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BUD SELECTION IN THE VALENCIA ORANGE: PROGENY TESTS OF LIMB VARIATIONS

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CONTENTS

Page	Page		
Introduction -----	1	Progeny performance records—Contd.	
Bud variation in the Valencia orange-----	2	Corrugated strain -----	20
Importance of bud selection in the		Ridged strain -----	22
Valencia orange -----	3	Coarse strain -----	23
Occurrence of undesirable Valencia		Yellow strains -----	25
variations -----	4	Missshapen-Leaf strain -----	27
Progeny tests of limb variations-----	4	Strains of minor economic im-	
Progeny performance records-----	5	portance -----	28
Unproductive strain -----	5	Other striking Valencia bud va-	
Willow-Leaf strain -----	8	riations -----	29
Dwarf strain -----	10	Lessons from the progeny tests-----	32
Persistent-Style strain -----	12	Isolation and propagation of superior	
Flattened strain -----	15	strains -----	34
Long strain -----	17	Summary -----	35
Fluted strain -----	19	Literature cited -----	37

INTRODUCTION

The two commercially important varieties of oranges grown in the Southwest are the Washington Navel, the fruits of which mature and are marketed mostly during the fall and winter months, and the Valencia, which produces its crop for marketing largely during the spring and summer months. The Washington Navel was the first variety to be grown extensively in the Southwest, having been introduced at Riverside, Calif., in 1873, and its reputation in the market was the foundation upon which the successful citrus industry of that section was developed.

The introductions of the Valencia orange into California were a little later than that of the Washington Navel, the first of which definite records are available being that of A. B. Chapman and George H. Smith, of Los Angeles County, who received trees from Thomas Rivers, Sawbridgeworth, Kent, England, in 1876. Several trees in this planting were subsequently identified as being of the Valencia variety. Later introductions of the Valencia were made

from Florida by several southern California nurserymen under the names of Hart's, Hart's Tardiff, Hart's Tardy, etc., the parent trees of which have been traced to the Rivers Nurseries. Subsequently they were found to be the Valencia variety, and they are not now ordinarily distinguished from the earlier introductions, the name Valencia being used for all the trees of this variety now grown in the Southwest. The trees in the orchards where the original individual-tree performance studies were made, as reported in this bulletin, are one or more bud generations removed from one of the Florida introductions.

TABLE 1.—*Total shipments of Washington Navel and Valencia oranges from California, seasons 1916-17 to 1924-25, inclusive*

[Data from F. O. Wallschlaeger, secretary California Citrus League, as reported by the railroads from car-lot loadings]

Season November to October—	Total shipments (boxes)		Season November to October—	Total shipments (boxes)	
	Washing- ton Navel variety	Valencia variety		Washing- ton Navel variety	Valencia variety
1916-17 ¹	13, 268, 128	5, 305, 178	1921-22 ²	6, 596, 462	5, 111, 892
1917-18	2, 468, 022	4, 234, 211	1922-23	9, 918, 766	8, 897, 730
1918-19	8, 590, 572	7, 235, 069	1923-24	12, 032, 036	8, 923, 601
1919-20	7, 544, 041	7, 301, 736	1924-25 ²	9, 438, 413	6, 267, 891
1920-21	10, 893, 635	9, 437, 859			

¹ An extremely hot period in June, 1917, greatly reduced the Valencia crop that year and the crops of both the Washington Navel and the Valencia varieties for the following season.

² Both the Washington Navel and the Valencia crops were affected by frost injury this season, and wind damage further reduced the Valencia crop in some districts in the season of 1924-25.

Soon after its first fruiting the Washington Navel orange became the leading variety in the country, and it has maintained this position continuously. In recent years, however, the full appreciation of the possibility of holding the Valencia fruit through the summer and early fall, when no other oranges are on the markets, has greatly stimulated increased plantings of this variety, and for the last few seasons the Valencia shipments from California have nearly equaled those of the Washington Navel. The numbers of boxes in the annual car-lot shipments of Valencia and Washington Navel oranges for the seasons 1916-17 to 1924-25, inclusive, are shown in Table 1. Separate records of the shipments of these two varieties were not kept previous to the 1916-17 season, but the proportion of the Valencia to the Washington Navel was higher in that season than at any previous time. It was estimated that but for the injury done by the hot weather in June, 1917, the Valencia shipments in the 1916-17 season would have been fully equal to 50 per cent of those of the Washington Navel.

BUD VARIATION IN THE VALENCIA ORANGE

The individual-tree performance records and tree-estimate studies which have been carried on for several years in many Valencia orchards in the Southwest, mainly in southern California, have developed conclusive evidence as to the presence of diverse strains of this variety.

In an earlier publication (*1*)¹ this variability within the Valencia variety is described and typical bud variations and strains are illustrated. Many of the limb variations which were noted were found to possess foliage and fruit characteristics similar to those observed in entire trees of the different strains in established orchards. In order to determine definitely whether or not the characteristics of the limb variations were perpetuated through bud propagations, some of these limb variations, with others which were found later, were propagated in progeny tests at the first opportunity.

The object of this bulletin is to present some of the data which have been obtained from the progenies of these striking limb variations, so as to present evidence of the unstable condition of this variety and to show the importance of systematic bud selection in its commercial propagation. A series of similar progeny propagations of limb sports which were found in Washington Navel orange trees has been previously reported (*2-10*).²

IMPORTANCE OF BUD SELECTION IN THE VALENCIA ORANGE

Twelve strains of the Valencia orange were described in the publication already mentioned (*1*) as occurring in the investigational performance-record plots in an orchard located near Corona, Calif.

The characteristics which have been determined as distinguishing one Valencia strain from another have generally been those exhibited by the fruits. Although in some instances the habit of growth of the trees, the size or shape of the leaves, or other vegetative characters of the trees serve to differentiate the various strains, the quantity, shape, size, color, texture, juiciness, or other characters of the fruits have usually been the determining strain characteristics.

The profitableness of the culture of the Valencia orange in the Southwest depends upon uniformly high production by the individual trees combined with desirable commercial quality of the crops. The isolation of the best strain, in which the trees produce crops of the maximum quantity and highest commercial quality, and the elimination of the poorer strains are therefore fundamentally important factors. The presence of trees of the diverse and inferior strains in the orchards lowers the quantity and commercial quality of the crops about in proportion to the number of trees of the undesirable strains in each orchard.

The practicability of isolating and propagating the Valencia strain, the trees of which are the highest yielding and produce the most desirable type of fruit, has been demonstrated both experimentally and commercially. This result has been obtained through the selection of buds for propagation from parent trees which have been found to bear regular and heavy crops of uniformly good fruits for a period of several successive seasons. At the present time bud wood for commercial propagation is being taken from the best trees in progenies which were propagated from selected trees found

¹ Reference is made by number (*italic*) to "Literature cited," p. 37.

² SHAMEL, A. D., POMEROY, C. S., and CARYL, R. E. BUD SELECTION IN THE WASHINGTON NAVEL ORANGE. VII. PROGENY TESTS OF THE GOLDEN NUGGET STRAINS. [Unpublished manuscript.]

POMEROY, C. S., and CARYL, R. E. BUD SELECTION IN THE WASHINGTON NAVEL ORANGE. VIII. PROGENY TESTS OF THE YELLOW STRAINS. [Unpublished manuscript.]

to be superior by individual-tree performance records through several consecutive seasons. This work has been carried on since May, 1917, in cooperation with the bud department of the Fruit Growers Supply Co. of the California Fruit Growers Exchange. About 95 per cent of the buds of the Valencia orange used by California nurserymen and growers, a total of 169,499 buds during the calendar year 1926, were supplied by that department.

The production of the orchard trees which have been propagated from the selected buds of superior parent trees has been considerably larger and the fruit of better commercial quality than from comparable orchards made up of the ordinary mixture of strains. Some Valencia orchards which have been unprofitable on account of the presence of many trees of inferior strains have been brought into profitable production through top-working the trees of the undesirable strains, or replanting them with young trees grown from selected buds.

OCCURRENCE OF UNDESIRABLE VALENCIA VARIATIONS

The number of trees of the undesirable strains in the orchards studied varies so much that it is impossible at this time to make a definite statement relative to the frequency of their occurrence. In a general way, an average of more than 25 per cent of the trees in the orchards under observation have been classified as belonging to one or more of the undesirable strains. In some orchards this number has been found to be less than 10 per cent, but in others it has proved to be more than 50 per cent.

The trees of several of the least productive and most undesirable strains have a very vigorous vegetative habit of growth. They often stand out conspicuously in comparison with the neighboring trees of the standard strain on account of their large size and dense foliage. Trees of some of the undesirable strains have been found to develop an excessive number of rank-growing, nonfruiting branches commonly called suckers. The use of these suckers as sources of bud wood was a common propagation practice prior to the time when these bud-selection investigations were begun in California. As a result, many buds were generally procured from the trees producing the most suckers and relatively few buds were obtained from those of the more productive strains, which commonly develop but few, if any, suckers. In this way the suckering strains increased in the Valencia orchards to a considerable degree.

PROGENY TESTS OF LIMB VARIATIONS

In order to determine whether or not the variations of the Valencia orange originating as limb sports may be perpetuated by budding, propagations of a number of limb and individual-tree variations which were typical of the most important strains of the Valencia variety were made in 1915. The buds from these variations were inserted on sour-orange root stocks in a commercial nursery in cooperation with the Citrus Experiment Station of the University of California, and the resulting progeny trees have been grown on the grounds of that station at Riverside.

The progeny trees were transplanted from the nursery in July, 1917. They were set 10 feet apart in rows spaced 22 feet apart, the close planting in the rows making possible the testing of twice as many progenies as would have been the case had the ordinary spacing been practiced. The planting is arranged so that when the trees reach such size as to interfere with cultural practices every alternate tree may be removed, thus attaining what is considered to be a normal spacing for this variety in this district.

The trees in this progeny planting have been given ordinary cultivation, irrigation, and other cultural care. Winter and summer cover crops have been grown each year with more than ordinary success and plowed under for the purpose of soil improvement. Very little fertilizer of any kind has been applied up to the present time, although it is believed that the use of additional organic fertilizer is now necessary. The trees have made normal growth thus far and have not suffered from serious frost damage at any time since their planting. Little or no injury from scale or other insect attack or from citrus-tree diseases has been observed, and the trees may be considered to have a somewhat better development than is usually the case in this region.

PROGENY PERFORMANCE RECORDS

In obtaining the performance records of the progeny trees propagated from the various bud variations, the fruits borne by each tree have been counted and classified annually according to their strain characteristics. For the last three years the weight of the crops has also been determined.

The number of progeny trees of each propagation was limited by circumstances of planting, and while records from a larger number of trees would have been desirable, it is the opinion of the writers that reliable and economically sound conclusions can be drawn from the data available for consideration. The sets of progenies of the various strains will be considered separately in order to show more clearly the results of the propagation tests.

UNPRODUCTIVE STRAIN

In the Unproductive Valencia orange strain studied in these investigations the type of fruit and the characteristics of the leaves are somewhat different from those of the productive or Valencia strain. The fruits are smaller in size and tend to be elongated or pear shaped with a thinner rind than is the case with normal fruits. The leaves on the Unproductive strain trees are somewhat smaller than those on normal³ trees and are more acutely pointed. Also, the foliage on the trees and limbs of this strain usually shows a marked chlorotic condition in the winter months.

