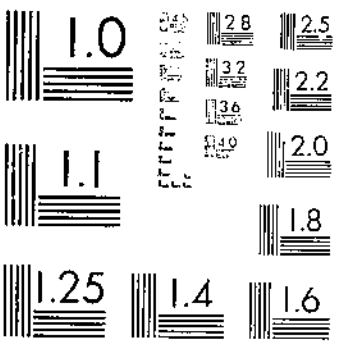
TB 531 (1936) USDA TECHNICAL BULLETINS UPDATA

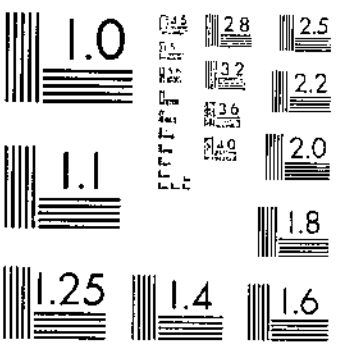
BUD SELECTION IN EUREKA AND LISBON LEMONS AND PROGENY TESTS OF BUD

SHAMEL, A. D.; POMEROY, C. S.; CARYL, R. E. 1 OF 1

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Technical Bulletin No. 531 November 1936

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

BUD SELECTION IN EUREKA AND LISBON LEMONS AND PROGENY TESTS OF BUD VARIATIONS

By A. D. Shamel, *principal physiologist*, C. S. Pomeroy, *associate pomologist*, and R. E. Caryl, formerly *assistant pomologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

CONTENTS

INTRODUCTION

The commercial culture of the lemon (*Citrus limonia* Osbeck) in the United States is largely confined to the southern counties of California. The introduction of the Lisbon variety into that State from Australia in 1874 and the origin of the Eureka variety at Los Angeles in 1877 marked the beginning of the development of this important industry. In 1887, the first year of available records of carlot shipments of lemons from California, 12 carloads were marketed; in the season of 1934–35 a total of 19,604 carloads were shipped.

The Eureka and Lisbon varieties are now almost universally planted for the production of the California lemon crop. A few trees of the Villafranca variety are propagated occasionally, and a few old trees

73585°—36——1

of the Genoa, Bonnie Brae, and other less well-known varieties are still in bearing, but their total production is of relatively small importance. The Eureka variety is largely grown in the interior lemon districts, and the Lisbon variety is more generally planted near the coast.

The fruits from the Eureka and Lisbon trees are packed and marketed without varietal segregation, the crops as a whole being known commercially simply as lemons. The characteristics of the trees of these varieties are quite distinct, particularly in the vigor of growth and thorniness of the trees and the season of maximum fruit production. Marked variations also have been found in the foliage and fruit characters, as shown by some entire trees in each variety as well as by striking variations in individual limbs in some trees.

The investigations reported herein were undertaken for the purpose of determining the nature and frequency of the occurrence of bud variations in the fruits and foliage of trees of the Eureka and Lisbon varieties. The first phase of the investigations was carried on through systematic individual tree-performance records in established citrus orchards of full-bearing trees over a period of years beginning in 1911. Statements of the early phases of the bud-variation studies were made in 1911 (*5*, *6*),[1] and further reports of the progress have been presented from time to time (*1*, *2*, *3*, *4*, *7*, *8*, *9*, *10*, *11*, *12*, *13*, *14*, *15*). The detailed results of the first studies with Eureka and Lisbon lemons up to June 1917 were reported in 1920 (*18*, *19*).

The second phase of the investigations has been the study of the performance records of progeny trees that were propagated from carefully selected parent trees in the original performance-record plots and from bud variations found in and near those plots.

This bulletin contains the results of some of the performance-record studies of these progeny propagations and deals primarily with the degree of perpetuation of the characteristics of the outstanding variations. The performance-record period during which the progeny trees have been studied began with their planting in 1918 and was continued until May 1934. A number of trees were removed from the progeny test plots early in 1933, so the tabulated data presented herewith cover the period from the first fruiting of the trees in the fall or winter of 1920–21 to December 1932, inclusive.

BUD VARIATIONS IN EUREKA AND LISBON VARIETIES

The striking variations of fruit and foliage previously reported in trees of the Eureka and Lisbon varieties may be grouped into two classes, (1) those occurring as limbs on otherwise normal[2] trees, and (2) as entire trees differing from the normal in one or more clearly defined characteristics. In addition, individual fruits have been found in some of the lemon trees under observation that differ markedly from the other fruits on the same tree in one or more characteristics. These individual-fruit variations in some cases closely resembled those borne by the limb and entire-tree variations that have been studied in these investigations.

[1] Italic numbers in parentheses refer to Literature Cited, p. 43.

[2] The word "normal" is used here and elsewhere in this bulletin in the sense of having the characteristics of the typical or normal strain of the variety.

Fruit variations are sometimes clearly correlated with foliage variations, but on account of the obvious economic importance of fruit variations and the practicability of obtaining definite data regarding them they have been given primary consideration in the present studies. Where unmistakable and economically important correlations of fruit and foliage characteristics have been observed they have been recorded and described.

Lemon variations may be further classified as affecting (1) the commercial quality of the fruit, (2) the quantity of fruit, and (3) the season of maximum production. In most instances the commercial quality of the fruits borne by the progeny trees that were propagated from the parent-limb or entire-tree variations is correlated with the quantity of fruits produced by these same trees.

Variations of fruits include those having characteristic shape, size, texture and color of rind, and number of seeds. Foliage variations include those showing characteristic habits of growth of the trees, density of foliage, color, shape, size, and thickness of leaves, number and size of thorns, and season and character of blossoms.

Tree-estimate records in some of the older lemon orchards in southern California in addition to those where the individual tree-performance record studies were made showed that limb and entire-tree variations were present in all of them. In some instances this variability was much more pronounced than in others, but typical cases of striking bud variations were found wherever observations were made.

The early discovery that the fruit and foliage characteristics of limb variations were very similar to those of some of the entire-tree variations in established orchards indicated that the entire-tree variations had been unintentionally propagated from similar limb sports. The subsequent studies of progeny trees propagated from typical limb variations and their comparison with the entire-tree variations in the older orchards have proved beyond reasonable doubt that the origin of the entire-tree variations was limb variations in the trees from which the buds were obtained to propagate the orchard trees.

