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NEW CITRUS CREATIONS OF THE DEPARTMENT OF AGRICULTURE.

BY

HERBERT J. WEBBER AND WALTER T. SWINGLE.

Vegetable Pathological and Physiological Investigations,
Bureau of Plant Industry.

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NEW CITRUS CREATIONS OF THE DEPARTMENT OF AGRICULTURE.

By Herbert J. Webber, *in Charge of Laboratory of Plant Breeding*, and Walter T. Swingle, *in Charge of Laboratory of Plant Life History, Vegetable Pathological and Physiological Investigations, Bureau Plant Industry.*

Introduction.

For a period of five years, from November, 1892, to October, 1897, the writers were associated in the study of diseases of citrus fruits in Florida, being located at Eustis, in the central part of the State. A careful study was made of the varieties cultivated and of the industry in general, primarily as a basis for an intelligent investigation of the diseases and methods of their control. In the course of these studies the attention of the writers was early drawn to the desirability of breeding more varied and improved sorts.

An examination of the manner of origin of the various native sorts shows that in almost all cases they originated as accidental seedlings. Some growers made hybrids and used systematic methods of breeding, but the number of fruits which have originated in this way are very few indeed. The long time required to bring seedlings to bearing, the cost of cultivation and manuring, and the uncertainty of results have deterred growers from experimenting very extensively in this field. Owing to these difficulties, it seemed from the nature of the case that the investigations should be undertaken by the National Department of Agriculture, in order that the necessary funds could be provided and that the work could be carried on continuously for a series of years. This course was approved, and, under instructions from the Secretary of Agriculture, the writers, under assignment of Dr. B. T. Galloway, now Chief of the Bureau of Plant Industry, in the winter of 1892–93 made a careful study of the various citrus varieties and began the work of hybridization as rapidly as the time at their disposal would permit. These first attempts were largely preliminary, and most of the seedlings obtained were lost in the great freeze of 1894–95, which killed to the ground all orange trees in the northern and central parts of Florida. This seriously interrupted the work and compelled its temporary abandonment, owing to the fact that no groves could be found in the State furnishing the conditions necessary for carrying on hybridization. The experiments were taken

up again in the winter of 1896–97, when the writers made an extensive series of crosses at Eustis and Braidentown, being assisted in the work by Mr. Otis H. Gates. Again, in the springs of 1898 and 1899, one of the writers made further crosses which resulted in greatly increasing the number of hybrids. There have now been produced a total of 1,780 hybrids, and these are being grown and tested under general instructions from Mr. A. F. Woods, Pathologist and Physiologist of the Bureau of Plant Industry.

In all of the operations of hybridization the greatest care was taken to avoid contamination with pollen from other sources. In all cases buds were selected for hybridizing before they had opened and given opportunity for cross-pollination. These were opened and emasculated, after which they were covered with paper bags to prevent the access of insects bringing in pollen. When the emasculated bud had matured sufficiently to be receptive, the bag was removed and pollen of the variety selected as the male parent was dusted over the pistil. The bag was then replaced over the flower and left until fecundation had taken place, after which it was removed and the flower labeled. The flowers which were used for supplying pollen were also covered with paper bags previous to their opening, to prevent insects from leaving other pollen on them, which might be transferred in the operation of hybridization.

In much of the hybridization and breeding work which has been carried on by different investigators little attention has been given to the choice of the varieties used as parents and to the objects sought in the experiments. The time of this haphazard work, however, is past, as experience has demonstrated that it is far better for the experimenter to have a definite object in view and to select, as parents for hybridization, varieties which possess the characters that it is desired to combine in the hybrid. In the present experiments the following were the primary objects sought: (1) Hardier varieties which would endure the occasional severe freezes which visit the orange sections, and, if possible, varieties sufficiently hardy to be grown farther north than the present citrus belt; (2) new fruits having the loose, easily removable rind of the mandarin and tangerine combined with the quality, flavor, and size of the ordinary sweet orange; (3) new fruits having the sprightly acid flavor of the pomelo with the bitterness reduced, and the loose, easily separable rind of the mandarin and tangerine; and, (4) new fruits intermediate between the pomelo and the orange which would possess desirable market qualities.

In all of the writers' experiments these primary objects have been kept clearly in view, and varieties have been selected for hybridization which by their combination would be likely to give hybrids having the characters desired. As the hybrid fruits matured they were sent to Washington, where the seeds were extracted and germinated in a

greenhouse. When the young seedlings had reached a size of from 12 to 18 inches in height they were sent to the Department's Subtropical Garden at Miami, Fla., where they have since been grown under the supervision of Prof. P. H. Rolfs. When the seedlings were sent south the tops were cut back and the twigs used to furnish budwood for budding proper stocks to obtain trees for trial. These trees were tested in cooperation with different growers, arrangements being made with a number of intelligent, trustworthy growers to bud from one to two stocks with each of these hybrids and grow them until sufficient fruits had been produced to show their character and value. In the case of the hybrids made with the idea of securing hardiness, trees were budded and grown under the direct supervision of the Department by Mr. G. L. Taber, at Glen St. Mary, in northern Florida. Owing to the conditions under which the various trees have been grown very few of them have yet fruited. Several freezes have visited Florida in the last five years, and in many instances all of the hybrid buds sent to growers have been killed. In but few instances have large stocks been used which would force the buds into early bearing; nevertheless, several very promising new types have been produced, and without doubt many more fruits of value will be obtained when all of the hybrids have been brought into bearing. It should be noted that in fruit trees of this sort all of the varieties are *clons*, that is, varieties which are propagated by buds, grafts, or cuttings. A hybrid of value, when once secured, can thus be propagated indefinitely by budding or grafting, without awaiting fixation, as is necessary in the case of plants propagated by seed, where a desirable hybrid must be selected through a number of generations and bred to a fixed type that will come true through the seed before it can be utilized.

Production of Hardy Citrus Fruits.

The citrus industry in Florida has frequently suffered from severe freezes. The most disastrous of these probably were the freezes of 1835, 1886, and 1894–95, which killed or seriously injured almost every tree in the State. Other minor freezes have occurred from time to time, which, while not so severe, have seriously damaged many orange groves. In California and Arizona, also, citrus trees are frequently injured by severe cold. It is thus clear that the most desirable improvement in the orange and other citrus fruits is the securing of varieties which can endure lower degrees of temperature and which may be grown throughout the present orange-producing sections without danger of injury by cold.