In the limited number of trees in the original Valencia performance-record plots from which buds were taken for these progeny propagations, no entire tree of the Unproductive strain was found. Later, in other performance-record studies in different Valencia

³The word "normal" is used here and elsewhere in this bulletin in the sense of "having the characteristics of the Valencia or normal strain of the Valencia orange."

orchards, entire trees which are wholly of the Unproductive strain have been found and studied.

The performance records of progeny propagations from four unproductive⁴ limbs in four different parent trees are shown in Table 2, compared with similar data from a progeny tree propagated from a normal Valencia limb in one of the same parent trees, and with additional records from another tree propagated from a Valencia tree which was entirely normal in character. Figure 1 shows progeny tree 12-36 of the Unproductive strain and tree 12-37 of the Valencia strain as indicated in Table 2. Figure 2 shows typical fruits from these two trees.

TABLE 2.—Records of annual production of progeny trees propagated in 1915 from limb variations of the Unproductive strain of the Valencia orange compared with records of trees propagated from the normal portion of one of the same parent trees and from a near-by normal tree

[The presence of the normal limb was not noted in the seasons indicated by an asterisk (*). It seems probable that part of the fruit produced in these seasons was on the normal limbs, which were fairly large when first observed; but all the fruits harvested before the variation in the limbs was noted have been recorded as from the unproductive limbs]

Progeny tree No.	Source of buds	Number of fruits produced by progeny trees												Remarks concerning progeny tree		
		On limbs of the Unproductive strain						On normal limbs								
		1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25		1925-26	Total
10-52	Unproductive limb in tree No. 130.	7	5	12	2	2	92	120	(*)	(*)	44	8	5	21	78	Only one normal limb.
10-53		13	22	7	8	0	80	130							17	
10-54	Unproductive limb in tree No. 132.	6	25	6	14	0	141	182	(*)	(*)	46	77	1	95	219	Only one normal limb.
11-3		1	38	4	7	0	28	78	(*)	(*)	26	417	89	455	987	
11-20	Unproductive limb in tree No. 141.	0	1	0	7	0	145	153								Entire tree Unproductive.
11-21		9	0	2	25	0	97	133	(*)	14	5	141	0	16	176	
11-22	Unproductive limb in tree No. 190.	2	8	1	10	0	50	71	(*)	(*)	(*)	21	0	0	21	Several small normal branches.
12-35		0	4	1	8	0	6	19	0	10	17	33	12	76	148	
12-36	Normal limb in tree No. 190.	5	1	3	7	0	52	68	0	0	7	18	0	9	34	Only one small normal branch.
12-37									20	133	215	159	208	282	1,017	
11-6	Normal tree No. 133								0	241	117	409	220	564	1,551	Do.

The progeny trees which were propagated from the unproductive limbs have shown more or less inherent instability. One tree in each of two progenies has remained unproductive throughout in fruit, foliage, and production characters. In the remaining seven progeny trees some of the limbs have been unproductive and some of them have developed normal foliage and fruit. In the propagations from parent tree No. 190, which possessed both unproductive and normal branches, the progeny trees of the Unproductive strain have each developed branches of both the Unproductive and Valencia strains, whereas the progeny tree which was propagated from a

⁴ The word "unproductive" is used here and elsewhere in this bulletin in the sense of "having the characteristics of the Unproductive strain."

normal limb in that same parent tree has produced only normal foliage and normal crops.

In order to show clearly the instability of the progeny trees propagated from unproductive parent limbs, the data showing the number of fruits borne by the unproductive limbs of the progeny trees have been segregated in Table 2 from those showing the production on the normal branches in the same progeny trees. With young trees it is sometimes impossible to decide definitely as to small differences in fruit or foliage characteristics, so that where any uncertainty existed no attempt has been made to differentiate the unproductive from the normal limbs in the progeny trees until this classification could be made without any question of doubt.

As can be seen from a study of the performance-record data presented, the progenies of the parent unproductive branches have



FIG. 1.—Progeny orange trees of the Unproductive (right) and Valencia (left) strains. These were grown from buds from (1) a limb variation of the Unproductive strain and (2) the normal part of the same parent tree. They are listed as trees Nos. 12-36 and 12-37 in Table 2, and fruits from them are shown in Figure 2. University of California Citrus Experiment Station, Riverside, Calif., June, 1925

shown marked unproductive tendencies, a condition of fruiting similar to that of the parent limbs. Although seven of the nine progeny trees of the Unproductive strain are somewhat broken up, as was the case in the parent trees, they are largely unproductive except in the case of progeny tree 11-3, where only one limb is unproductive and the remainder of the tree is typical of the normal productive strain. The unproductive limb in this case is very unmistakable in its foliage characters, and during the winter months it becomes very chlorotic in appearance.

The decided tendency of the unproductive and normal progeny trees to produce crops typical of the parent trees and of limb variations in these trees, as herein shown, constitutes definite evidence as to the importance of careful and systematic selection of bud wood from superior parent trees in commercial propagation in order to perpetuate a productive and desirable fruiting strain.

WILLOW-LEAF STRAIN

The trees of the Willow-Leaf strain are somewhat spreading and drooping in their habits of growth. They are slow growing, with small, short twigs which make them dwarf and dense. The leaves are small and willowlike in shape, being very narrow and sharply pointed.

The production of the trees of the Willow-Leaf strain is characteristically much less than that of comparable normal trees. The

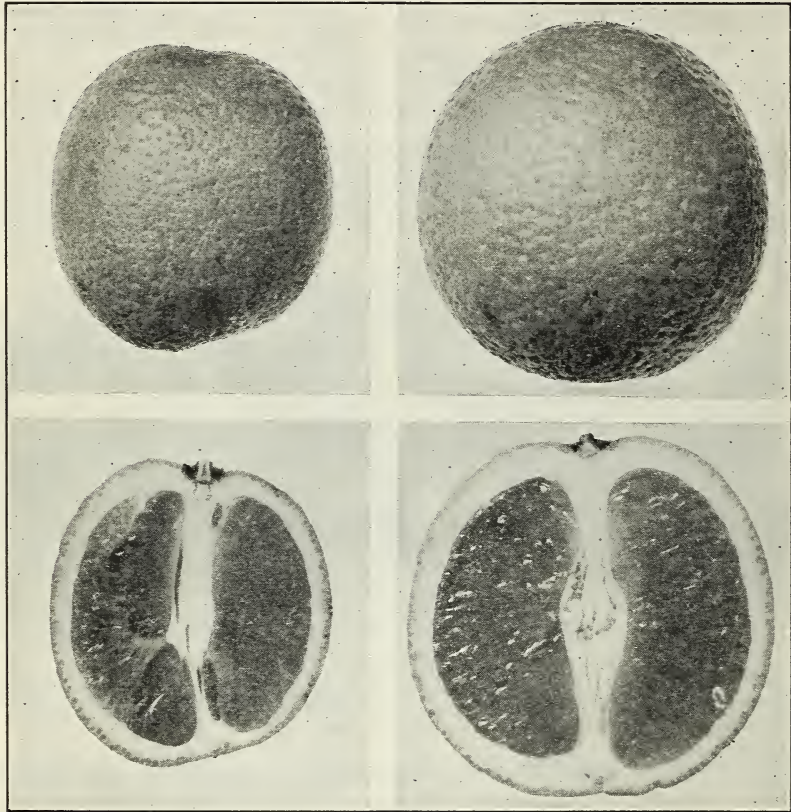


FIG. 2.—Valencia orange fruits produced by the progeny trees of the Unproductive (left) and Valencia (right) strains illustrated in Figure 1. Riverside, Calif., June, 1925. (About five-sevenths natural size)

fruits are of small size, light yellowish in color, and have coarse texture of skin and thick, somewhat ridged rinds. They are worthless for marketing, but on account of their striking characteristics as compared with the normal Valencia fruits, they are of unusual interest in these investigations.

In both foliage and fruit characteristics the trees of the Willow-Leaf strain are very conspicuous wherever found in Valencia orchards. Limb variations of the Willow-Leaf strain have been found in several otherwise normal Valencia trees, and entire trees

of this strain have been observed in Valencia orchards, probably the result of the unintentional propagation of limb sports of this character.

In 1910 a typical limb variation of the Willow-Leaf strain was found in one of the performance-record plots in the Valencia orchard of the Chase plantation at Corona, Calif. This limb was one of the main branches of the parent tree which otherwise bore normal fruits. The peculiar appearance of the foliage as well as the abnormal character of the fruits makes this variation of special interest. In 1915 buds were obtained from this limb for a progeny test, the record of which is presented in Table 3, together with that of a neighboring progeny tree propagated at the same time from a branch of a normal



FIG. 3.—A Valencia orange tree of the Willow-Leaf strain (right), which was propagated from a similar limb variation, in comparison with a tree of the normal Valencia strain (left) of the same age. These are listed as trees Nos. 11-7 and 11-6 in Table 3, and fruits from them are shown in Figure 4. University of California Citrus Experiment Station, Riverside, Calif., June, 1924

parent tree. These two progeny trees are shown in Figure 3, and Figure 4 shows typical fruits from the same trees. From these data it will be observed that during the period of 1920-21 to 1925-26, inclusive, the Willow-Leaf progeny tree has produced a total of only 112 fruits, all of which have been typical of this strain, whereas the comparable normal tree has borne a total of 1,551 fruits during the same period, all of which have been normal.

Other progeny propagations have been made from time to time from this same Willow-Leaf bud variation, and although some of these trees have been located where performance records could not be obtained, observations have proved that in every instance the characteristics of the parent limb have been perpetuated as regards both foliage and fruit characters.