The variations described in this bulletin must be clearly distinguished from those due to soil, climate, rootstock, cultural, or other environmental influences. Fluctuating variations and changes, such as modifications in vigor of growth, size of trees, size of fruits, or differences in the color of the leaves or fruits resulting from changes in soil, climate, cultural practices, unsuitable rootstocks, or other causes that are not inherent and are not perpetuated through bud propagation, have not been considered in this publication except as indicating the effect of environmental factors upon tree and fruit development.

Some of the limb and entire-tree variations found in these studies were uniformly abnormal in their fruit or foliage characteristics. In other instances more than one type of variation from the normal was found in a single tree, either normal fruits and foliage with the abnormal ones, or two or more distinctly different types of abnormal foliage or fruits.

The uniform limb and entire-tree variations have been found through progeny propagation tests to perpetuate the characteristics of the parent variations, whereas those that are not uniform have transmitted their characteristics with about the same condition of variability as appeared in the parent limbs or entire trees.

The uniform limb and entire-tree variations have been termed inherently stable ones, and those lacking in uniformity have been called inherently unstable ones, as shown by their performance in progeny tests.

FREQUENCY AND SIGNIFICANCE OF BUD VARIATIONS

From the economic viewpoint the variations in Eureka and Lisbon lemon trees as observed in these investigations may be classed as desirable when they are more satisfactory for commercial culture than the normal, and undesirable when less valuable than the normal for the production of profitable crops.

In the Eureka lemon orchard where the striking variability of the trees of this variety was discovered, 2,200 trees out of a total of 16,000, or about 14 percent, were found to be undesirable entire-tree variations having exceptionally vigorous vegetative types of growth, a condition that was found to be correlated with an inferior commercial quality of fruit and light yields. These large unproductive trees with characteristically spreading habit of growth and dense and abundant foliage were called "shade trees" and "dense unproductive"[3] trees. A subsequent study of the orchard from which the buds had been obtained for the propagation of the trees under investigation showed that only about 5 percent were of the Shade-Tree or Unproductive strains.[4] The explanation of this condition was found to be that the bud cutters in securing propagating material found it easier to obtain budwood from the vigorous-growing vegetative trees than from the less vigorous productive ones. There were many more vegetative branches, commonly called suckers, in the vegetative type of trees than in the normal productive ones, consequently the natural tendency was to secure more budwood from the rank-growing trees than from the more fruitful ones.

In addition to the entire-tree Shade-Tree and Unproductive variations, limbs having leaves and fruits typical of these strains were found in otherwise apparently normal Eureka trees in both the parent orchard and the younger one that was propagated from it. Some of the inferior strain trees in the younger orchard doubtless resulted from the cutting of budwood from such limb variations in the parent trees. More than 25 percent of the trees in the younger orchard were found to be entire-tree variations differing from the normal in one or more characteristics, particularly in the habit of growth of the trees, density of foliage, shape of leaves, season of production of fruits, shape, texture, and size of fruits, number, shape, and size of seeds contained in the fruits, structure of flowers, and quantity of production.

The condition of variability of the trees of the Lisbon variety regarding both entire-tree and limb variations in the orchard where performance-record studies were conducted was found to be similar to that observed in the trees of the Eureka variety.

[3] The term "dense unproductive" used in earlier publications as a strain designation has been shortened in this report to the one word "unproductive."

[4] The term "strain" as here used designates a group of individuals of a horticultural variety differing from all other individuals of the variety in one or more constant and recognizable characteristics and capable of perpetuation through bud propagation.

VARIATIONS OF THE EUREKA VARIETY

The Eureka lemon has been determined as having been first propagated as a type in 1877 at Los Angeles, Calif. (*18*). This propagation was from a superior seedling which was one of a lot that had been grown from seed taken from Sicilian lemons secured in New York City in 1858.

The original Eureka performance-record investigations were carried on from July 1911 to June 1917, inclusive, in an orchard planted at Corona, Calif., in the spring of 1904 by the National Orange Co. and owned by that company at the time of those studies. It is now owned by the American Fruit Growers, Inc.

The important variations of the Eureka lemon variety are described in the following sections under the classification of typical strains, and some of the less common but striking variations are also included. All of the variations discussed are of importance from the standpoint of the scientific study of the phenomenon of bud variation in the lemon and in the selection of suitable propagating material for the growing of commercial nursery trees.

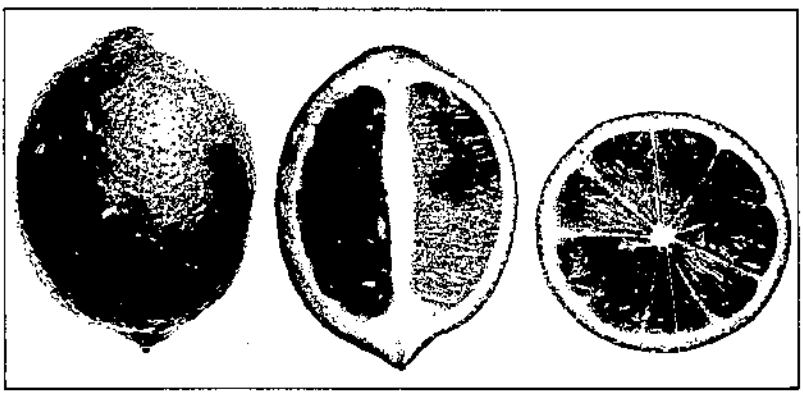


FIGURE 1.—Fruits of the Eureka strain of the Eureka lemon from a progeny tree propagated from a typical tree of this strain in the original Eureka performance-record plot. Corona, Calif., April 1933.

EUREKA STRAIN

Tree medium size, medium vigor, spreading, open; trunk smooth; bud union usually badly overgrown on sour orange (*Citrus aurantium* L.) but usually smooth on sweet orange (*C. sinensis* Osbeck) rootstock; branches medium size and number, practically thornless; leaves rather sparse, medium size, broadly elliptical, bluntly rounded, crenate, color deep green; blossoms abundant during spring and fall but develop throughout the entire year, perfect, fairly large; fruits very uniform, oblong, medium size, rind thin, smooth, color deep green, rag tender, juice abundant and of relatively high acidity, seeds few; rate of growth of fruits medium; largest picks during spring and fall; high quantity of production; excellent commercial quality.