In attempting to improve citrus fruits in hardiness, two methods present themselves. One method would be to grow a large number of seedlings and select from them the individuals which possess the

greatest degree of hardiness, and continue this selection throughout numerous generations in the hope of augmenting any greater degree of hardiness that might be discovered. To pursue this policy with citrus fruits would require so long a period to secure any marked results that the method is impracticable. This is shown by the fact that for many years citrus growers have been making selections based on the hardiness of seedlings, and as yet no appreciable advance has been made in this direction.

A second method would be to select some hardy wild or cultivated type and cross this with the sweet orange or lemon in the hope of obtaining good varieties, combining the hardiness of one with the good fruit quality of the other. If such a hardy type exists, this method would certainly seem to be the quickest and most practicable way of securing hardy varieties. A species of citrus known as the trifoliate orange (*Citrus trifoliata*) is such a hardy type, which can be grown without protection as far north as Philadelphia. The common variety of the trifoliate orange (Pl. X) was introduced into this country by the late William Saunders, of the Department of Agriculture, in 1869. The tree is small and bushy and very spiny, and the leaves are trifoliolate and deciduous. It is quite commonly grown as a lawn tree in the North and as a hedge plant in the South, while in the colder sections of Florida it is used as a hardy stock on which to bud the common orange and other citrus fruits. The fruit (Pl. XII, fig. 4, and Pl. XIII, fig. 2) is round and small, ranging from 1¼ to 2 inches in diameter, and is orange-colored. The surface is covered with minute fuzzy hairs and is in most cases smooth, being rough only in the larger and more vigorous specimens. The rind, which adheres tightly, is about one-sixteenth inch in thickness. The pulp is acrid, bitter, and gummy, and the enormous number of seeds leave little room for pulp. The fruit is thus worthless as far as edible qualities are concerned. It is highly aromatic and attractive in appearance, making the plant desirable for ornamental purposes. Unfortunately, however, for its use in the South, the tree is deciduous, losing its leaves in the fall, and in general throughout this section an evergreen hedge is most desired. Notwithstanding this, it is generally cultivated as a hedge plant because of other qualities which make it desirable for this purpose. Its hardy character, however, is the factor of importance in connection with the experiments in the production of a hardy orange.

A second variety of the trifoliate orange, having rather larger leaves and very large flowers, has been found growing in several places in Washington, D. C., but has not been used in the present experiments.

The first variety described, the ordinary trifoliate orange, was the one used in the work of the writers, though the second might be more promising to use with the lemon, and some of these crosses have been

BRANCH OF TRIFOLIATE ORANGE.

[About one-half natural size.]

made. However, no fruits have thus far been obtained. All varieties of the trifoliate group are deciduous, and ripen their fruit early in the fall before frost. They are also late in blooming in the spring, the flowers, which appear before the foliage, not even showing until the common sweet orange is nearly through blooming. The trifoliate is thus about two to three weeks later to start growth in the spring, and is never caught by late frosts. The early ripening of the fruit in the fall, moreover, allows the tree to become dormant at a time much earlier than the common sweet orange, which is evergreen and inclined to grow more or less through the winter during warm periods.

It is a well-known principle in plant breeding that in hybridization the characters of races and species break up and become combined in different ways in the hybrids. It would thus seem entirely probable that by crossing and recrossing the common orange with the hardy trifoliate orange a hybrid could ultimately be obtained combining the desirable fruit characters of the former with the hardiness of the latter. Many instances are recorded where hybrids have been obtained combining certain characters of the parents, and a few cases are known of hybrids which are intermediate in character of hardiness between the parents, being more tender than one parent and much hardier than the other. The improbability of obtaining the hardy quality in an orange variety is thus not so great as one might be inclined to think. If, by infusing the blood of the trifoliate orange into the sweet orange, we can modify the season of growth of the latter and cause it to remain more dormant during the winter and later into the spring, our object would be accomplished. If, on the other hand, a hybrid can be secured having an entire segregation of the characters and combining the hardiness of the trifoliate with the superior fruit qualities of the sweet orange, a far greater success would be achieved.

The sweet orange and the trifoliate orange are very distinct in character, and it has been found in the course of the experiments that they are very difficult to hybridize. Even by using the utmost care in the process of hybridization only about 2 per cent of the flowers operated upon set fruit. The process of crossing flowers of the trifoliate orange with pollen of the ordinary orange is much more difficult than the opposite cross where the orange is used as the female, as the flowers of the trifoliate orange are quite small at the time of emasculation, are attached very lightly, and are easily broken off or injured. It would thus seem that the lack of success in getting fruits to set was caused partially by the injury to the flower in the process of emasculation. This, however, is certainly not the only reason for the small percentage of fruits that set, as there is also a great loss when the reciprocal cross is made; that is, when the common orange is used as the mother parent. The seeds resulting from these crosses were also poor in germinative

power, not more than half of the seeds obtained finally producing seedlings. In the course of the experiments, however, a number of hybrids were secured where both the common orange and the trifoliate were used as the seed-bearing parent. Some of these hybrids plainly show the characteristics of both parents and are doubtless true hybrids. Out of 40 hybrids of the trifoliate orange crossed with the pollen of the sweet orange, 29 resembled the former in habit and foliage characters, so far as could be observed, while 11 were clearly intermediate in these characters. These 11 intermediate plants are very similar to each other, deriving certain characters from each parent. The leaves are trifoliolate in form and are much larger in general than those of the normal trifoliate orange. The central leaflet has a tendency to be much larger, but the lateral leaflets remain about the size of those in the trifoliate orange, and in some of the seedlings these lateral leaflets tend to become abortive, thus approximating the unifoliolate sweet orange.

FIG. 12.—Three seedlings grown from a single seed of a hybrid (tangerine crossed with trifoliate); seedling with trifoliolate leaves (on the right) is a true hybrid; the other two seedlings with tangerine-like leaves are false hybrids.