TABLE 3.—Records of annual production of a progeny tree propagated in 1915 from a limb variation of the Willow-Leaf strain of the Valencia orange compared with records from a normal Valencia tree propagated from a near-by parent

Progeny tree No.	Source of buds	Number of fruits produced by progeny trees						
		1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total
11-7	Willow-Leaf limb in tree No. 135.....	4	1	45	19	32	11	112
11-6	Limb in normal tree.....	0	241	117	409	220	564	1,551

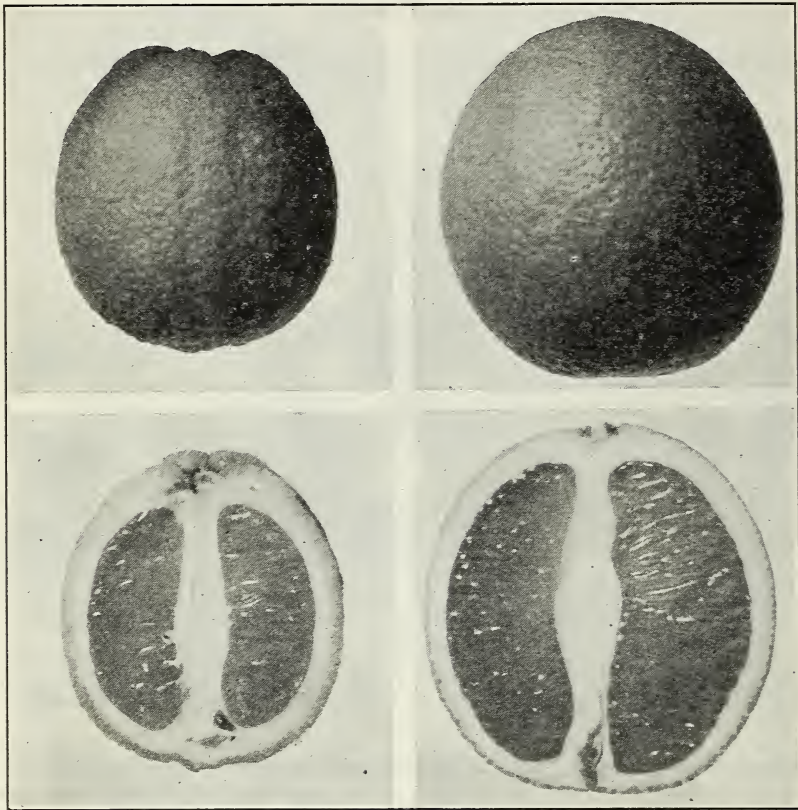


FIG. 4.—Fruits of the Willow-Leaf (left) and Valencia (right) strains of oranges produced by the progeny trees shown in Figure 3. Riverside, Calif., January, 1926. (About two-thirds natural size)

DWARF STRAIN

The trees of the Dwarf strain of the Valencia orange are very slow growing and smaller even than those of the Willow-Leaf strain. The twigs are very small. The foliage is dense, the leaves being small, generally acutely pointed, and set close together on the branches. The trees bloom profusely, but produce only very light crops.

The chlorotic condition which develops in the foliage of the trees of some of the most abnormal strains in the winter months is

extremely marked in this strain, so that the outer leaves become greenish cream colored. In the summer these trees are as dark green as those of the Valencia strain.

The fruits borne by trees of the Dwarf strain are very small, of coarse texture of rind, and somewhat yellowish green in color.

The parent tree of progeny trees Nos. 10-47 and 10-48, as listed in Table 4, was included in the original performance-record plot of the Valencia variety on the Chase plantation of the National Orange Co., near Corona, Calif. These progeny trees were propagated from a typical Dwarf limb variation and are true to type in all respects. One of these Dwarf trees is shown in Figure 5 with an adjoining tree of normal size and of the same age. Aside from the normal limbs, the parent tree also produced a limb variation which was named the Coarse Australian strain, as it had the rank vegetative



FIG. 5.—A Valencia orange tree of the Dwarf strain (right), which was propagated from a similar limb variation, in comparison with a normal-sized tree (left) of the same age. This Dwarf tree is listed as No. 10-48 in Table 4, and fruits from it are shown in Figure 6. University of California Citrus Experiment Station, Riverside, Calif., June, 1925

growth which is characteristic of the Australian strain of the Washington Navel orange and bore rather large fruits with thick rinds and coarse texture of the skin. Progeny tree No. 10-45 (Table 4) was propagated from a bud taken from this Coarse Australian limb variation.

It was not considered necessary to propagate from the normal part of the parent tree from which the Dwarf strain tree and Coarse Australian progeny trees were grown. Progeny tree No. 10-40, which was propagated from a Valencia strain tree in the same performance-record plot, has been used for comparison with the Dwarf and the Coarse Australian progeny trees. The performance records of the two progeny trees of the Dwarf strain, one of the Coarse Australian strain, and one of the Valencia strain are shown in Table 4. All the fruits borne by trees No. 10-47 and No. 10-48 have been small and coarse, typical of the Dwarf strain; those borne by

tree No. 10-45 have been large and coarse or normal, as indicated; and those produced on tree No. 10-40 have been entirely normal in character.

TABLE 4.—Records of annual production of two progeny trees propagated from a limb variation of the Dwarf strain of the Valencia orange in comparison with records from two other trees, one propagated from a limb variation of the Coarse Australian strain occurring in the same parent tree and the other propagated from a near-by tree of the Valencia strain

Progeny tree No.	Source of buds	Character	Fruits produced by progeny trees						
			Number						
			1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total
10-47	Dwarfed limb in tree No. 124...	Small and coarse.	8	16	2	24	13	103	166
10-48			3	30	3	19	3	29	87
10-45	Coarse Australian limb in tree No. 124.	Large and coarse.	7	51	36	33	104	32	263
	do.-----	Normal.	0	24	176	112	42	228	582
10-40	Normal portion of tree No. 114.	do.-----	12	90	139	223	227	318	1,009

It is apparent from a study of these data that the yields of the two progeny trees of the Dwarf strain variation have been consistently light since these trees came into bearing. All of the fruits harvested from these two trees have been typical of the strain. Fruit from one of these trees is shown in Figure 6 in comparison with normal fruit.

The total yield of the progeny tree propagated from the Coarse Australian limb variation has been almost five times that of either of the progeny trees of the Dwarf strain. However, many of the fruits of the Coarse Australian progeny tree have been coarse and undesirable as compared with the fruits from the comparable progeny tree of the Valencia strain. The yield of this normal Valencia progeny tree has been very much larger than that of the two Dwarf strain progeny trees and considerably greater than that of the Coarse Australian strain progeny tree. Furthermore, the fruits from the normal Valencia tree have been of much higher grade and of consistently better commercial quality than those of the other strains.

PERSISTENT-STYLE STRAIN

Among the most striking Valencia limb variations discovered thus far in these studies is one which has been named Persistent Style on account of the fact that the styles remain attached to the fruits through growth and maturity, instead of dropping early in the development of the fruits as is usually the case.

The trees of the Persistent-Style strain are slow growing and have a decidedly dwarfed habit of growth but a more open habit than the Willow-Leaf or Dwarf strains. The leaves are clustered closely together at very short intervals on the branches and are shorter and more obtusely or bluntly pointed than those of normal Valencia orange trees.

The fruits are very small in size as compared with normal Valencia fruits. They are of a yellow color, round in shape, and have thin rinds of very smooth texture. The styles are rather large in size

and are firmly attached to the fruits, it being only rarely that one falls or is broken.

A limb variation of the Persistent-Style strain was found in a normal Valencia tree in the original performance-record plots of the Valencia orange. The fruits borne by this limb have continued to show generally the characteristic persistent style during the entire period of observation, but in a few instances typical fruits have failed

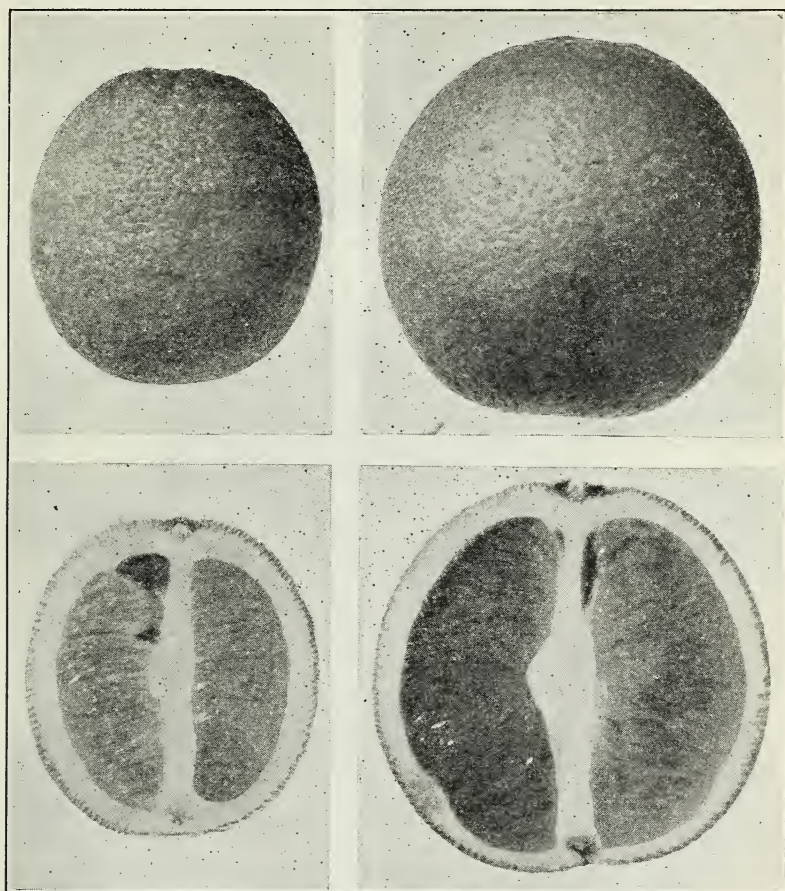


FIG. 6.—Fruits of the Dwarf strain (left), which were produced on the progeny tree shown in Figure 5, in comparison with normal (right) Valencia orange fruits. Riverside, Calif., January, 1926. (About three-fourths natural size)

to develop the persistent style, and a small number of apparently normal fruits have been produced by this limb. The foliage of this limb variation has been the same as that of typical trees of this strain, having the clustered leaves with short internodes characteristic of the vegetative growth of the strain.

Two trees propagated in 1915 from this Persistent-Style variation are being grown in the progeny orchard, and one of them is shown in Figure 7 with a fruit produced by the same tree.

The performance records of these two progeny trees are shown in Table 5 and the record of another tree propagated from a normal Valencia orange tree is given for comparison. One of the Persistent-Style trees has developed a few small branches which produce normal foliage and bear normal Valencia oranges.



FIG. 7.—A Valencia orange tree of the Persistent-Style strain, which was propagated from a similar limb variation. This tree is listed as No. 10-42 in Table 5. Inset: A view of one of the fruits (natural size) from this tree. University of California Citrus Experiment Station, Riverside, Calif., June, 1924

The performance record of progeny tree No. 10-41 shows a total production of 486 fruits having persistent styles and 140 normal Valencia fruits. The progeny tree No. 10-42 has produced a total of 546 fruits during the same period, all of which have been found to have the persistent styles characteristic of the fruits of this strain.

The normal progeny tree No. 10-40 has produced a total of 1,009 fruits during the performance-record period as compared with total

yields of 626 and 546, respectively, for the two progeny trees of the Persistent-Style strain. From these data it will be seen that the tree of the Valencia strain has been almost twice as productive as the trees of the Persistent-Style strain.

TABLE 5.—Records of annual production of progeny trees propagated from a limb variation of the Persistent-Style strain in a Valencia orange tree compared with records from a normal Valencia tree propagated from a near-by parent

Progeny tree No.	Source of buds	Number of fruits produced by progeny trees														
		Persistent-Style strain							Valencia strain							
		1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	Total
10-41	} Persistent-Style limb variation in tree No. 120. Normal portion of tree No. 114.	6	67	9	99	52	253	486	0	0	19	30	4	87	140	626
10-42		34	143	17	135	45	172	546	-----	-----	-----	-----	-----	-----	-----	546
10-40		-----	-----	-----	-----	-----	-----	-----	-----	12	90	139	223	227	318	1,009

The light production of fruit from the trees of the Persistent-Style strain has been correlated with inferior commercial quality on account of the small size, undesirable shape, and poor color of the fruit. The persistent styles are also an undesirable feature from the commercial standpoint, because they are likely to be injured during picking or other handling operations, thus leading to the possible development of decay during transportation and marketing.