An undesirable characteristic of the trees of this strain is that there is a tendency for the fruits to sunburn in some locations, owing to the open habit of growth and sparse foliage. A desirable characteristic of these trees is their tendency to bear throughout the entire year, with a fair summer production. Typical fruits of this strain are illustrated in figure 1 and a typical leaf is shown in figure 2, *A*.

SMALL-OPEN STRAIN

Tree medium to small, medium vigor, somewhat spreading, open; trunk slightly fluted, smooth; bud union usually badly overgrown on sour orange but

smooth on sweet orange rootstock; branches medium to small size and number, practically thornless; leaves rather sparse, medium size, broadly elliptical, bluntly rounded, crenate (fig. 2, *B*), color dark to deep green; blossoms abundant during spring and fall, but develop throughout the entire year, perfect, medium size; fruits very uniform, globose, slightly shorter than those of the Eureka strain and with a tendency for crescent-shaped creases at blossom ends, rinds thick to

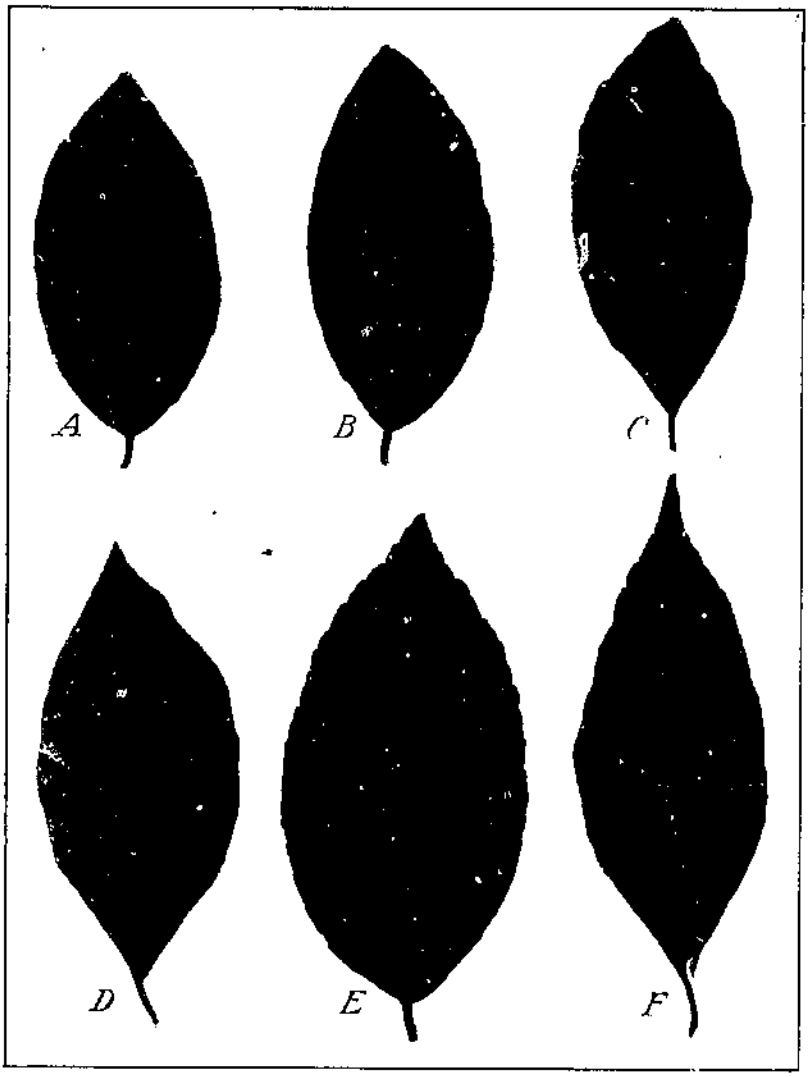


FIGURE 2.—Leaves of important strains of the Eureka lemon from progeny trees propagated from typical trees of the same strains in the original Eureka performance-record plot: *A*, Eureka, *B*, Small-Open; *C*, Crumpled-Leaf; *D*, Pear-Shape; *E*, Shade-Tree; *F*, Unproductive. Corona, Calif., May 1933.

medium, smooth, color deep to dark green, rag tender, juice abundant and of relatively high acidity, seeds few; rate of growth of fruits medium; largest picks during spring and fall; slightly less quantity of production than comparative Eureka strain trees; good commercial quality.

The most important differences between the Small-Open and Eureka strains are the shape and size of fruit, the globose shape of typical Small-Open strain

fruits rendering them somewhat less suitable for packing than the oblong shape of the typical Eureka strain fruits. The darker green color of the Small-Open fruits and their slower curing are also distinguishing characteristics. Typical fruits of this strain are shown in figure 3.

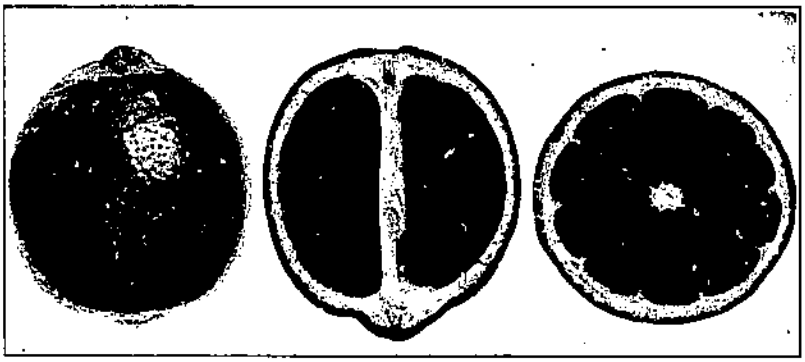


FIGURE 3.—Fruits of the Small-Open strain of the Eureka lemon from a progeny tree propagated from a typical tree of this strain in the original Eureka performance-record plot. Corona, Calif., April 1933.