During these experiments it has been found that some complexity is liable to arise, owing to the polyembryonic nature of citrus fruits. It is well known that seeds of various citrus fruits frequently produce more than one seedling. Instances have been noted where a single seed has produced as many as 13 seedlings. In cases where strikingly distinct types of citrus fruits were crossed, the interesting observation was made that where two or three seedlings were developed from a single seed they not infrequently showed marked foliage differences (fig. 12). Strasburger, in his critical study of the polyembryony of this group, found that the embryos, other than those developed from the fecundated egg cell, are derived from certain cells of the nucellus, lying near the embryo sac wall, which become specialized, grow, and develop rapidly, and form a tissue mass, which pushes out into the embryo sac and forms an embryo similar to that formed in the normal way from the egg cell. The embryos formed in this way Strasburger called "adventive." If we correctly understand the action of fecundation, it is clear that in this group only those embryos that develop from the egg cell proper as a result of the fecundation would show an indication of hybridization. Since the adventive embryos develop directly from the mother tissue, in these we should not expect to see any of the characters of the male parent. This conclusion was reached by

the writers early in the experiments, before the growing of the seedlings had shown definitely what would take place, and the development of the hybrids has proved this conclusion to be well founded. In several hybrids of the sweet orange, which is unifoliolate, with the trifoliate orange, which has trifoliolate leaves, where the former was used as the female parent, two and three seedlings have been produced from the same seed, one of which had trifoliolate leaves, showing clearly the influence of the male parent, while the other or others had strictly unifoliolate leaves exactly like the mother parent. It is certain in such cases that the trifoliolate seedling inherits this character from the male parent, and that the embryo from which it grew was developed from the egg cell proper. The other seedlings in such cases which have unifoliolate leaves were doubtless developed from the so-called adventive embryos. The same phenomenon has also been observed where the trifoliate orange was crossed with pollen of the common orange and also in hybrids of the tangerine orange crossed with the common orange (fig. 12). The observations have been sufficient to establish its common occurrence in citrus hybridization. Attention was called to this phenomenon by one of the writers[a] in February, 1900.

In hybridizing citrus fruits to secure improved sorts this effect unfortunately causes serious complications. In many cases citrus hybrids resemble the female parent in foliage characters, or the parents differ so little in their foliage characters that the hybrid can not be clearly distinguished, and it may thus be seen that until the seedlings fruit it is impossible to determine whether they are true hybrids or simply false hybrids developed from adventive embryos. It will thus be unavoidable in such work to grow many seedlings which come from adventive embryos and which are not true hybrids. Such false hybrids ordinarily would not be expected to give valuable varieties, and growing them greatly adds to the trouble and expense.

The increase in vigor which is commonly exhibited by hybrids between distinct parents is clearly shown by hybrids between the trifoliate and the common orange. Those which have intermediate characters, showing that they are true hybrids, are almost invariably much more vigorous than the seedlings of either parent. The hybrids which exhibit no intermediate characters and are probably developed from adventive embryos, do not exhibit this increased vigor. Illustrations of this increase in vigor will be given later.

The Citrange, a New Group of Citrus Fruits.

In the course of these experiments two fruits have been produced which are hybrids between the common sweet orange and the trifoliate orange, and which promise to be of considerable value. They lie

[a] Webber, H. J., Complications in Citrus Hybridization Caused by Polyembryony. Science, n. s., 11:308, February 23, 1900.

about midway between the two parents, but are not sweet oranges, trifoliate oranges, nor lemons, and are totally different from any other group of citrus fruits. It therefore becomes necessary to refer these hybrids to a new group of citrus fruits, and it is proposed to call them "citranges," a term made up of the first syllable of the word *citrus* and the last syllable of the word *orange*. The two varieties which are to be referred to this group are described in detail below.

RUSK CITRANGE.

[PLATES XI AND XII, AND PLATE XIII, FIGURE 1.]

NAME AND ORIGIN.—The Rusk citrange originated as a hybrid between the common orange (used as the female parent) and trifoliate orange (used as the male parent). The trees are far more hardy than the common orange, and produce a fruit intermediate in qualities between the two parents. This being the first hardy orange or citrange produced, and belonging to an entirely new group of citrus fruits which will doubtless become of very great importance in many parts of the world and be improved in a marked degree, has been named the *Rusk*, in honor of the first Secretary of Agriculture, Hon. J. M. Rusk, under whose administration the first work on citrus fruits in Florida was undertaken by the Department of Agriculture.[a]

The Rusk citrange was one of three seedlings grown from a single hybrid fruit which developed in the grove of Col. G. H. Norton, at Eustis, Fla., in 1897. Two of the seedlings, from which several budded trees have been grown, resemble the ordinary sweet orange in foliage and general character, and are apparently false hybrids from seeds of adventive, polyembryonic embryos, which, as explained above, are developed from certain cells of the mother tissue without the intervention of the male element. These two seedlings have unifoliolate leaves, and are evergreen like the common orange, and while they have not yet fruited, owing to the fact that they have been several times frozen back, it is not expected that they will produce anything of value, nor, judging from a test already made, will they produce hardier types. The other seedling, No. 716, was a strictly intermediate type, having trifoliolate leaves similar to the male parent, though rather larger (Pl. XI). Even the first leaves of the young seedling exhibited this character, and a photograph of a seedling but slightly over 1 inch high published by the writers at that time plainly shows this trifoliolate character.[b] No. 716 was furthermore much larger and more vigorous than the other two seedlings,

[a] In the Cosmopolitan Magazine for July, 1904, Mr. H. Gilson Gardner referred to this citrange as the *Webber*, but the writers suggest, with the approval of the Secretary of Agriculture, that it be known as the Rusk.

[b] Swingle and Webber, Hybrids and their Utilization in Plant Breeding, Yearbook of the Department of Agriculture for 1897, p. 400, fig. 13.

HYBRID SEEDLINGS OF COMMON ORANGE (FEMALE PARENT) AND TRIFOLIATE ORANGE (MALE PARENT).

[No. 716 (on right), Rusk citrange; Nos. 714 and 715, seedlings from the same fruit as No. 716, but resembling the mother parent.]

1 2 3

FRUITS OF RUSK AND WILLITS CITRANGES WITH TRIFOLIATE ORANGE FOR COMPARISON.

[Fig. 1, Rusk; fig. 2, trifoliate; fig. 3, Willits. Natural size.]

showing an increase in vigor, which is such a marked character of hybrids in general. Trees were budded with these hybrids in the spring of 1899, in the nursery of Mr. G. L. Taber, at Glen St. Mary, Fla. The first fruits were received in September, 1902, one tree that season bearing about a dozen fruits. In the fall of 1903 the same tree produced about a bushel of fruits, and several other trees, budded on trifoliate-orange stock, gave about a half-dozen fruits each. A similar number was also produced in 1904. There have thus been produced sufficient fruits to afford a fairly thorough test of this hybrid.