FLATTENED STRAIN

The trees of the Flattened strain of the Valencia orange do not differ in foliage characteristics, so far as observed, from those of the Valencia strain, their habit of growth, the number, size, shape, and distribution of their leaves being about normal.

The fruits of this strain are markedly flattened at both the stem and blossom ends. This characteristic is not uniform for all of the fruits on the trees of this strain thus far studied, and fruits of normal shape have been found in the crops of all of these trees. On the other hand, in trees of the Flattened strain in Valencia orchards other than the one in which these investigations have been carried on, the writers have found instances where nearly all of the fruits have shown a decidedly flattened shape in contrast to the normal shape of fruits borne by other comparable normal trees in the same orchards.

Flattened strain limb variations in otherwise normal trees were found in two of the trees in the original Valencia performance-record plots. The fruits from both of these limbs were not all flattened in any season during the period of individual-tree study. However, typical flattened fruits were found to occur in the crops produced by these limbs each season, together with normal ones and others having thick rinds and coarse texture. Neither of the parent limbs have at any time been considered to be inherently stable. The four progeny trees propagated from these limbs have proved that

the parent limbs are inherently unstable, as shown by their performance records presented in Table 6.

TABLE 6.—Records of annual production of progeny trees propagated from limb variations of the Flattened strain of the Valencia orange compared with records from trees propagated from normal limbs in the same parent trees

Progeny tree No.	Source of buds		Number of fruits produced by the progeny trees														
			Flattened strain							Valencia strain							
	Parent tree No.	Limb	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	Total
11-1 ¹	132	Limb bearing flattened coarse fruits.	0	6	0	18	29	11	64	3	176	98	26	47	347	697	761
11-2 ¹			0	52	0	68	53	5	178	13	89	86	134	13	177	512	690
11-3 ²	132	Limb bearing normal fruits.															
11-47	162	Limb bearing flattened fruits.	3	6	29	5	0	14	57	1	38	30	424	89	483	1,065	1,065
11-48			1	0	18	4	2	8	33	22	82	295	50	1	297	747	804
11-51	162	Limb bearing normal fruits.								51	128	244	68	137	379	1,007	1,007

¹ The flattened fruits borne on trees 11-1 and 11-2 were also coarse in texture like those produced on the parent-limb variation.

² Tree 11-3 was budded from an unproductive limb variation, as has been described in Table 2. It is included here to show its freedom from flattened fruits, although it was propagated from the same parent tree as Nos. 1 and 2.

It will be noted in Table 6 that the progeny trees Nos. 11-1 and 11-2, which were propagated from a limb variation bearing flattened coarse fruits, have produced totals of 64 flattened with 697 normal and 178 flattened with 512 normal fruits, respectively, during the performance-record period. Progeny tree No. 11-3, propagated from a normal limb in the same parent tree from which progeny trees Nos. 11-1 and 11-2 were budded, has produced a total of 1,065 fruits, all of which have been of the Valencia strain.

The two progeny trees Nos 11-47 and 11-48, which were propagated from a limb variation bearing flattened fruits occurring in another apparently normal Valencia tree, have produced totals of 57 flattened with 747 normal and 33 flattened with 714 normal fruits, respectively, during the performance-record period. Some of the fruits classified as normal in the performance records were somewhat flattened, but were not clearly of the Flattened strain, and all such oranges have been counted in these studies as normal fruits. Typical fruits of the Flattened strain produced by one of these progeny trees are shown in Figure 8.

Progeny tree No. 11-51, which was propagated from a normal limb occurring in the same parent tree from which progeny trees Nos. 11-47 and 11-48 were budded, has produced a total of 1,007 fruits during the performance-record period, all of which have been typical of the Valencia strain.

These performance-record data show that the limb variations of the Flattened strain under investigation are inherently unstable and tend to produce fruits of both Flattened and Valencia strains. The production of the progeny trees propagated from these two parent Flattened strain limb variations has been lower than that of the progeny trees from normal limbs of the same parent trees, and the fruits have been of inferior commercial value on account of

their flattened shape, which renders them somewhat difficult to pack satisfactorily under present commercial methods.

LONG STRAIN

The trees of the Long strain of the Valencia orange do not differ from those of the normal strain in observed characteristics of habit of growth or foliage development. The fruits of the Long strain have a somewhat cylindrical shape and are longer in comparison with their transverse diameter than is the case with fruits of the normal strain.

There is more or less variation in the shape of fruits produced by trees of the Long strain, as is also the case with the trees of the Flattened strain of the Valencia orange. There is a marked tendency toward the production of oblong fruits in trees of the Long strain, but so far as studied these trees also produce some fruits of approximately the normal shape as well as others more or less inter-

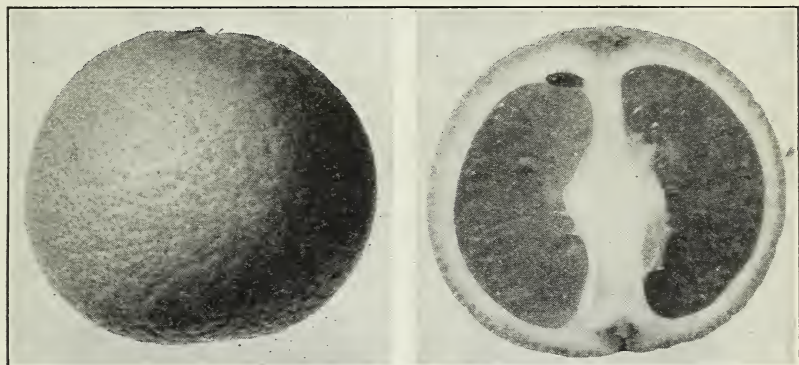


FIG. 8.—Fruits of the Flattened strain of the Valencia orange. These were grown on progeny tree No. 11-47, as listed in Table 6, which was propagated from a similar limb variation. Riverside, Calif., January, 1926. (About three-fourths natural size)

mediate so far as the typical long and normal shape of fruits is concerned.

In Table 7 are presented the performance records of eight progeny trees which were propagated from five limb variations bearing oblong fruits in otherwise apparently normal Valencia trees. It will be noted in this table that all of the progeny trees of the limb variations have produced fruits of both Long and Valencia strains each season during the performance-record period. In the case of progeny trees Nos. 11-15 and 11-16 the tendency has been to produce a large proportion of Long strain oranges, as has also been true of progeny trees Nos. 12-29 and 12-31. On the other hand, progeny trees Nos. 11-28 and 12-24 have produced a greater total number of fruits of the Valencia strain than of the Long strain. Typical fruits of the Long strain produced by one of these progeny trees are shown in Figure 9.

The performance record of the comparable progeny tree No. 12-19, which was propagated from a normal limb of a tree of the Valencia

strain, has produced only normal-strain fruits during the performance-record period.

TABLE 7.—Records of annual production of progeny trees propagated from limb variations of the Long strain of the Valencia orange compared with records from progeny trees propagated from the normal portion of near-by parent trees

Progeny tree No.	Source of buds		Number of fruits produced by progeny trees														
	Parent tree No.	Limb	Long strain							Valencia strain							Total
			1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	
11-15	139	Limb variation bearing long fruits.	8	89	70	109	58	306	640	8	3	4	145	8	2	170	810
11-16			12	80	69	56	4	175	396	0	9	0	63	1	4	77	473
11-27			0	50	18	75	92	404	639	4	52	50	188	110	0	404	1,043
11-28	145	do	0	20	7	40	44	76	187	0	39	40	56	53	200	388	575
12-24			1	33	53	7	9	176	279	1	38	5	174	47	108	373	652
12-29	182	do	17	134	66	273	3	444	937	0	7	4	93	2	39	145	1,082
12-31	187	do	6	129	73	229	51	672	1,160	6	7	23	347	6	48	437	1,597
12-32	188	do	4	11	83	31	126	198	453	9	86	6	161	28	106	396	849
12-19			0	0	0	0	0	0	0	21	63	163	356	120	338	1,061	1,061
12-19	177	Normal part of tree															

With the exceptions of the three progeny trees Nos. 11-16, 11-28, and 12-24, the production of the progeny trees of the Long strain limb variation has been fairly good, approximating that of the

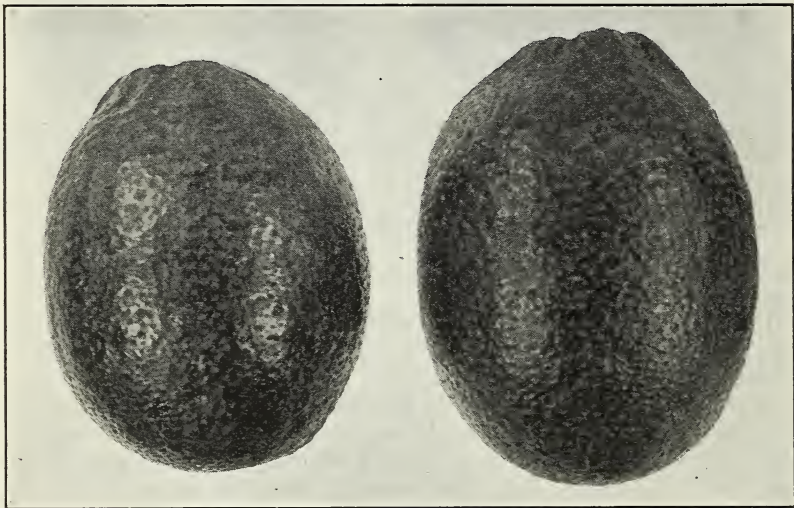


FIG. 9.—Fruits of the Long strain of the Valencia orange. These were produced by progeny trees No. 12-31, as listed in Table 7, which was propagated from a similar limb variation. Riverside, Calif., September, 1921. (About two-thirds natural size)

comparable progeny tree of the Valencia strain. The total yields of progeny trees No. 11-16, 11-28, and 12-24 have been low, and it is possible that they represent light-yielding strains, although sufficient data on this point are not yet available to permit of final conclusions on this matter.

FLUTED STRAIN

The trees of the Fluted strain of the Valencia orange variety do not differ from those of the Valencia strain in observable characteristics of the foliage or habit of growth.

The fruits borne by the trees of this strain are very distinct in appearance as compared with those produced by trees of the Valencia strain, on account of shallow parallel furrows occurring in the surface of their rinds. These furrows give the fruits a fluted appearance, which distinguishes them clearly from the smooth, even rinds of normal oranges.

The Fluted strain of the Valencia orange includes several minor or substrains which are identified by the color, size, shape, or other characteristic of the fruits in addition to the furrows. For example, in one substrain the trees bear fluted fruits with a yellowish green color as compared with the reddish yellow color of the typical fruits of this strain. The trees of another substrain produce very small and rather deeply furrowed fruits having persistent styles.

The performance records of four progeny trees propagated from Fluted strain limb variations which were found in two otherwise normal Valencia parent trees in the original Valencia performance-record plots are shown in Table 8. These data show that the two progeny trees Nos. 10-35 and 10-36 have produced totals of 516 fluted, with 219 normal and 861 fluted with 793 normal fruits, respectively. In the case of progeny trees Nos. 11-9 and 11-10 the data show a total yield of 1,026 fluted with 973 normal and 730 fluted with 556 normal fruits, respectively, for the performance-record period. Typical fruits of the Fluted strain produced by one of the progeny trees are shown in Figure 10.