PEAR-SHAPE STRAIN

Tree large, with tendency to produce many suckers, erect, dense; trunk normally smooth; bud union somewhat overgrown on sour orange but smooth on sweet orange rootstock; branches many, small, giving the tree a brushlike appearance, practically thornless; leaves abundant, small in size, ovate, obtuse, crenate (fig. 2, *D*) in whorls at ends of branches, light-green color; blossoms abundant in midwinter and few at other seasons, small, weak, perfect but with small amount of pollen of deficient vitality, mainly on tips of branches; fruits very uniform,

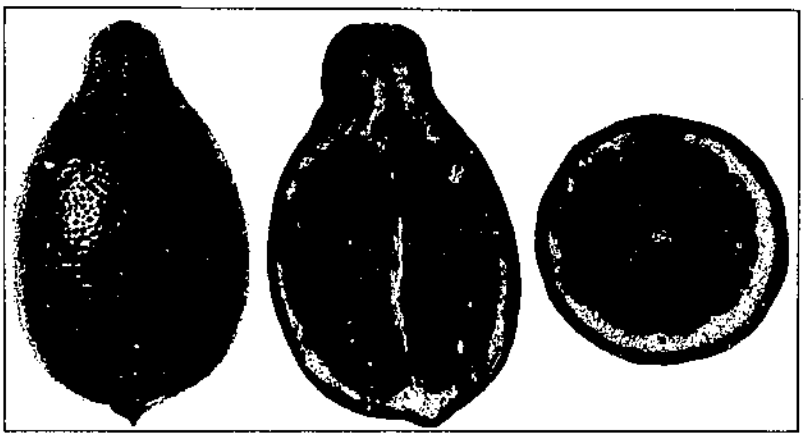


FIGURE 4.—Fruits of the Pear-Shape strain of the Eureka lemon from a progeny tree propagated from a typical tree of this strain in the original Eureka performance-record plot. Corona, Calif., May 1933.

pyriform, frequently with elongated or bottle-necked stem ends, small to medium size, rind very thin and of smooth texture, color light green, rag tender, juice abundant and of relatively low acidity, seeds very few; rate of growth of fruits medium; largest picks during fall; medium quantity of production; inferior commercial quality.

The Pear-Shape fruits shown in figure 4 are of inferior commercial value, and established orchard trees of this strain should be top-worked or replanted.

SHADE-TREE STRAIN

Tree very large, very vigorous, wide spreading, dense; trunk smooth; bud union smooth on both sour and sweet orange rootstocks; branches dense with considerable sucker growth, practically thornless; leaves abundant, elliptical and large, tapering with a tendency to acuminate tips, undulate and crenate (fig. 2, *E*), deep-green color; blossoms abundant during spring, large, weak, many with pistils imperfect or absent, falling shortly after blooming; fruits very uniform, oblong, very large, rind coarse and rough, very thick, dark green, rag coarse and very abundant, juice scant, lacking acidity, seeds very few; rate of growth of fruits rather rapid; most production during fall; low quantity of production; inferior commercial quality.

The outstanding characteristics that distinguish the Shade-Tree from the Eureka strain include the development of many imperfect flowers that drop shortly after the bloom appears, large, acutely pointed leaves, fruits of very large size and oblong shape, and particularly the vigor of the vegetative growth, which results in very large, conspicuous trees that can be easily seen from a considerable distance in the orchards. Typical fruits of this strain are shown in figure 5. It also has imperfect flowers similar to those illustrated for the Unproductive strain of the Lisbon lemon (fig. 13).

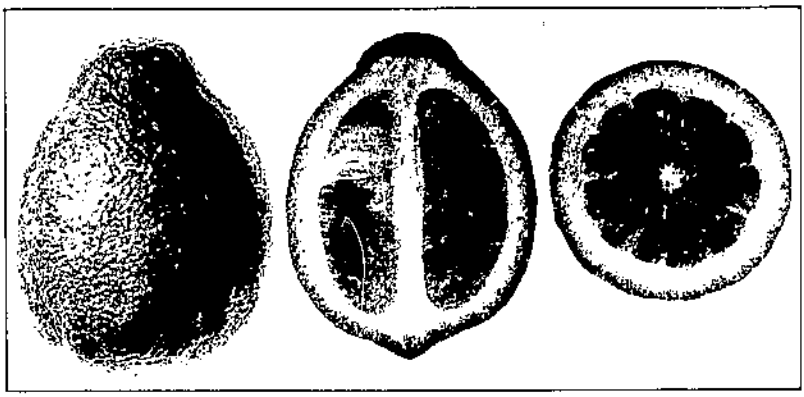


FIGURE 5.—Fruits of the Shade-Tree strain of the Eureka lemon from a progeny tree propagated from a typical tree of this strain in the original Eureka performance-record plot. Corona, Calif., May 1933.

UNPRODUCTIVE STRAIN

Tree large, vigorous, erect, very dense; trunk smooth; bud union smooth on both sour and sweet orange rootstocks; branches dense, few small thorns; leaves abundant, smaller than those of the Shade-Tree strain, elliptical and tapering with strong tendency to acuminate tips, crenate (fig. 2, *F*), dark-green color; blossoms abundant during spring, large, weak, very many imperfect with pistils rudimentary or lacking and with scant pollen of low vitality; fruits fairly uniform, oblong, large, rind coarse and rough, thick, dark green, rag tough and abundant, juice scant, poor flavor and of low acidity, seeds very few; rate of growth of fruits fairly rapid; most production during fall; very low quantity of production; inferior commercial quality.

The low production of poor commercial quality and the dense, erect growth of the trees are the most important distinguishing characteristics of this strain. Typical fruits of this strain are shown in figure 6.

CORRUGATED STRAIN

Tree large, medium vigor, rather spreading, somewhat dense; trunk smooth; bud union badly overgrown on sour orange rootstock; branches rather large and many practically thornless; many leaves, large, broadly elliptical, bluntly rounded, crenate, color deep green; blossoms abundant during spring, many imperfect, medium size, along branches at leaf axils; fruits uniformly corrugated, oblong, large, rind thick, deeply corrugated, color yellow when mature, rag coarse, juice lacking in quantity and of low acidity, seeds few; rate of growth

of fruits medium; largest picks during fall and winter; light quantity of production; commercial quality poor.