DESCRIPTION OF FRUIT AND TREE.—Fruit compressed-spherical or nearly round; small, 1½ to 2 inches in diameter, 1¼ to 1⅝ inches high; color, when fully mature, deep orange, with reddish flush of cadmium orange at apex; surface smooth and glossy, with a few scanty hairs visible under magnification; very heavy, frequently sinking in water; calyx persistent, green, rather larger than that of the ordinary orange; skin adhering very close to the fruit, thin, $\frac{3}{32}$ to $\frac{1}{8}$ inch thick, tender; oil glands small and round; pulp tender, melting, exceptionally juicy (fig. 13); color orange yellow; pulp cells small, similar in shape to those of ordinary orange; segments, 10; membranes thin and tender, thus making very little rag; axis small, $\frac{1}{8}$ to $\frac{3}{16}$ inch in diameter; flavor sprightly acid and slightly bitter; nearly seedless, averaging one seed to two fruits; aroma strong and pleasant, a combination of that of the sweet orange and the trifoliate orange. Tree similar in shape to trifoliate orange, vigorous and hardy, evergreen or semi-evergreen, tall and shapely; foliage dense, leaves trifoliolate and larger than those of ordinary trifoliate orange. Season of maturity very early, from September 1 to November 1.

The fruit of the Rusk is a beautiful little orange of excellent texture and exceedingly juicy. It is rather too sour to be eaten out of hand, but with sugar is very palatable. The bitterness is no more pronounced than in the grape fruit, and the aroma, which is derived largely from the trifoliate orange, is very strong and pleasant. The fruit of the Rusk may be utilized for making citrangeade, similar to lemonade or limeade, or may be eaten with sugar as a breakfast fruit. It also makes excellent pies, preserves, and marmalade, and may be used for general culinary purposes.

WILLITS CITRANGE.

[PLATE XIII, FIGURE 3, PLATE XIV (777), AND PLATE XVI.]

NAME AND ORIGIN.—The second citrange which has given evidence of value has resulted from a hybrid of trifoliate orange with pollen of the common orange, being thus what is known as a reciprocal hybrid of the Rusk citrange. In general it possesses characters intermediate between the two parental varieties, and is similar to the Rusk in tree and fruit characters, yet differing considerably in detail, so that there is no trouble in clearly distinguishing it from the Rusk citrange.[a]

[a] This citrange the writers propose, with the approval of the Secretary of Agriculture, to call the *Willits*. In the Cosmopolitan Magazine for July, 1904, Mr. Gardner called this citrange the *Swingle*, but the writers would prefer that it be known as the *Willits*, in honor of the First Assistant Secretary of Agriculture, Hon. Edwin Willits.

The Willits citrange was one of 40 seedlings from a single hybrid fruit grown and developed in the grove of the late Col. G. H. Norton, at Eustis, Fla. Of the 40 hybrids of this series 11 exhibited characters clearly intermediate between the two parents, being evergreen and having trifoliolate leaves much larger than those of the trifoliate orange (Pl. XIV). The remaining 29 seedlings are all deciduous and have leaves apparently like the typical trifoliate orange. Eighteen of these have fruited and all produced fruits indistinguishable from the trifoliate orange. It would thus seem clear that the 29 which resemble the trifoliate parent are false hybrids, having developed from adventive embryos, as already explained. Four of the apparently intermediate seedlings have fruited, and all have given fruits clearly partaking of the nature of both parents. These are, therefore, certainly true hybrids.

All of the hybrids of this series which show intermediate characters are exceptionally vigorous, showing in this regard also their true hybrid nature. The smallest of them was as large as the largest of the seedlings which exhibited no intermediate characters. The vigor of the young hybrid seedlings in comparison with both parents and the comparative size of leaves is shown in Plate XV. Here No. 845, a cross of two typical oranges and one of the largest of 500 seedling oranges of similar kind, is yet far smaller than the medium-sized true hybrid No. 772. No. 780, one of the largest of the 29 false hybrids, affords a comparison of the size of the true hybrids with the type of the mother parent. The true hybrid No. 772, used here for comparison, is not the largest of the hybrids secured, but is of medium size. The hybrids between distinct species and races are ordinarily intermediate between the two parents and mainly very uniform, so that the hybrids of the first generation usually resemble each other very closely. In the case of the hybrids between the trifoliate orange and the common orange, however, the seedlings have been found to differ from each other very markedly. The fruits of all of those which have thus far come into bearing are essentially distinct in flavor, size, and appearance. The seedlings also differ in tree and foliage characters. They are all similar, however, in having fruits nearly intermediate in size, with some of the bitter flavor of the trifoliate fruit, and in having trifoliolate leaves and semi-evergreen foliage. The difference in foliage characters of some of these hybrids and their parents is shown in Plates XIV and XV.

Description of fruit and tree.—Fruit compressed-spherical, or nearly round; small, from 1¾ to 2⅜ inches in diameter (Pl. XIII, fig. 3, and Pl. XVI), and from 1½ to 2 inches in height; color from cadmium yellow to orange; surface rough with deep depressions over the largest oil glands, and with more or less pronounced furrows or ridges running from base to apex; weight medium, about the same as water or somewhat lighter; calyx persistent, with large and fleshy lobes; rind thin, ⅛ inch in

SEEDLING HYBRIDS OF TRIFOLIATE ORANGE CROSSED WITH POLLEN OF THE COMMON ORANGE.

[No. 776, a false hybrid, showing no intermediate characters and having small deciduous leaves; No. 777, seedling of Willits citrange, showing the evergreen foliage and other intermediate characters; Nos. 778 and 779, two seedlings grown from the same seed, No. 779 (on the right), showing intermediate characters, No. 778 (on the left), showing only the normal characters of the trifoliate orange.]

SEEDLINGS OF CITRUS HYBRIDS, SHOWING RELATIVE VIGOR OF TRUE AND FALSE HYBRIDS.

[No. 780, a false hybrid (trifoliate × sweet orange); No. 772, a true intermediate hybrid (trifoliate × sweet orange), with large trifoliolate leaves; No. 845, a cross of two ordinary orange varieties. All seedlings of same age.]

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WILLITS CITRANGE NATURAL SIZE

thickness, and tender, not adhering so close to fruit as in the Rusk citrange; pulp translucent, light lemon yellow, resembling the ordinary lemon; segments 6 to 10, separated by thin tender membranes; texture of fruit very tender, being equal to that of the best lemon; axis small, about ¼ inch in diameter; flavor sprightly acid, similar to lemon, with very slight bitter taste of trifoliate orange; nearly seedless, averaging about one seed to four fruits; aroma mild and pleasant, combining the aromatic resinous odor of the trifoliate orange with the very delicate odor of the common orange. Trees similar to trifoliate orange, vigorous and hardy, evergreen or semi-evergreen, medium height and shapely; foliage dense, leaves trifoliolate and larger than those of the ordinary trifoliate orange (Pl. XIV); season of maturity very early, from September to the last of November.