TABLE 8.—Records of annual production of progeny trees propagated in 1915 from limb variations of the Fluted strain of the Valencia orange

Progeny tree No.	Source of buds		Number of fruits produced by progeny trees														
	Parent tree No.	Limb	Fluted strain							Valencia strain							
			1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	Total
10-35	107	{Limb bearing Fluted fruits.	8	15	12	65	1	415	516	14	63	48	27	0	67	219	735
10-36			8	37	42	249	11	514	861	5	101	116	143	347	81	793	1,654
11-9	136	{-----do-----}	12	105	21	234	91	563	1,026	1	45	165	459	141	162	973	1,999
11-10			6	90	35	83	51	465	730	4	41	150	253	43	65	556	1,286

The parent-limb variations in both instances produced both fluted and normal fruits, but no record was kept of the proportion of each during the original performance-record work with the parent trees. Subsequent to the propagation of these four progeny trees many other Fluted strain limb variations and entire trees bearing wholly Fluted strain fruits have been discovered in different Valencia orchards.

It is apparent from the performance records of these Fluted progeny trees that the parent-limb variations and progeny trees

are in an inherently unstable condition, as is the case with the limbs and progeny trees of the Flattened and Long strains described above.

CORRUGATED STRAIN

The Corrugated strain variation of the Valencia orange was the first striking bud variation which was found in the bud-selection studies of this variety. The rough, coarse, and corrugated appearance of the fruits makes this variation very conspicuous after its characteristics have once been identified. A study of the block of Valencia trees in which the first variations of the Corrugated strain were discovered revealed the fact that about 12 per cent of the trees were of this strain. Subsequent individual-tree studies in other Valencia orchards showed the presence of a considerable proportion of trees of the Corrugated strain and of normal trees producing limb variations bearing typical corrugated fruits, wholly or in part, the

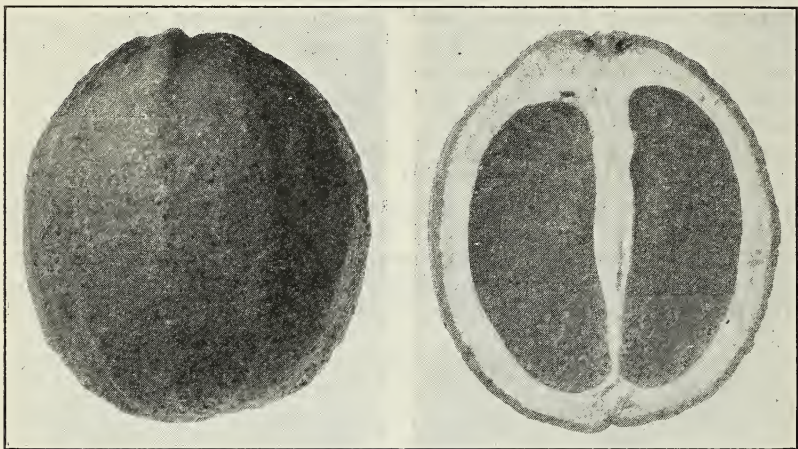


FIG. 10.—Fruits of the Fluted strain of the Valencia orange. These were produced by progeny tree No. 10-35, as listed in Table 8, which was propagated from a similar limb variation Riverside, Calif., January, 1926. (About four-fifths natural size)

number in some instances being as much as 25 per cent of the total number of trees.

The trees of the Corrugated strain have a drooping habit of growth, and the leaves are larger and more sharply pointed than those produced by trees of the Valencia strain. As a rule, the trees of the Corrugated strain are considerably less productive than trees of the Valencia strain.

The typical fruits are usually large and oblong or cylindrical in shape, very rough in texture, and with thick, greenish, corrugated rinds. The rag is tough, the juice scant in quantity and of poor flavor. The fruits do not mature as early as the fruits borne by trees of the Valencia strain. They are usually discarded during picking or grading as not being worth shipment, on account of their inferior appearance and quality.

There is a marked tendency for trees of the Corrugated strain to produce both normal Valencia oranges and fruits typical of the strain. This condition is also true of limb variations of the Corru-

gated strain in Valencia trees otherwise normal. Oftentimes, fruits of the Corrugated strain alternate on the same branch with normal ones. On the other hand, instances have been noted where the entire trees or whole limb variations have produced only Corrugated fruits during a period of eight years of observation.

The performance records of three progeny trees from three limb variations of the Corrugated strain are shown in Table 9,

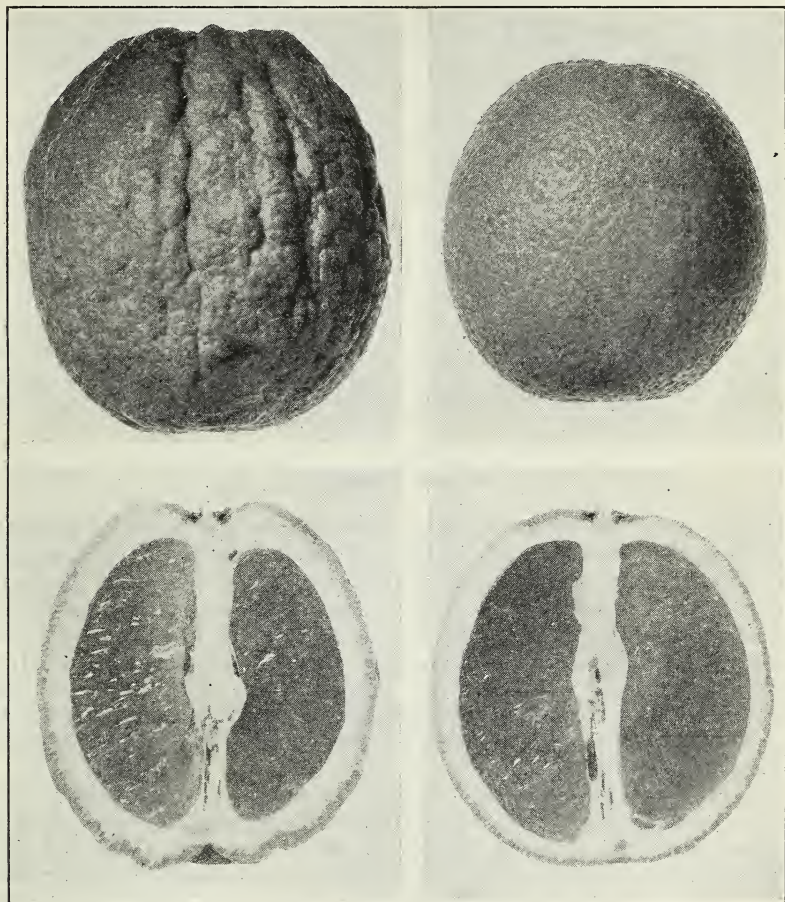


FIG. 11.—Fruits of the Corrugated (left) and Valencia (right) orange strains. These were produced by progeny trees Nos. 12-17 and 12-19, as listed in Table 9, which were propagated from an unstable limb variation of the Corrugated strain and from a normal limb in the same parent tree. Riverside, Calif., June, 1925. (About five-sevenths natural size)

together with the record of a progeny tree propagated from a normal limb of one of the same parent trees. All of the parent Corrugated strain limb variations have borne both corrugated and normal fruits during the entire period they have been under observation, and the trees propagated from these limbs have shown the same unstable condition continuously. Corrugated and normal Valencia fruits from one of these trees are shown in Figure 11. The

progeny tree No. 12-19, propagated from the normal limb in the same parent tree from which the Corrugated strain progeny tree No. 12-17 was propagated, has produced only normal fruits during this same period. It is apparent that the parent Corrugated limbs from which the Corrugated strain progeny trees were propagated are inherently unstable and that this characteristic has been transmitted to their progenies by budding.

TABLE 9.—Records of annual production of progeny trees which were propagated in 1915 from bud variations of the Corrugated strain of the Valencia orange compared with records from a normal Valencia tree which was propagated from a normal branch in one of the same parent trees

Progeny tree No.	Source of buds		Number of fruits produced by progeny trees														
			Corrugated strain							Normal Valencia strain							
	Parent tree No.	Limb	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	Total
12-17	176	Limb bearing corrugated fruits	13	54	37	41	62	114	321	9	66	133	137	105	205	655	976
12-19	176	Normal Valencia limb								21	63	163	1356	120	338	1,061	1,061
12-21	178	Limb bearing corrugated fruits	2	13	26	76	18	49	184	2	46	73	224	97	290	732	916
12-27	186	do	1	28	74	55	22	156	336	0	33	73	47	37	169	359	695

¹ One ribbed fruit produced this season.

RIDGED STRAIN

The trees of the Ridged strain have an upright habit of growth, develop a large number of suckers or rank-growing branches, and have dense foliage, the leaves being large and somewhat pointed. The considerable number of trees of this strain in many established Valencia orange orchards is accounted for by the cutting of suckers or vigorous nonfruiting branches as bud wood for propagation, formerly practiced by propagators. With the use of this kind of bud wood more buds would be obtained from the suckering strains of trees than from the same number of trees of the heavily fruiting and nonsuckering strains.

The typical Ridged strain fruits are large and globular, with coarse texture, and with broken longitudinal ridges. The rind is medium to thick, greenish yellow in color, the rag abundant and tough, and the juice only fair in quality and quantity. On account of the inferior appearance of the fruits they are of less commercial value than those of the Valencia strain. This strain has been found to occur in many established orchards as entire trees and as limb variations in Valencia trees that are otherwise normal.

The performance records of three progeny trees which were propagated from two limb variations of the Ridged strain in otherwise normal Valencia trees are shown in Table 10 together with records of a comparable progeny tree propagated from a normal branch of a tree of the Valencia strain. It will be noted that the progeny trees of the Ridged strain limb variation have produced fruits of both the Ridged and Valencia strains each season, as was the case in the fruiting of the parent limbs. Typical fruits of the Ridged

strain are shown in Figure 12. It is apparent that the Ridged progeny trees Nos. 11-11 and 11-45 have been about half as productive as the Ridged progeny tree No. 11-12 which was propagated from the same parent limb as progeny tree No. 11-11, and also about half as productive as progeny tree No. 11-46 of the Valencia strain.