This strain has been eliminated from commercial propagation, and trees in bearing orchards should be top-worked or replanted.

RIBBED STRAIN

Tree medium size, medium vigor, open and rather upright; trunk smooth; bud union slightly overgrown on sour orange rootstock; branches medium to large, few, practically thornless; leaves rather sparse, small, oval and bluntly rounded, tendency to crumple, color green; blossoms fairly abundant in spring, many small, imperfect; fruits oblong, ovoid, ribbed with tendency to deeply fluted characteristic, rind thin, ridged, and somewhat rough, deep green, rag tender, juice abundant and of medium acidity, seeds few; rate of growth of fruits rapid; largest picks during fall and winter; low quantity of production; poor commercial quality.

An undesirable strain for commercial culture. The uniformity of type of fruits in the trees of this strain is very marked.

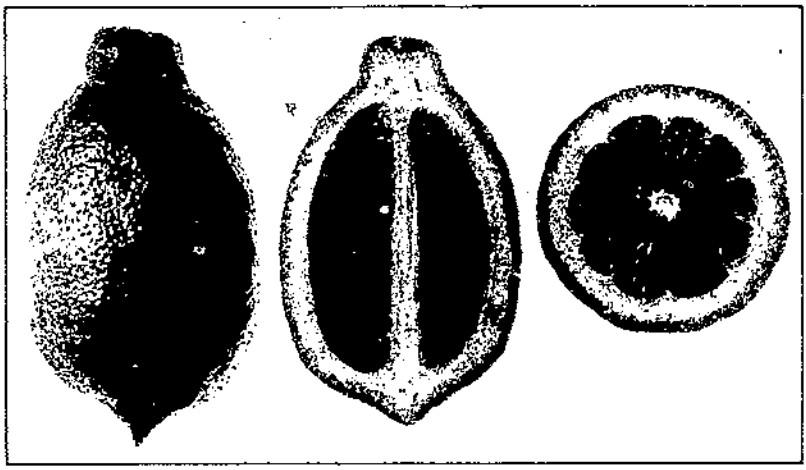


FIGURE 6.—Fruits of the Unproductive strain of the Eureka lemon from a progeny tree propagated from a typical tree of this strain in the original Eureka performance-record plot. Corona, Calif., May 1933.

VARIEGATED STRAIN

Tree small, weak vigor and slow growing, erect, open; trunk smooth; bud union makes large overgrowth on sour orange rootstock; foliage particularly susceptible to sunburn and frost injuries; branches small, few in number and striped when young, very few small thorns; leaves sparse, small, elliptical and irregular in shape, slightly crenate, color variegated, some almost entirely cream colored, others nearly entirely green with sharply marked areas of two or three shades and most of them partly green and cream color; blossoms abundant during spring, with heavy drop, many small, imperfect; fruits ovoid, small, rind very thin, slightly ridged, color striped when immature and yellow when mature, rag rather coarse, juice fairly abundant and of relatively high acidity, seeds medium number; rate of growth of fruits medium; largest picks during spring and fall; very low quantity of production; poor commercial quality.

The trees of this strain are used to some extent for ornamental purposes, owing to the striking appearance of the leaves and fruits. Fruit and foliage of this strain are shown in an earlier publication (*18, pl. 5*). Another variegated strain has been found (fig. 7) which has pinkish-colored flesh (*16*).

STRIPED STRAIN

Tree very large, vigorous, spreading; trunk smooth and somewhat furrowed; bud union slightly overgrown on sour orange rootstock; branches large, many

practically thornless; leaves many, medium to small, oval, crenate, color light green; blossoms very abundant during spring, mostly perfect, large; fruits oblong, ovoid, medium size, medium rind, smooth with slight ridges where striped, color dark green striped longitudinally, rag coarse, juice abundant and of low acidity, seeds few, rate of growth of fruits medium; largest picks during fall; same tree often bears, in addition to striped fruits, those typical of the Pear-Shape strain and round ones; medium quantity of production, poor commercial quality.

An interesting bud variation, but of no commercial value.

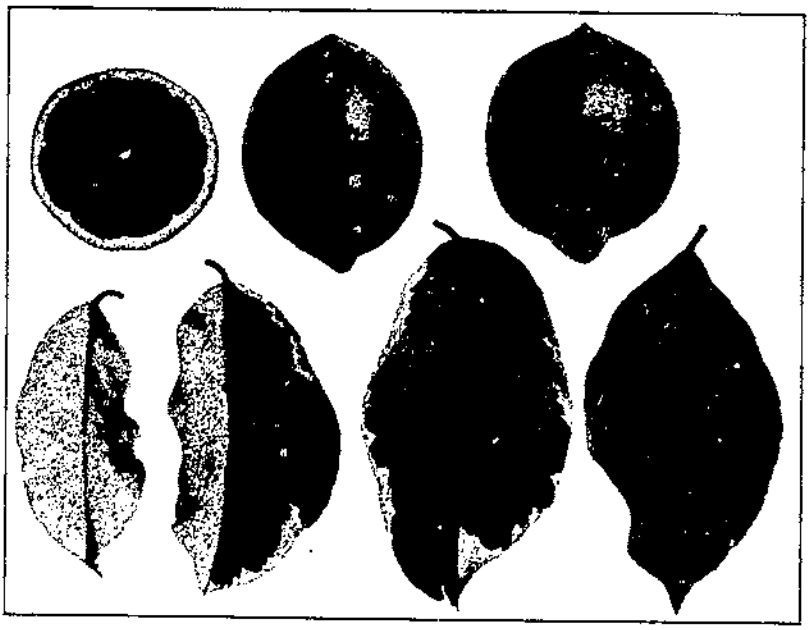


FIGURE 7.—Variegated leaves and pink-fleshed, striped fruits from a limb variant in a Eureka lemon tree. Burbank, Calif., April 1931.