The Willits citrange makes a beautiful, vigorous-growing tree and gives evidence of being of value as a decorative or lawn tree. The fruit makes a fine drink similar to lemonade or limeade and will be found pleasant as an acid fruit to eat with sugar. It is an excellent substitute for the lemon to serve with fish or oysters and is valuable also for culinary purposes, for which its seedlessness renders it specially desirable. The products made from the Willits citrange are very different in flavor from those made from the Rusk citrange. They possess more nearly the character and flavor of those made from the lemon.

HOW HARDY IS THE CITRANGE?

All of the different citrange seedlings were budded on trifoliate orange stocks at Glen St. Mary, in northern Florida, in the spring of 1899. In January of 1900, when the buds were about 8 months old, a severe freeze occurred in which the temperature went down to about 15° or 18° F. Mr. Taber recorded a temperature of 18° above zero at Glen St. Mary. At Macclenny, Fla., 3 miles east of Glen St. Mary, a minimum temperature of 15° was recorded, while at Lake City, about 20 miles west, the minimum temperature recorded was 17° F., the record at Macclenny and Lake City being made by voluntary observers of the United States Weather Bureau with specially corrected instruments. After this freeze a report from Mr. Taber stated that the foliage on the buds of Rusk (No. 716) and Willits (No. 777) citranges still remained green on the tree, and that the tops were apparently entirely uninjured. All of the hybrids between the trifoliate orange and the common orange which show intermediate characters also remained uninjured and retained their foliage fresh and green, with the exception of an occasional twig which at the time of the freeze was soft and immature.

In this freeze ordinary oranges suffered severely, large buds in many parts of the State being frozen to the ground, and this was the case with ordinary orange buds growing immediately beside the citranges at Glen St. Mary. Although no freeze which has occurred since has been so severe, temperatures of from 20° to 23° have been

several times recorded. In none of these freezes have the citranges been injured, although buds of ordinary oranges have frequently been severely damaged.

Aside from the tests made at Glen St. Mary, Fla., sets of the hybrids which had been made with the idea of producing hardy varieties were sent to the Florida, Georgia, South Carolina, Alabama, and Louisiana experiment stations to be grown and tested in cooperation with the Department of Agriculture. These were planted in March, 1900. At the experiment station at Lake City, Fla., which is in about the same latitude as Glen St. Mary, the trees have passed through the winters since March of 1900 without serious injury. Here the trees have been grown under the direction of Prof. H. Harold Hume, who reports that the temperature has several times fallen to a point where all ordinary orange trees were severely injured or killed without resulting in injury to the Rusk or Willits citranges or to the other hybrids of intermediate nature. Professor Hume reports that the minimum temperature recorded during this period was 21° in December of 1901.

At the Georgia experiment station a set of the trees has been tested under the supervision of Director R. J. Redding and Prof. H. N. Starnes. At this place the temperature fell in February, 1901, to 17° F. above zero, and in December, 1901, to 8°. The majority of the intermediate hybrids passed through these freezes without serious injury. The Rusk citrange was killed back to some extent, but lived through, and is now reported to be in good condition. The trees of the Willits citrange planted at this station have died, but whether directly from the effects of the cold is not certain.

At the Alabama experiment station, Auburn, Ala., a set of the trees has been grown under the supervision of Professors Earle and Mackintosh. At Opelika, Ala., about 10 miles distant, the lowest temperature recorded, since the trees were planted, was 9° F. above zero in December, 1901. Trees of the Willits have remained uninjured, while trees of the Rusk citrange are all reported as dead. Here again, however, it is not clear from the records whether they died as a result of injury from freezing, although this might be assumed. However, almost all of the strictly intermediate hybrids have survived the winters at this place without serious injury.

At the South Carolina experiment station, Clemson College, S. C., a number of the hybrid trees have been grown and tested under the supervision of Prof. C. C. Newman. Unfortunately a complete set of the hybrids was not sent to all of the cooperating stations, owing to a lack of trees of certain numbers. It happened that neither the Rusk nor the Willits citrange was among the number sent to the South Carolina station. However, a number of the intermediate

hybrids similar to the Rusk and Willits citranges have been grown and tested at this station, and have passed through the winters since March, 1900, without serious injury. At this station they have endured a minimum temperature of 6° F. above zero, which occurred in December, 1901.

At the Louisiana experiment station a set of the hybrids, among them the Rusk and Willits citranges, have been tested under the immediate supervision of Dr. W. C. Stubbs. At this station the temperature in December, 1901, fell to 21° F. above zero, and remained below 26° above zero for nearly a week. All of the hybrids survived the freezing without serious injury, although trees of the ordinary orange in the vicinity were in many cases killed.

It will be noticed from the above tests that both the Rusk and the Willits citranges are much hardier than ordinary oranges. While the Rusk citrange endured the freeze of December, 1901, at Experiment, Ga., it was killed, or at least died, at Auburn, Ala. On the other hand, the Willits citrange died at the Georgia experiment station and survived at the Alabama experiment station. It is well known that the condition of a tree at the time a freeze occurs has a great deal to do with its hardiness. Trees which endure the most severe winters at the latitude of Washington, D. C., have been killed in some of the freezes in Florida, owing to the fact that they were in a sappy, growing condition at the time the freeze occurred. That some of these citrange trees were killed, therefore, at certain stations does not indicate that they are tender. The fact that they have survived the same degree of cold at other stations indicates that they would have survived in all cases had they been in a properly dormant condition. It is believed from the evidence now accumulated that these two citranges may be grown without protection throughout South Carolina, Georgia, Alabama, Mississippi, Louisiana, Arkansas, and parts of Tennessee and Texas. It is also probable that they can be grown in parts of Washington and Oregon, and in northern California, which are only slightly too cold for the orange, and in certain irrigated regions of low altitude in Arizona and possibly New Mexico. It will be remembered that the peach tree, which is considered to be fairly hardy, suffered very severely in Georgia in the freeze of December, 1901, to which these citranges were exposed. Large peach trees were frozen to the ground, and the damage to the peach industry was very great. The range of latitude at which the citrange may be safely grown has not been fully determined, but it is believed that they will succeed in any of the above-named places where the altitude is not too high.

OF WHAT VALUE IS THE CITRANGE?

