information as to the number, morphological and physiological characteristics and relationships of the wild relatives of our cultivated plants will soon be recognized as absolutely essential to any defensible project for the improvement of our staple crop plants.

SAMPSON TANGELO.

Young fruiting tree growing at the Plant Introduction Garden, Chico, Calif. This hybrid is now cultivated commercially, and trees often fruit abundantly while still very young. (Plate 6.)



TANGELO AND LIMEQUAT.

Above and below is a Sampson Tangelo, while in the center is a limequat, obtained by crossing the common lime and kumquat. This is much more cold resistant than the ordinary lime. Fruits natural size. (Plate 7.)