CRUMPLED-LEAF STRAIN

Tree small, weak growing, open; trunk smooth; badly overgrown bud union on sour orange rootstock; branches few, medium to small, practically thornless; leaves few, medium size, broadly elliptical, rounded, crenate, crumpled (fig. 2, *C*), color green; blossoms few and mainly during spring, many small, imperfect; fruits oblong, uniform, medium size, rind thick, rough, color bright yellow when mature, rag coarse, juice fairly abundant and of medium acidity, seeds many; rate of growth of fruits rather slow; largest picks during spring and fall; low production; medium commercial quality.

The characteristics that distinguish the trees of this strain from those of other strains are the crumpled leaves and the relatively small size of the trees.

VARIATIONS OF THE LISBON VARIETY

It has been determined that the Lisbon variety was introduced into California through two separate importations of nursery trees from Australia in 1874 and 1875 (*19*). It is probable that the trees in the orchard where the Lisbon performance-record studies were begun were descended from the North-Burnham introduction, which was made in 1875 in the Riverside district.

The original study of Lisbon lemon variations was carried on in the Corona district in an orchard then owned by the Corona Lemon Co. and now owned by the Jameson Co. This orchard was planted in 1893, and the performance-record studies were made from July 1913 to June 1917, inclusive. A number of very striking entire-tree variations were observed in this orchard about a year after beginning the studies of the Eureka variety, and several limb variations were found which were apparently similar in foliage and fruit characteristics to some of the entire-tree variations. After the 4-year period of individual-tree performance-record studies in that orchard, propagations were made of selected limb and entire-tree variations, and the resulting progeny trees have furnished the material for the Lisbon lemon studies reported herein. Descriptions of the most important and of several minor strains are presented herewith.

LISBON STRAIN

Tree large, vigorous, erect and somewhat spreading, semidense; trunk somewhat ridged; bud union slightly overgrown on sour orange but smooth on sweet orange rootstock; branches dense, thorns few, small; leaves abundant, medium size, oval obtuse, slightly crenate (fig. 8, *A*), color deep to dark green; blossoms abundant, medium size, strong, perfect, occurring throughout the tree and developing large proportion of inside fruit; fruit very uniform, with very small percentage of off-types, oblong to oval, medium size, rind thin, smooth, deep- to light-green color, rag tender, juice abundant with strong acidity, seeds few; fruits rapid growing; production high, with heaviest crops during spring; commercial quality excellent.

The vigor of growth and density of the foliage, large proportion of inside protected fruit, and high yields of uniformly good fruit distinguish most clearly the Lisbon from the other strains of this variety. Typical fruits of this strain are shown in figure 9.

DENSE STRAIN

Tree very large, very vigorous, spreading, dense; trunk ridged; bud union overgrown; branches dense, somewhat resistant to wind and other stresses, thorns many, large; leaves abundant, very large, oval, acutely pointed, crenate (fig. 8, *B*), color light to deep green; blossoms abundant, large, strong, perfect, located throughout tree; fruits oblong, necked, large, rind very thick, rag abundant and tough, juice scant, lacking in acidity and flavor, seeds few; rate of fruit growth very rapid, uniformity poor, many offtype fruits and frequent limb variations; quantity of yield high, with heaviest production during spring; commercial quality poor.

The very large size of tree, thorniness, dense growth, extreme variability of fruits, and their large size and necked shape serve to distinguish the Dense strain trees from those of other strains of the Lisbon variety. Typical fruits of this strain are shown in figure 10.

OPEN STRAIN

Tree medium size, medium vigor, spreading, open; trunk usually smooth but occasionally slightly ridged; bud union slightly overgrown on sour orange but smooth on sweet orange rootstock; foliage and fruit susceptible to damage from sunburn; branches few, giving the trees an open appearance, thorns very few and very small; leaves few, medium size, ovate, obtuse, slightly crenate (fig. 8, *C*), light- to deep-green color; blossoms medium to abundant, rather small, fairly strong, usually perfect, occur nearer to tips of branches than in the Lisbon strain; fruits uniform, oval to oblong, medium size, rind thin, smooth, light green, rag tender, juice abundant with strong acidity, seeds few; rate of fruit growth slow; medium quantity of production; commercial quality excellent most of the year, but on account of slow fruit growth a larger proportion of the crop is held on the trees until summer than in the Lisbon strain, with a consequent production of a relatively high proportion of tree-ripe, weak fruits during that season; heaviest production in spring.

The open habit of tree growth and tendency to bear fruits throughout the entire year distinguish this from other Lisbon strains. Typical fruits of this strain are shown in figure 11.