The fruits of the citranges thus far produced are small, acid, and bitter, and from the standpoint of the ordinary orange grower would be considered practically worthless. This opinion, however, would be based entirely on a comparison of the citranges with oranges of fine quality such as are produced in Florida and California. When it is considered that these fruits can be grown through the Gulf and South Atlantic States without protection, where there is now a dearth of acid fruits, their great value can be understood. Both the Rusk and the Willits citranges make a refreshing "citrangeade," similar to lemonade and limeade. It is also very similar to the orangeade

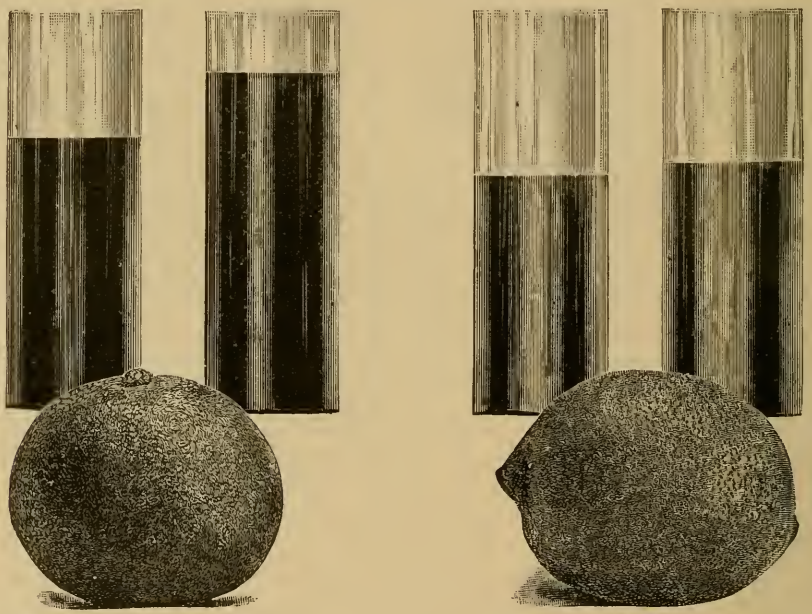

FIG. 13.—Rusk citrange (on left) and lemon (on right), showing comparative amount of juice from fruits of same volume. (Five-eighths natural size.)

made from the native sour oranges of Florida. The citrangeade has been tested by a large number of people, and all who have made a comparison pronounce it fully equal to lemonade or limeade, while some think it superior. The fruits are exceptionally juicy, the Rusk citrange in particular giving a much larger proportion of juice than the best lemons on the market (fig. 13). The fruits make excellent pies and marmalade, and for this purpose they are probably equal to the orange or lemon. Fortunately, the pies and marmalade made from the two fruits are of distinctly different quality, and both differ again from the lemon in this respect. The Rusk citrange

has also been found to make an excellent preserve. The fruits will probably prove valuable for general culinary purposes in the making and flavoring of cakes, for use in making jellies where lemons are now employed, and probably in many other ways. While they are too acid to eat out of the hand they will be found very palatable to anyone enjoying an acid fruit, especially when eaten with sugar. The citrange will probably prove of value mainly as a home fruit for cultivation throughout the Southern States mentioned above, where the sweet orange, the lemon, and the lime can not be grown. A few trees should be cultivated in every yard in this section. The trees are attractive in shape and semi-evergreen, so that they will make desirable lawn trees. Wherever a home can be supplied with them, it will be possible on the warm days between the 1st of September and the 1st of November to pick a few fruits and make a desirable, refreshing beverage. It is believed that they will prove a decided boon to a very large section of the country. While the fruits already obtained present results far-reaching and important, even more striking and valuable results will doubtless be obtained when seed from these fruits can be grown and selections of the best citranges made from among their progeny. These two citranges, it is confidently believed, will be the progenitors of a large and numerous group of hardy, edible fruits.

The Tangelo, a New Group of Loose-Skinned Citrus Fruits.

During the course of these experiments a hybrid has been produced between the pomelo and tangerine which occupies a position intermediate between these two well-known fruits. It is neither a pomelo nor a tangerine, but is different and unique and bids fair to take a place by itself. The fruit is intermediate in size between the two parental varieties, has the easily removable rind of the tangerine, and in flavor is somewhat sweeter than the pomelo, with less bitterness. It is distinct from any of the various groups of citrus fruits and should, therefore, be referred to a new group. The term "tangelo" is suggested by the writers as a name for this group of loose-skinned fruits, which lie midway between the pomelo and tangerine, the word being a combination of the first syllable of the word *tangerine*, with the ending of the word *pomelo*. A variety of citrus fruits known as the "nocatee," which has already been described and introduced, is apparently somewhat similar to this fruit and is evidently a hybrid between the tangerine and pomelo. This and the new Sampson tangelo which is described below, are at present the only two varieties that can be referred to the tangelo group.

THE SAMPSON TANGELO.

[PLATES XVII, XVIII, AND XIX.]

NAME AND ORIGIN.—The Sampson tangelo is a hybrid between the ordinary pomelo (female parent) and the Dancey tangerine (male parent). The fruit from which the seedlings came was from a cross made in the grove of Mr. Frank Savage, at Eustis, Fla. The hybrid fruit contained a very large number of seeds, 76 in all, which gave a total of 106 seedlings, several of the seeds having produced more than one seedling. A large majority of these seedlings have not yet fruited, but of those that have borne fruit all have the appearance of pure pomelo, except No. 1316, which exhibits characters plainly intermediate between the pomelo and the tangerine, being about midway between the two in size and other characteristics. The color of the fruit is darker orange than the pomelo, though not so red as the tangerine, and the color of the pulp is more nearly like the tangerine than any of the varieties of the pomelo. In flavor it is sprightly acid, but rather sweeter than the pomelo, and it has a slightly bitter taste derived from that parent. Its most pronounced characters, however, are the looseness of the rind and the ease with which the segments can be separated; in these qualities it partakes of the nature of the tangerine. The fruit may be described as a small "kid-glove" pomelo.

The hybrid seedling from which this variety developed was grown and fruited by Mr. F. G. Sampson, of Boardman, Fla., who since the beginning of the citrus experiments of the Department has given material aid in many ways. The writers therefore take pleasure in suggesting for this new tangelo the name of *Sampson*, in recognition of his aid in connection with the experiments.

Of the 106 seedlings of the series from which the Sampson originated, 5 have leaves with narrow, winged petioles, the foliage resembling more closely the tangerine than the pomelo. The only one of these that has thus far fruited is No. 1316, the Sampson, which, as indicated above, in fruit characters clearly exhibits its true hybrid nature. The other 101 seedlings have foliage which would be classed as purely pomelo in character. Only 6 of these have thus far borne fruit, and all of the fruits produced resembled pure pomelo. From these observations it would seem that only the 5 seedlings having tangerine-like foliage are in reality true hybrids. The others are probably false hybrids, developed from adventive embryos.