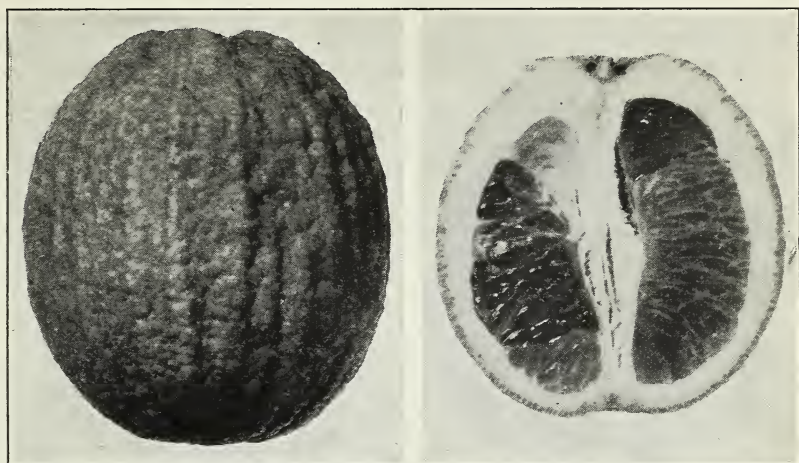


FIG. 12.—Fruits of the Ridged strain of the Valencia orange. These were produced by progeny tree No. 11-11, as listed in Table 10, which was propagated from a similar limb variation. Riverside, Calif., April, 1926. (About three-fourths natural size)

TABLE 10.—Records of annual production of progeny trees propagated in 1915 from limb variations of the Ridged strain of the Valencia orange compared with the record of a normal Valencia tree propagated from a near-by tree at the same time

Progeny tree No.	Source of buds		Number of fruits produced by the progeny trees																					
			Ridged strain							Normal Valencia strain														
	Parent tree No.	Limb	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	Total							
11-11	137	Limb bearing ridged fruits.	2	46	95	87	62	224	516	2	15	32	76	9	135	269	785							
11-12			3	49	54	230	113	266	715	0	69	88	251	55	361	824	1,539							
11-45			157	do	13	17	37	4	16	45	132	8	54	156	8	122	242	590	722					
11-46	134	In normal Valencia tree.	-----							-----							0	241	117	409	220	564	1,551	1,551

It seems probable that in the Ridged strain occasional trees occur which are about as productive as those of the Valencia strain, but on the whole observations have proved them to be comparatively low yielding. Both the Ridged limb variations and the progeny trees are apparently in an inherently unstable condition.

COARSE STRAIN

The trees of the Coarse strain are similar to those of the Valencia strain in appearance and in all observed foliage characteristics.

The fruits of this strain closely resemble those of the Valencia strain except that the texture of the skin is coarse instead of smooth and

the thickness of the rind is usually somewhat greater than that of normal Valencia oranges. The typical fruits of several other strains, including the Dwarf, Willow-Leaf, Corrugated, and Unproductive, are also very coarse, but in those cases this characteristic is correlated with shape, size, quality, or other character of the oranges, which is not the case with the typical fruits of the Coarse strain.

The performance records of five progeny trees propagated from three Coarse strain limb variations in Valencia trees otherwise normal are shown in Table 11, and fruits from one of them are

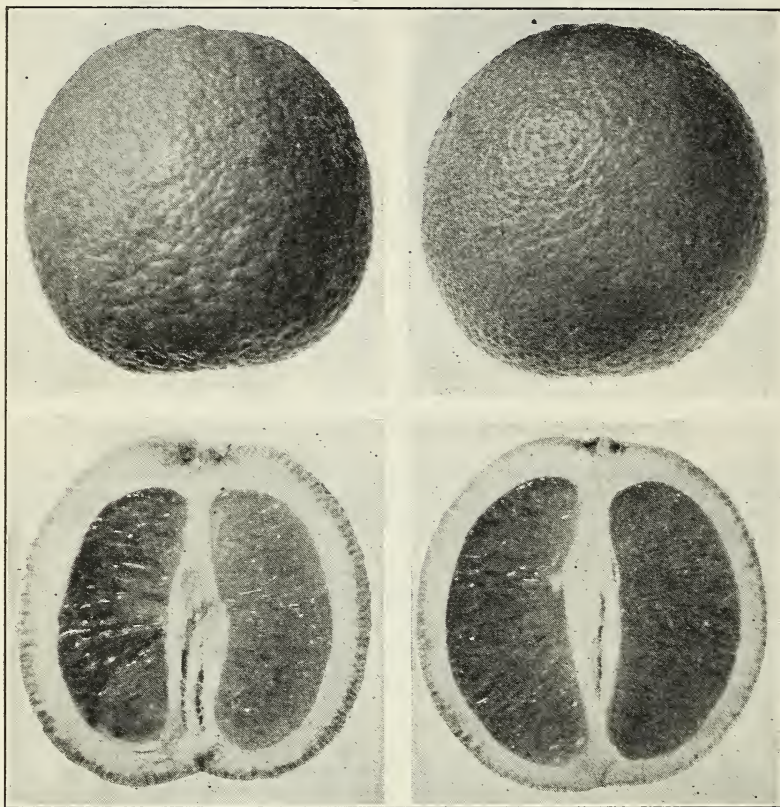


FIG. 13.—Fruits of the Coarse (left) and Valencia (right) orange strains. These were produced by progeny tree No. 12-9, as listed in Table 11, which was propagated from an unstable limb variation of the Coarse strain. Riverside, Calif., January, 1926. (About three-fourths natural size)

shown in Figure 13. It will be noted that all of the progeny trees have produced both typical Coarse and Valencia strain fruits each season. The proportion of coarse to normal fruits has been fairly equally divided in the crops of the progeny trees, as was the case in the crops from the parent limbs. The crops of three of the Coarse-strain progeny trees have been smaller than those from comparable progeny trees in the same planting which were propagated from normal limbs in trees of the Valencia strain. The production has been about equal to progeny trees of the Valencia strain, and the character of the tree growth and habit of fruiting of these trees thus

far indicate that they may be inherently more productive than the other progeny trees of the Coarse strain in this test.

TABLE 11.—Records of annual performance of progeny trees propagated in 1915 from limb variations of the Coarse strain of the Valencia orange

Progeny tree No.	Source of buds		Number of fruits produced by progeny trees														
			Coarse strain							Valencia strain							
	Parent tree No.	Limb	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	Total
10-45	123	Limb bearing coarse fruits	7	51	36	33	104	32	263	0	24	176	112	42	225	582	845
11-23	142	do	26	136	64	141	91	151	609	0	12	92	123	132	266	625	1,234
11-24		do	15	102	45	73	57	102	394	1	14	31	50	98	127	321	715
12-9		do	2	33	22	274	6	400	737	11	18	67	55	35	125	311	1,048
12-10	171	do	2	53	26	193	18	50	342	14	25	106	23	79	315	559	901

YELLOW STRAINS

In the original performance-record plot on the Chase plantation at Corona, Calif., two distinct classes of Yellow strain fruits were observed as individual trees or as limb variations in trees of the Valencia strain. In one the fruits were very similar to those of the Valencia strain, except in color, whereas in the other the yellow fruits were very much smaller in size than the normal Valencia fruits. In the propagation of progenies from Yellow strain limb variations, buds were taken only from those bearing small yellow fruits because of the necessity for limiting these propagations to the smallest possible number and by reason of the more striking characteristics of the small yellow fruits. Yellow-colored fruits are also borne by the trees of several of the other strains, including the Persistent-Style, Dwarf, and Misshapen-Leaf strains.

The trees of the Small Yellow strain have a spreading and drooping habit of growth, the foliage is of medium density, and the leaves are of medium size and sharply pointed.

TABLE 12.—Records of annual performance of progeny trees propagated in 1915 from two limb variations of the Yellow strain occurring in the Valencia strain trees compared with records from a normal Valencia tree which was propagated from a normal branch of a near-by tree

Progeny tree No.	Source of buds		Number of fruits produced by progeny trees														
			Small Yellow strain							Valencia strain							
	Parent tree No.	Limb	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	Total
10-49	128	Limb variation bearing small smooth yellow fruits	3	17	50	154	65	436	725	1	21	11	59	20	7	119	844
11-31	147	do	0	12	33	253	8	388	694	0	6	14	35	9	76	140	834
12-37	190	Normal Valencia								20	133	215	159	208	282	1,017	1,017

The typical fruits are small and globular, yellow in color, with a very smooth texture, thin rind, very tender rag, and an abundance of juice of high quality. Frequently the skins of these fruits have small knobs or streaks of orange red, as is the case with Yellow strain fruits in the Washington Navel orange. The yields of the Small Yellow strain trees are light in comparison with those of Valencia strain trees, as regards both number and weight of oranges. On account of their small size and pale color, these fruits are of very

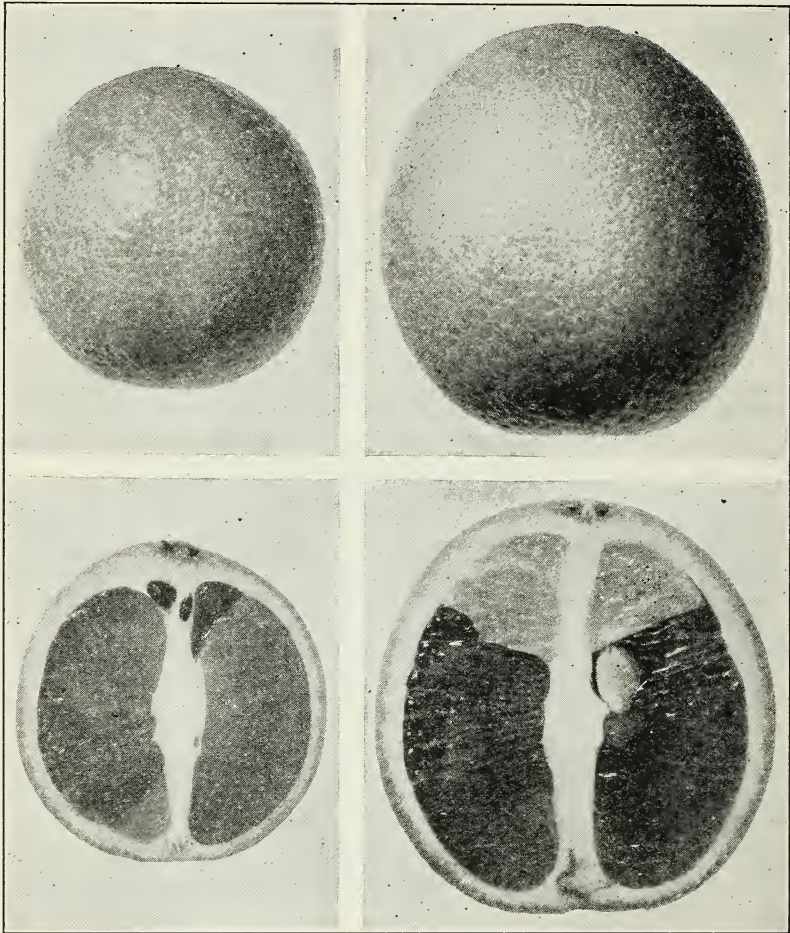


FIG. 14.—Fruits of the Small Yellow (left) and normal (right) strains of the Valencia orange. These were produced on progeny tree listed as No. 10-49 in Table 12, which was propagated from an unstable limb variation of the Small Yellow strain. Riverside, Calif., January, 1926. (About four-fifths natural size)

inferior commercial value under prevailing market conditions. They ripen about a month earlier than normal Valencia oranges, and for this reason may prove to be of some value for local or home use under some conditions.

The performance records of two progeny trees which were propagated from limb variations of the Small Yellow strain in two

otherwise apparently normal Valencia trees are shown in Table 12, together with the record of a comparable progeny tree propagated from a normal limb of a tree of the Valencia strain. It will be noted that the two progeny trees of the Small Yellow strain have produced both small yellow and normal fruits, as was the case in the fruiting of the parent limbs. Typical fruit from one of these trees is shown in Figure 14. The total yields of the two Small Yellow strain progeny trees for the performance-record period are smaller than that of the comparable Valencia strain progeny tree.