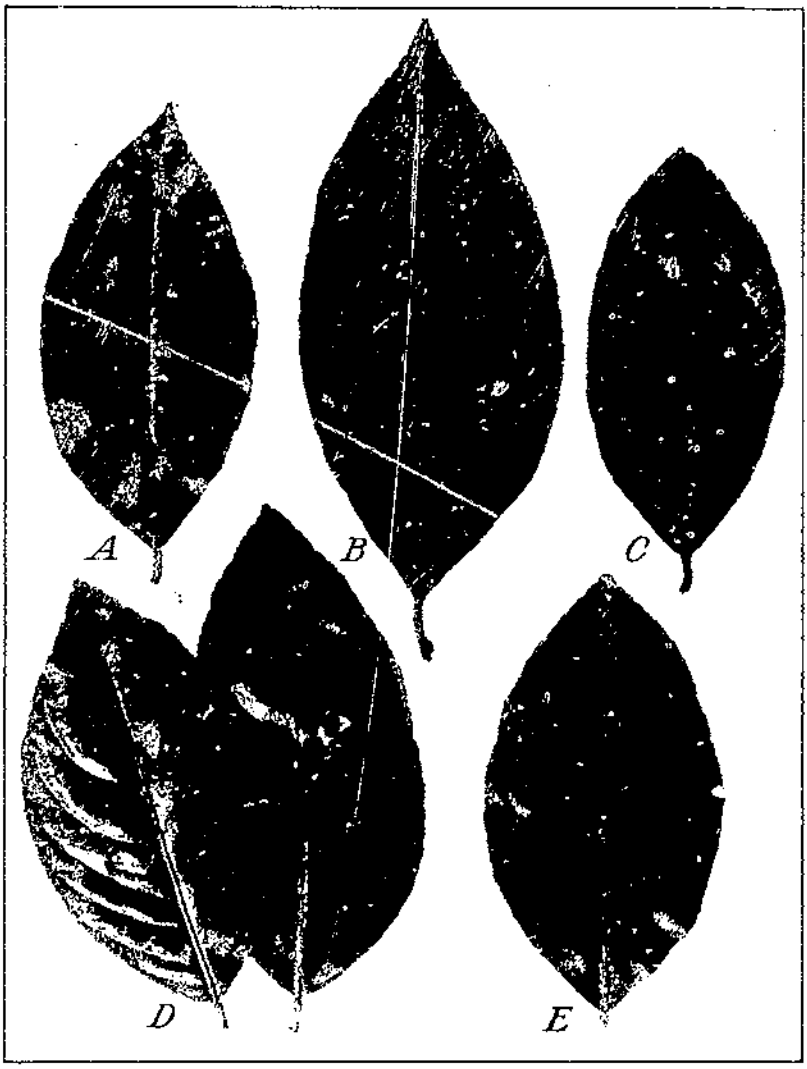


FIGURE 8.—Leaves of important strains of the Lisbon lemon from progeny trees propagated from typical trees of the same strains in the original Lisbon performance record plot: *A*, Lisbon; *B*, Dense; *C*, Open; *D*, Corrugated; *E*, Unproductive. Corona, Calif., May 1933.

UNPRODUCTIVE STRAIN

Tree very large, very vigorous but inherently of very weak growth, spreading, very dense with many suckers and upright vegetative branches; trunk ridged; bud union somewhat overgrown on sour orange but even on sweet orange rootstocks; branches very dense, very susceptible to damage from wind, climatic hazards, and other stresses, thorns many, long, sharply pointed; leaves very abundant, large oval with acutely pointed tips, crenate, somewhat crumpled (fig. 8, *E*), deep-green color; blossoms few, mostly at tips of branches, some small, weak, with female parts abnormal; fruits uniform, very poor, oblong,

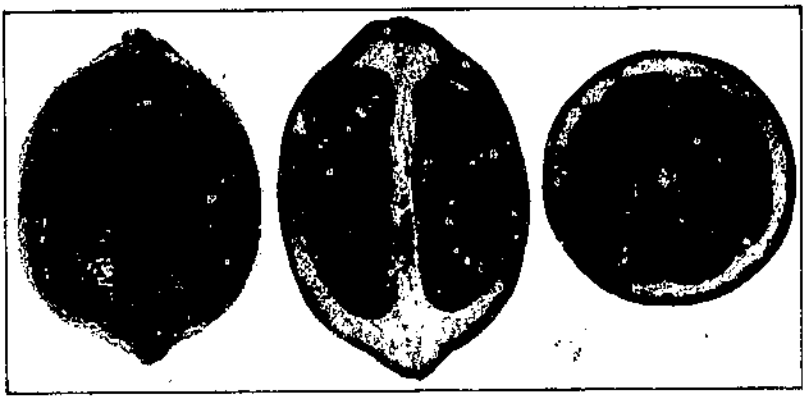


FIGURE 9.—Fruits of the Lisbon strain of the Lisbon lemon from a progeny tree propagated from a typical tree of this strain in the original Lisbon performance-record plot. Corona, Calif., May 1933.

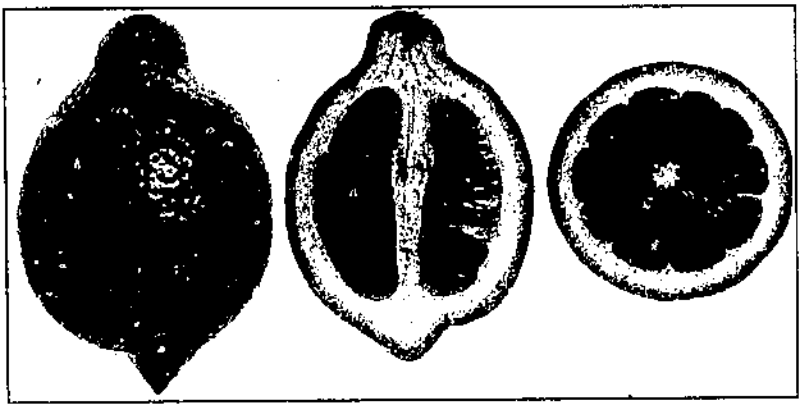


FIGURE 10.—Fruits of the Dense strain of the Lisbon lemon from a progeny tree propagated from a typical tree of this strain in the original Lisbon performance-record plot. Corona, Calif., April 1933.

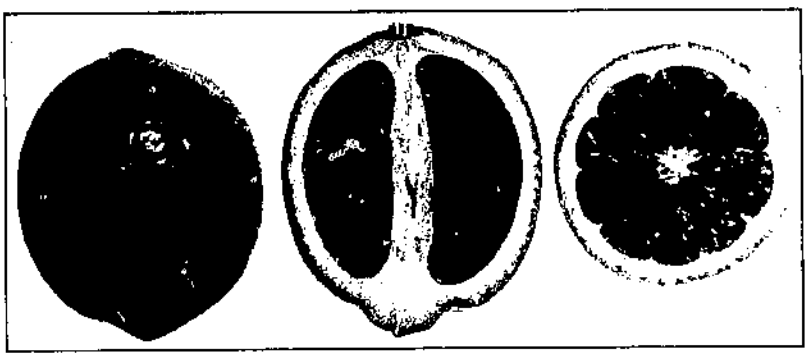


FIGURE 11.—Fruits of the Open strain of the Lisbon lemon from a progeny tree propagated from a typical tree of this strain in the original Lisbon performance-record plot. Corona, Calif., April 1933.

flattened at blossom end, with very short to very long necks, medium to large, rind thick, coarse, rough, ridged, color dark green, rag abundant, tough, juice scant with low acidity, seeds very few; rate of fruit growth very slow; quantity of production very low, largest proportion produced during winter; commercial quality of fruit very poor.