DESCRIPTION OF FRUIT AND TREE.—Fruit compressed-spherical, slightly drawn out at stem end like tangerine; of medium size, averaging 2½ inches in diameter and about 2¾ inches in height; weight from 163 to 248 grams; calyx persistent as in common orange; color chrome yellow, considerably darker than the pomelo, though not so red as the tangerine; specific gravity about the same as water; skin thin, about one-eighth of an inch in thickness, loose and easily removable, like the skin of the

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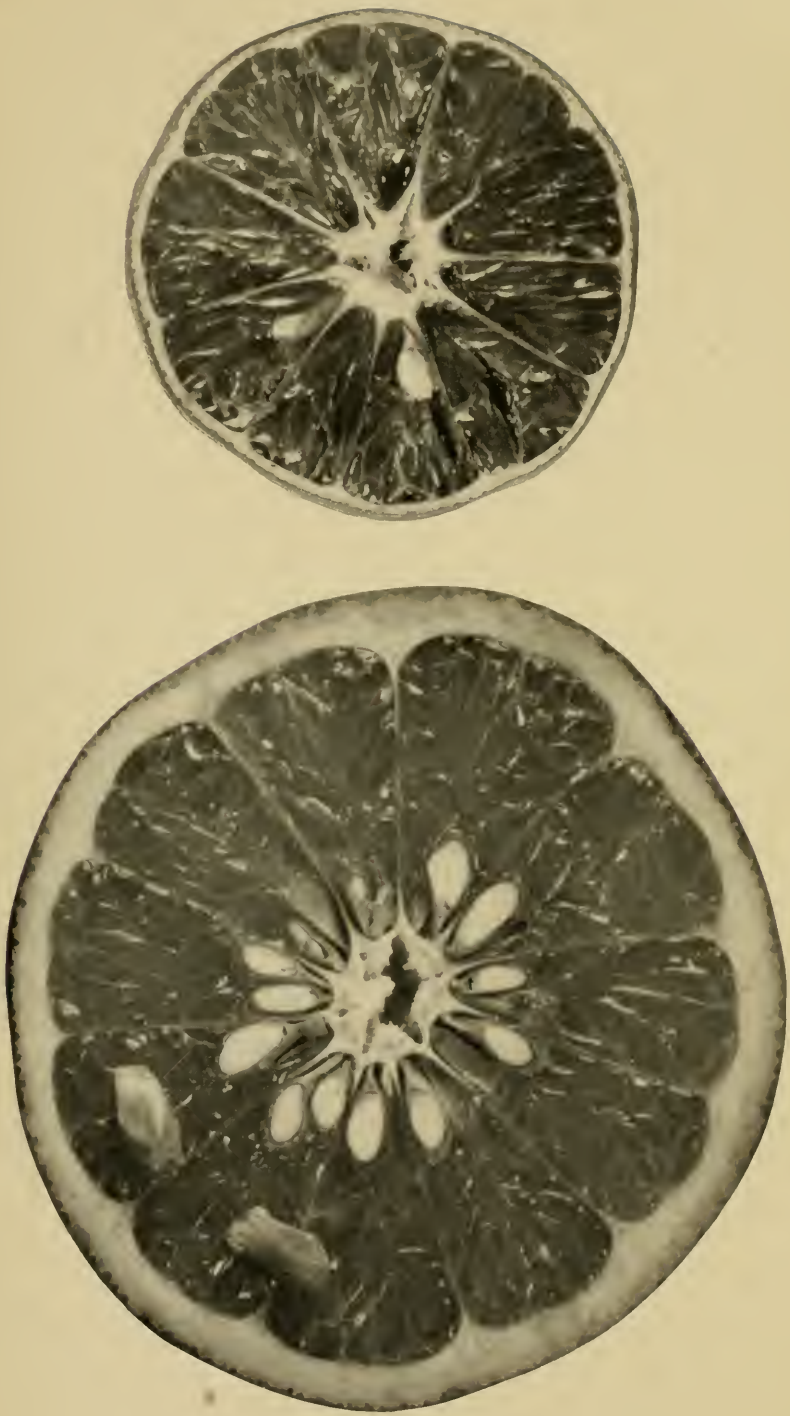
CITRUS TANGELO — NATURAL SIZE

SAMPSON TANGELO, SHOWING EASILY REMOVABLE RIND.

[Natural size.]



SAMPSON TANGELO ABOVE; ORDINARY POMELO BELOW.

[Natural size.]

tangerine; surface smooth and glossy; oil glands large and conspicuous, rendering the rind translucent; larger glands oblate spherical, smaller ones nearly spherical; segments 9 to 11, separating easily like tangerine; membranes thin and tender; axes small and compact, about one-half inch in diameter; rag very slight; quality excellent; texture very tender and juicy; flavor sprightly subacid, somewhat sweeter than pomelo, but with more acid than the tangerine and with a slight bitter taste derived from the pomelo; color of pulp, ochraceous-buff to orange buff, differing in this respect from both parents; seeds 10 to 15, medium in size; aroma slight, giving suggestion of both parents; in general appearance very attractive, resembling small pomelo, but of rather darker orange color; tree evergreen, tender, vigorous, and productive, having general character of ordinary tangerine; leaves unifoliolate, with comparatively narrow petioles like tangerine.

USES OF THE TANGELO.

The Nocatee tangelo, which has been previously described, is not familiar to the writers, and they are unable to pronounce on its value. The Sampson tangelo, however, is very likely to become an important commercial fruit. Those who have tasted it pronounce its flavor excellent. Its very attractive appearance and color of flesh, together with the ease with which it can be peeled and the segments separated, favor its growth in popularity. The bitter taste which is so pronounced in the pomelo is in the Sampson tangelo reduced to a suggestion which only adds to its sprightliness. Altogether it is a sprightly acid, highly flavored fruit, being not so acid as the pomelo and not so sweet as the tangerine, and it is believed that many people will prefer it to either of these fruits. It is a vigorous grower and probably productive. It is of course no hardier than either parent and can be grown only in the orange belts of Florida and California. It is believed that the Sampson tangelo will become a popular breakfast fruit, to be used by peeling and separating the segments, as in the case of the tangerine, and eaten by dipping the segments in sugar. The popularity of the pomelo, or grape fruit, is due largely to its use as a breakfast appetizer, and it is recognized as especially beneficial for invalids. It is also thought that the bitter element, probably due to some alkaloid, furnishes a slight healthful stimulation. The pomelo, however, is too bitter and acid to suit the taste of many. The Sampson tangelo, being somewhat sweeter and lacking much of the bitter taste, would seem to furnish a happy medium between the tangerine and pomelo, which would recommend it to many who find the pomelo too harsh. In some ways the flavor of the tangelo resembles the most improved bitter-sweet orange, but is certainly superior to it. Altogether, it is believed that the fruit will occupy a place not now filled by any other citrus fruit and that it will become valuable for commercial cultivation. Its superior quality and the "kid-glove" character of the rind mark it as a distinct and most valuable creation.