MISSHAPEN-LEAF STRAIN

The trees of the Misshapen-Leaf strain are easily distinguished on account of their sparse foliage and irregular misshapen leaves, which are slightly variegated and show a very pronounced chlorotic condition during the winter months. They are similar in habit of growth to the trees of the Valencia strain, but their sparse foliage gives them an open appearance.

The fruits are small and pear shaped or elongated, yellowish orange in color, with coarse texture, tough rag, and a normal quantity of juice of only fair quality. The peculiar shape and small size of these fruits render them of inferior commercial value.

The performance records of three progeny trees propagated from a limb variation of this strain are shown in Table 13. Each of these trees has produced one or more branches bearing normal foliage and fruit, an apparent reversion to the Valencia strain, but the larger part of each tree is typical of the variation. The total production of each of the Misshapen-Leaf strain progeny trees has been from one-third to one-half that of a comparable progeny tree which was propagated from a normal branch of a near-by Valencia tree. The commercial quality as well as the quantity of fruit produced by the Misshapen-Leaf strain progeny trees have been so poor as to render their crops of little or no value.

TABLE 13.—Records of annual production of progeny trees propagated in 1915 from a limb variation with misshapen, somewhat variegated leaves and pear-shaped fruit in a Valencia orange tree compared with records from a tree propagated from a normal limb in a near-by tree

Progeny tree No.	Source of buds		Number of fruits produced by progeny trees														
	Parent tree No.	Limb	Pear shaped						Normal						Total		
			1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25		1925-26	Total
11-17	140	Limb variation with misshapen, somewhat variegated leaves and pear-shaped fruits.	0	19	47	20	0	302	388	0	25	15	55	1	10	106	494
11-19			2	2	48	65	4	234	355	0	0	20	86	8	52	166	521
11-19			2	6	33	18	0	173	232	4	7	17	53	0	54	135	367
12-19	176	Normal							21	63	163	356	120	338	1,061	1,061	

The sparse condition of the foliage of the progeny trees is shown in Figure 15, and typical leaves from one of them are shown in Figure 16. The pear-shaped fruits of this strain are illustrated in Figure 17.

STRAINS OF MINOR ECONOMIC IMPORTANCE

Other limb and tree variations have been noted during these investigations which are apparently of less frequent occurrence or of less striking appearance and hence of minor economic importance. The performance records of five progeny trees which were propagated from four such small limb variations in otherwise normal trees are presented in Table 14. Fruits of progeny trees Nos. 10-33 and 11-29 are shown in Figures 18 and 19, respectively.



FIG. 15.—Trees of the Misshapen-Leaf strain of the Valencia orange which were propagated from a similar limb variation. Leaves from one of these trees are shown in Figure 16, and typical fruits are illustrated in Figure 17. University of California Citrus Experiment Station, Riverside, Calif., June, 1925

TABLE 14.—Records of annual production of progeny trees propagated from various limb variations of the Valencia orange compared with records from a progeny tree propagated from the normal part of one of the same parent trees

Progeny tree No.	Source of buds		Number of fruits produced by progeny trees														
	Parent tree No.	Limb	Like parent-limb variation							Valencia strain							Total
			1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	Total	
10-33	106	Limb bearing long yellow, pebbled fruit with orange stripes.	8	26	10	10	4	78	136	9	76	116	261	181	267	910	1,046
10-34		Limb bearing small, yellow ridged fruit.	7	22	4	0	0	48	81	5	13	38	18	6	117	197	278
11-29	146	Limb bearing coarse, yellow ridged fruit with orange-colored ridges.	0	18	12	61	0	237	328	2	20	44	79	3	249	397	725
11-49	162	Limb bearing granular-textured fruit with tendency to ribbing.	0	38	52	87	67	75	319	5	70	169	245	177	410	1,076	1,395
11-51	162	Normal part of tree.	1	49	46	21	30	91	238	8	62	163	86	113	219	651	889
										51	128	244	68	137	379	1,007	1,007

The trees of these strains are very similar to those of the Valencia strain. The fruits differ from the normal ones in color, texture, and to some extent in shape, as indicated in the table, and they are all of a commercial quality inferior to the fruits of the Valencia strain.

With the exception of progeny tree No. 10-34 their production has been about the same as that of the comparable progeny tree No. 11-51, which was propagated from a normal limb in the parent tree in which the limb variation occurred from which progeny tree No. 11-49 was propagated.

The production of the trees propagated from limb variations has been made up of fruit typical of the parent-limb variations as well as those typical of the Valencia strain. Each of these parent-limb variations was very small, with only a few fruits, and these data indicate that the tendency to the production of the off-type fruits has been perpetuated.



FIG. 16.—Typical orange leaves from one of the progeny trees of the Misshapen-Leaf strain which are illustrated in Figure 15, showing their characteristic shape and the variegated and chlorotic condition, which is particularly marked during the winter months. Riverside, Calif., January, 1926. (About four-ninths natural size)

OTHER STRIKING VALENCIA BUD VARIATIONS

In addition to the bud variations and the resultant progeny propagations which have been described in the foregoing pages, other striking limb variations in Valencia orange trees have been found from time to time which are of more than ordinary interest from the standpoint of bud variation and bud selection. These variations, for the most part, have been discovered in trees growing in orchards other than those in which the original individual-tree performance-record work with the Valencia variety was carried on, and most of them have been found in connection with subsequent tree-estimate studies with full-bearing trees in established orchards. A few of these variations which have been found to be perpetuated through budding, but which on account of their infrequent occur-

rence appear to be of little commercial importance, will be briefly described in the following paragraphs.

Variiegated-leaf limb variations occurring in trees of the Valencia strain otherwise normal have been found thus far in three orchards. In two of these instances the outer edges of the leaves have been of a light creamy color, and the central portions have been normal, showing one or more shades of light green with a dark-green central area. In one instance the leaves of the variegated-limb variation had small sharply defined light-colored spots of irregular shape rather evenly distributed over the entire surface of both the upper and lower sides of the leaves. In all cases the vigor of growth of the variegated limbs was less than that of normal branches on the same parent trees.

On some variegated limb sports the fruits are apparently normal, whereas on others they are very similar to normal fruits except in color and texture. Where the fruits are abnormal in color they

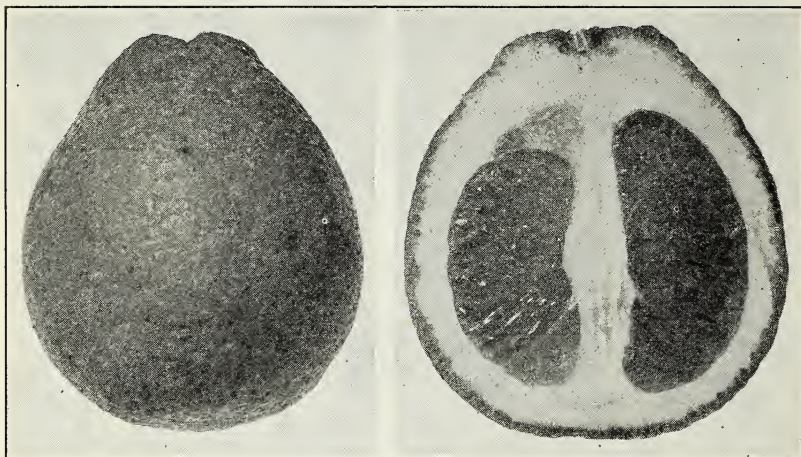


FIG. 17.—Typical fruits of the Misshapen-Leaf strain of the Valencia orange which were produced by one of the progeny trees illustrated in Figure 15. Riverside, Calif., June, 1915. (About seven-tenths natural size)

are usually marked with streaks or sections of darker orange color, which are coarser in texture and raised somewhat above the adjacent areas of the rind. These characteristics, as well as their slightly smaller average size, render the commercial value of these oranges inferior to that of the normal fruits.

Although the progeny tests of variegated Valencia limb variations have not gone far enough to warrant final conclusions as to their fruit production, the growth of the progeny trees, particularly the character of their leaves, proves conclusively that the variegated-leaf condition has been perpetuated through budding. A branch from a young progeny tree of the variegated strain is shown in Figure 20.

Limb and individual-fruit variations showing oranges with typical navels have been found in trees of the Valencia strain as well as in those of several other Valencia strains. As a rule, the navels are of small size, and the navel opening is usually very small or entirely lacking. Otherwise these fruits, so far as studied, seem to

be very similar to those of the normal strain. Recent progeny tests of some of these limb variations indicate that this strain may be isolated through the selection of buds from limb variations which produce all navel fruits.

The finding of limb variations bearing navel fruits in Valencia trees is of special interest because it probably explains the origin of the Navelencia variety, which was grown commercially during former years to a limited extent in the Southwest. As this strain was not found to possess any advantages as compared with the Valencia strain, its commercial propagation has been abandoned, and most of the established trees of the variety have been top-worked.

Limb variations of trees of the Valencia strain bearing dry fruits have been found in two orchards. These fruits, so far as juice content is concerned, resemble those of the Dry strain of the

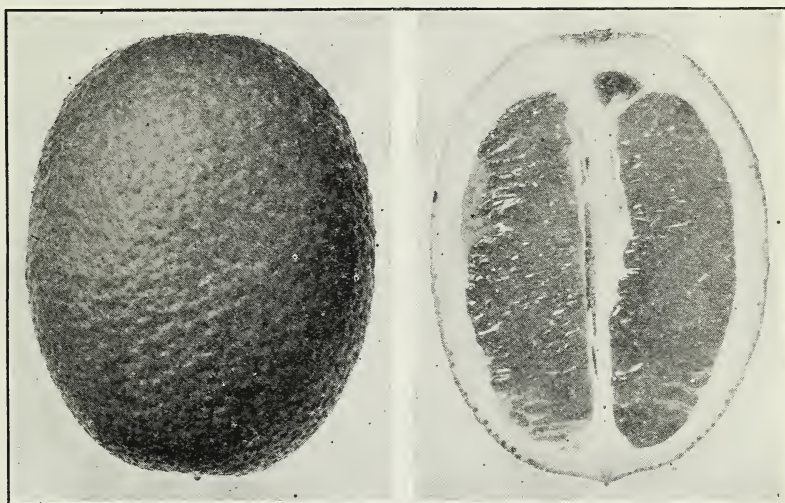


FIG. 18.—Long yellow pebbled Valencia orange fruits with orange-colored stripes. These were borne on the progeny tree No. 10-33, as listed in Table 14, which was propagated from a similar limb variation. Riverside, Calif., June, 1925. (About three-fourths natural size)

Washington Navel orange which have been described in a previous publication (5).

Although the progeny tests of the Dry strain of the Valencia orange are incomplete as yet, enough evidence has been obtained to prove that this strain has been perpetuated through bud propagation. (Fig. 21.)

A limb variation bearing very small and ribbed fruits (fig. 22) with persistent styles has been found in an otherwise normal tree of the Valencia strain. Progeny tests of this variation now under way indicate that the characteristics of this limb variation have been transmitted to its progenies through bud propagation.

Several limb variations bearing oranges of normal Valencia appearance except for the presence of reddish knobs or streaks on the skin have been observed from time to time in the course of the tree-estimate studies of Valencia orchards. Others producing fairly

normal fruits but having only comparatively few oil cells in the rind have also been observed. These and other limb variations are being tested in progeny propagations, and the early fruiting of these trees indicates that the characteristics of the parent-limb variations have been perpetuated through budding.

LESSONS FROM THE PROGENY TESTS

These various progeny tests indicate the inheritance of the different characters which were noted as limb variations and show the necessity for care in the selection of bud wood for commercial propagation in order to avoid the perpetuation of such undesirable variations in orchard plantings. Individual-fruit variations typical of all of the recognized strains of the Valencia orange have been observed from time to time in these investigations in trees otherwise normal, but these instances of bud variations have not been reported in detail in this bulletin. The limb variations are of

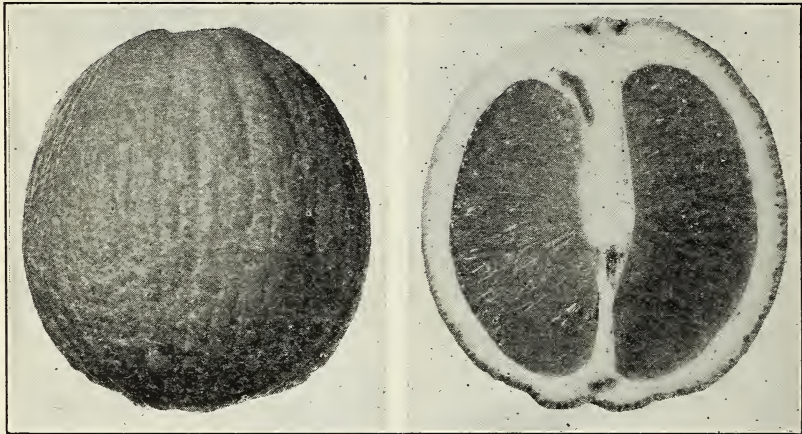


FIG. 19.—Coarse yellow Valencia orange fruits with orange-colored ridges. These were grown on progeny tree No. 11-29, as listed in Table 14, which was propagated from a similar variation. Riverside, Calif., June, 1925. (About three-fourths natural size)

greater economic importance than the single-fruit variations by reason of the probability that in obtaining bud wood for nursery purposes buds taken unintentionally from such limbs have perhaps given rise to many of the trees of the diverse strains observed in many of the older orchards of this variety in the Southwest.

Some of the limb variations studied in this work have been found to be uniform in their fruit and foliage characteristics throughout all of the branches. These limbs, in the light of the performance of the progeny trees propagated from them, are considered to be inherently stable. On the other hand, many of the limb variations show a mixed or variable condition of fruiting, and in some instances produce both the fruit and foliage characters typical of the variation and normal fruits or foliage as well. As a result of the progeny tests of such of these limb variations as have been studied, they are considered to be inherently unstable from the fact that the progeny trees also produce both fruit and foliage characteristic of the variations and also normal fruits and foliage.

In these progeny studies the quantity of fruit produced generally has been found to be correlated with its market quality. The high-yielding trees have been found to bear consistently a high percentage of first-grade fruit, and the low-yielding trees have borne a small proportion of first-grade oranges. In the high-yielding trees the large proportion of the fruit has usually been of the desirable medium sizes and of the most desirable shape for packing. In the case of the low-yielding trees there has been a tendency to produce fruits of ex-



FIG. 20.—Variegated foliage from a Valencia orange tree which was propagated from a similar limb variation. Riverside, Calif., January, 1926

tremely large or abnormally small sizes and of irregular shapes which are not so well adapted for packing under present methods as the shape typical of the Valencia strain.

The characteristics of the foliage of the limb variations studied in these progeny tests have been perpetuated in a manner similar to those of the fruits. In some instances, as for example in the case of the Willow-Leaf strain, the characteristics of the foliage are correlated with certain characters of the fruits, so that it is possible to identify such limb variations by either the foliage or the fruits.

ISOLATION AND PROPAGATION OF SUPERIOR STRAINS

Most of the limb variations which have been studied are apparently regressive in nature, and their fruits are less desirable for commercial purposes than those of the Valencia strain. On account of the rank growth of some of them and the development of an unusually large number of large and vigorous-growing nonfruiting branches which were formerly considered to be particularly desirable as sources of buds for propagation, the proportion of the trees of these strains has increased rapidly where systematic bud selection has not been practiced in the propagation of this variety. For this reason it was formerly considered by some growers that the Valencia variety was "running out" in the Southwest and that some new variety must be developed to take its place.

Recent observations of Valencia orchards where the buds for the propagation of the trees were carefully selected from superior-yielding and uniformly fruiting parent trees give conclusive evi-

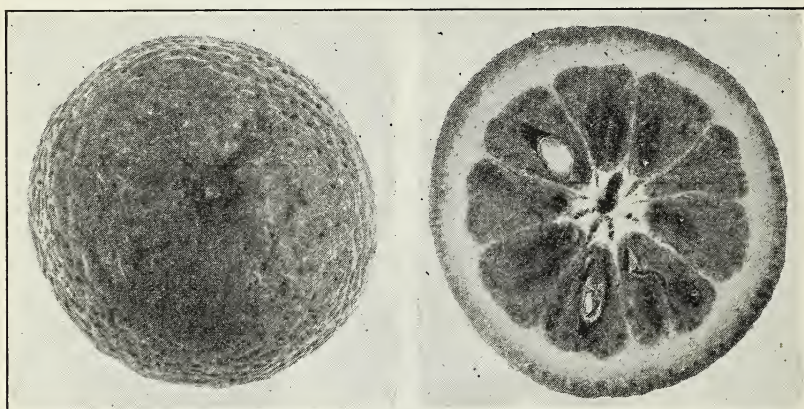


FIG. 21.—Fruits of the Dry strain of the Valencia orange from a tree which was propagated from a similar limb variation. Riverside, Calif., June, 1923. (About three-fourths natural size)

dence that the undesirable strains have been practically eliminated. So far as known, these commercial progenies of selected parent trees have not developed a single markedly variable tree, and only a very small proportion of individual-fruit and limb variation has been observed in any of these orchards. In some of these progeny plantings more than 50 per cent of the trees are now considered to be satisfactory sources of bud wood for further propagation, as compared with 1 per cent or less in orchards where systematic methods of bud selection were not used in the propagation of the trees. These tests, together with related commercial progeny plantings, show that it is possible to isolate a uniform and productive strain which is to be desired in commercial fruit growing.

The application of the results of these investigations has led to improved yields and the more profitable culture of the Valencia orange. The business of growing this fruit has been stabilized through the isolation and propagation of the best strain and the elimination of the undesirable ones. Indications at present are that

by selections from progenies now in fruiting, which have been propagated from apparently superior parent trees or limb variations, strains better yielding than any now in commercial cultivation will be obtained.

SUMMARY

The individual-tree performance record studies of bearing Valencia orange trees which have been carried on since 1912 in established orchards located in southern California have shown that these groves consist of at least 12 strains of commercial importance, together with a number of others of minor economic consequence. The trees of these strains have either fruit or vegetative characteristics, or both, which serve to distinguish them from all other trees of this variety so far as known.

In the course of these investigations it was found that certain Valencia trees had produced striking limb variations. In these instances the fruit or foliage characteristics of the limb sports were

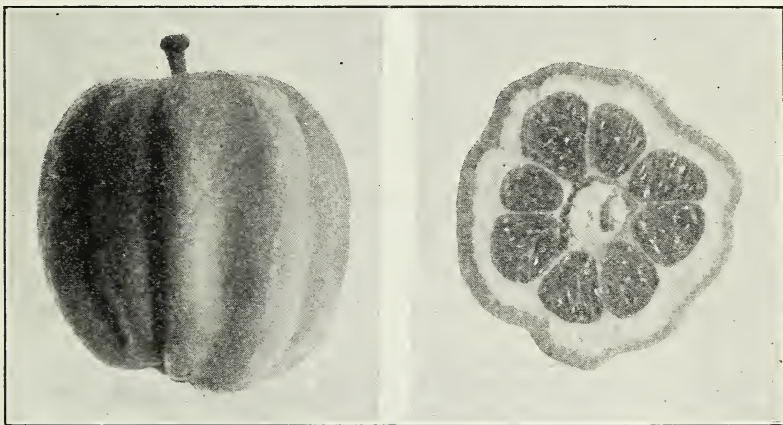


FIG. 22.—Very small ribbed Valencia orange fruits with persistent styles on a limb variation. Santa Paula, Calif., May, 1922. (Natural size)

very different from the characteristics of the remainder of the trees, and when once identified they were easily recognized during subsequent studies in these and other Valencia orchards.

In these limb variations two conditions of development have been found: (1) Stable ones or those in which the entire limb variation is uniform in its fruit and foliage characteristics, and (2) unstable ones in which the limb variation has fruit or foliage normal as well as typical of the variation.

The similarity of the fruits and foliage of the limb variations with those of entire-tree variations in established Valencia orchards suggested the probability that the tree variations were the result of the unintentional propagation in commercial nursery practice of limb variations occurring in otherwise normal trees.

Propagations of a number of limb variations occurring in otherwise normal Valencia trees were made in the spring seasons of 1915 and 1916. The resulting progeny trees were planted in the orchard of the Citrus Experiment Station of the University of California

at Riverside in the summer seasons of 1917 and 1919, respectively. The performance records of a number of these trees from the beginning of their fruiting during the season of 1920-21 to the season of 1925-26, inclusive, are presented in this bulletin.

The progeny-performance records of 12 limb variations which are typical of the trees of important economic strains of this variety, as well as those of several limbs representing tree variations of minor commercial consequence, show that the fruit and foliage characteristics of the parent-limb variations have been transmitted to their progenies through bud propagation.

The progeny trees which were propagated from the stable or uniform limb variations are similar to their parent limbs in all respects. On the other hand, the progeny trees which were propagated from unstable limb variations have produced fruits and foliage normal as well as typical of the present limb variation.

The results of these progeny tests indicate that the mixed stock of many established Valencia orange orchards has been due to the unintentional cutting of bud wood from limb variations. The trees of most, if not all, of the diverse strains of the Valencia orange described in this bulletin are inferior to those of the Valencia strain from the standpoint of profitable orange culture. Their presence in commercial orchards lowers both the quantity and the quality of the production and increases the cost of preparing the crop for the market, on account of the greater care necessary in assorting and packing the fruits.

Limb variations marked by characteristic foliage differences, including size, shape, and variegated conditions of the leaves, have been transmitted to the progeny trees through bud propagation.

The habit of tree growth of the progeny trees is similar to the arrangement of the branching and the condition of the growth of their parent limbs.

Low quantity production, as well as differences in quality and appearance of fruit, have been proved to be inherited characters transmitted by progeny propagations.

The progeny propagations of productive normal Valencia trees having uniform fruit and foliage characteristics throughout, as shown by their performance records for a period of years both experimentally and commercially, have shown little variability and have produced heavy crops of superior commercial quality.

The results of these progeny tests, together with observations of many commercial propagations, emphasize the importance of careful bud selection in the propagation of the Valencia orange.

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July 15, 1927

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