New Tangerine Oranges.

[PLATES XX, XXI, AND XXII.]

One of the primary objects in the citrus breeding experiments was to produce hybrids between the common sweet orange and tangerine in order to secure a new fruit having the size, quality, and flavor of the ordinary orange combined with the loose, easily removable rind of the tangerine. A few of these hybrids have now fruited, and two of them, crosses of the Dancey tangerine with pollen of the Parson Brown orange, have produced fruits which are of considerable value. Both of these seedlings were grown from one fruit which was the result of a cross made in the grove of Mr. W. K. Trimble, of Braidentown, Fla. While the fruits were supposed to be hybrids, they nevertheless resemble the tangerine orange in all important characters, differing from the Dancey tangerine, which was used as the mother parent, mainly in being larger and considerably earlier in time of maturity and in being of rather better quality.

THE WESHART TANGERINE.

Name.—One of these new tangerines, the Weshart (Pls. XX and XXI), is named in honor of Mr. W. S. Hart, of Hawks Park, Fla., in recognition of his valuable assistance in these experiments. Both of the new tangerine oranges were grown and fruited under his supervision.

Description of fruit and tree.—Fruit compressed-spherical, slightly protruded at stem end and somewhat depressed at the apex, having the same general form as the tangerine. Size from $2\frac{1}{2}$ to $3\frac{5}{16}$ inches in diameter, averaging about 3 inches. Height from $2\frac{1}{4}$ to $2\frac{7}{8}$ inches. Color deep orange red, like tangerine. Surface smooth, glossy, and very attractive, much smoother than the Trimble tangerine, to be described later. Rind loose, as in other varieties of this group; thin, from $\frac{3}{32}$ to $\frac{1}{8}$ inch thick. Oil glands medium size, surface of rind slightly sunken over the largest. Segments mainly 10, easily separable. Membranes tender. Axis hollow, from $\frac{3}{4}$ to 1 inch in diameter, star-shaped. Rag tender and in moderate quantity. Quality and texture excellent. Flavor sweet, subacid, very juicy. Bouquet characteristic and very pleasant. Color of pulp buff orange; cells small like ordinary tangerine. Seeds few, from 9 to 15. Tree vigorous and prolific. Foliage branching, and shape of tree like the tangerine. Season very early for tangerine.

The Weshart tangerine is a delicious fruit of exceptionally fine appearance and flavor. Its large size, superior quality, and earliness indicate that it will prove of great value for general cultivation in orange regions. In general it is smoother in surface and rather smaller than the Trimble tangerine, but is apparently superior in flavor.

THE TRIMBLE TANGERINE.

Name.—The Trimble tangerine (Pl. XXII) is named after Mr. W. K. Trimble, of Braidentown, Fla., in whose grove the original hybrid was produced. The resulting seedling was grown and tested in the grove of Mr. W. S. Hart, of Hawks Park, Fla., as was also the Weshart tangerine.

P. G. Passmore

WESTART TANGERINE. NATURAL SIZE

GROUP OF WESHART TANGERINES (CENTER) WITH PARENT VARIETIES, TANGERINE (ON LEFT) AND PARSON BROWN (ON RIGHT).

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TRIMBLE TANGERINE. NATURAL SIZE.

DESCRIPTION OF FRUIT AND TREE.—Fruit compressed-spherical, of same shape as the Weshart tangerine, and with slightly protruded stem end and depression at apex. Size large, from 3 to 3⅝ inches in diameter and from 2 to 2⅜ inches in height. Heavy, averaging about 5.6 ounces. Color deep orange red, like Dancey tangerine, or slightly darker. Surface somewhat rough and bumpy, in larger specimens similar to King orange; frequently with slight grooves running from base to apex. Oil glands small, with the surface of the rind slightly sunken over the larger ones. Rind loose, thin, $\frac{3}{32}$ to $\frac{1}{8}$ inch in thickness. Segments 9 to 11. Membranes thin and tender. Axis ⅜ inch in diameter and hollow. Rag comparatively little for fruit of this class. Flesh deep orange yellow and very attractive, tender, and juicy. Pulp cells medium size. Flavor sprightly acid and excellent, with pronounced bouquet. Seeds few, averaging about 10. Tree vigorous and prolific. Foliage branching, and shape of tree like Dancey tangerine. Season of maturity very early for tangerine.

The Trimble tangerine is a fine large tangerine, the rough, bumpy appearance serving to distinguish it from other tangerines, and at the same time not detracting from its appearance. In general the fruits are somewhat larger than those of the Weshart tangerine, but are slightly inferior to them in flavor.

GENERAL QUALITIES OF NEW TANGERINES.

The Weshart and Trimble tangerines, it will be seen from the above descriptions, differ from other varieties of tangerines primarily in being larger and earlier and more highly flavored. Fruits of these two varieties have been received in some quantity for the past two seasons, and have been compared with those of the Dancey tangerine, grown by Mr. W. S. Hart in the same grove, and with the best tangerines that could be procured on the market. In every case they have been superior in color, size, and flavor. In Mr. Hart's grove they have uniformly colored up and ripened about two weeks earlier than the Dancey tangerine, and it would thus seem that they may be highly recommended for general culture. They have not been tested in any other parts of Florida nor in California, and it can not be definitely stated what they will do under different conditions. The Dancey tangerine, however, is generally cultivated, and it is believed that the new fruits will prove superior to this variety in almost every respect. While these two tangerines developed from a fruit of Dancey tangerine crossed with pollen of Parson Brown, they show no clear indication of intermediate characters (Pl. XXI). They are in every respect, so far as can be judged, true tangerines. The Parson Brown orange, which was used as the male parent, is a typical orange and one of the earliest varieties cultivated. The new fruits are larger than those of the tangerine, and it may be that the large size, and their earliness, are qualities derived from the Parson Brown. If it were not for the possibility of their having developed from adventive embryos, this would be the normal conclusion. It is, however, impossible to determine this matter from the characters exhibited by the trees up to the

present time. As the trees mature other [illegible] visible which may throw some light upon this point. Practically speaking, however, it does not matter whether the new fruits have any orange blood in them, so long as they possess valuable qualities. The Weshart and Trimble, it should be remembered, are tangerine varieties, and, like the ordinary tangerine or common orange, can be cultivated only in Florida and California, where citrus fruits are ordinarily grown. They are unhesitatingly recommended for further testing and cultivation in these sections.