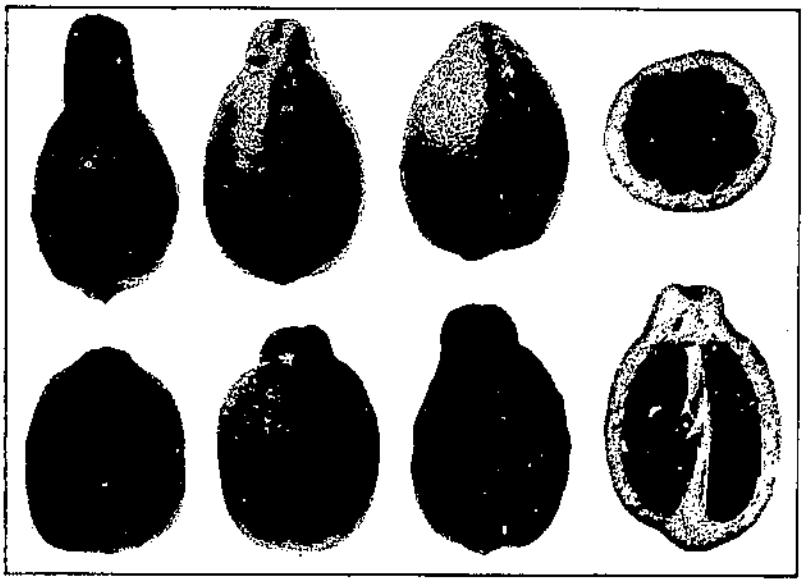


FIGURE 12.—Fruits of the Unproductive strain of the Lisbon lemon from a progeny tree propagated from a typical tree of this strain in the original Lisbon performance-record plot. Corona, Calif., May 1933.

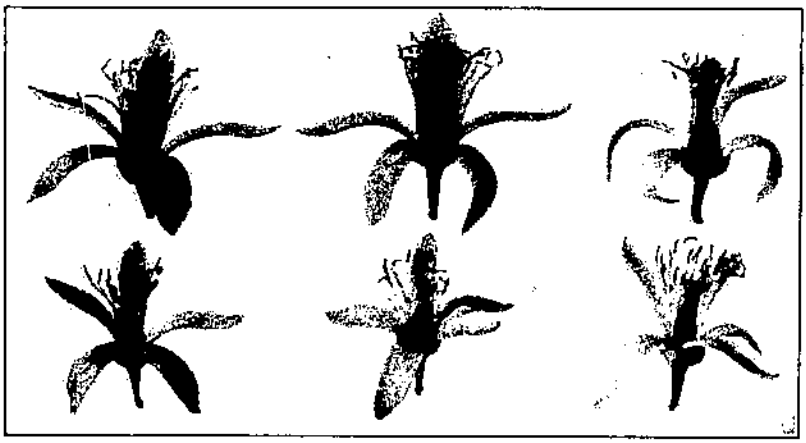


FIGURE 13.—Flowers of the Unproductive strain of the Lisbon lemon from a progeny tree, showing in the lower row examples of the smaller type with abnormal style and ovary. Corona, Calif., May 1933.

The outstanding characteristics of the trees of the Unproductive strain include vigorous but very weak vegetative growth, dense appearance, extreme thorniness, and very low production of fruit of very inferior commercial quality. The weak character of the wood makes it difficult to top-work these trees, and replanting has been found the most satisfactory method to replace them. Typical fruits of this strain are shown in figure 12, and illustrations of the variable flower forms are presented in figure 13.

RIBBED STRAIN

Tree medium size, medium vigor of growth, spreading, medium dense; trunk smooth; bud union only very slightly overgrown on sour orange rootstock; branches semidense, thorns many, large; leaves abundant, medium size, oval, acutely pointed, crenate, deep-green color; blossoms few, medium size, weak, perfect, located throughout trees; fruits obovoid, collared, small, rind thick, coarse, more or less strongly ribbed, light-green color, rag abundant, tough, juice scant, lacking in acidity, very poor flavor, seeds few; rate of fruit growth slow, slight tendency for production of normal appearing fruits; quantity of yield low with heaviest production during winter; commercial quality poor.

The strongly ribbed fruits distinguish this strain most clearly from other Lisbon strains.

CORRUGATED STRAIN

Tree medium to small, weak growth, drooping, medium open; trunk ridged; bud union overgrown on sour orange rootstock; branches semidense, thorns many, small; leaves medium number and size, oval with acute to obtuse tips, crenate, mostly crumpled (fig. 8, *D*), light-green color; blossoms few, large, strong, mostly perfect, located throughout trees; fruit oblong, medium size, rind thick, deeply corrugated, some fruits normal in appearance, light-green color, rag abundant and coarse, juice scant, lacking in acidity, insipid, seeds few; rate of fruit growth slow; quantity of yield very low, heaviest production during fall and early winter; commercial quality very poor, worthless.

The most striking characteristic of this strain is the deeply corrugated fruits, as shown in figure 14.

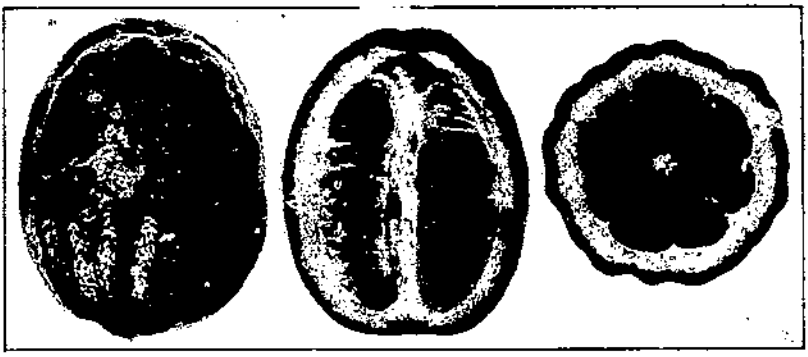


FIGURE 14.—Corrugated fruits from a progeny tree propagated from a similar limb variation in a tree of the Dense strain of the Lisbon lemon in the original Lisbon performance-record plot. Corona, Calif., May 1933.

COLLARED STRAIN

Tree medium to small, medium vigor of growth, drooping, dense; trunk smooth; bud union overgrown on sour orange rootstock; branches dense, thorns few, small; leaves abundant, medium size, oval, acute, crenate, deep-green color; blossoms medium number and size, strong, perfect, located throughout tree, fruits long, oblong and with large collarlike projection at stem end; some fruits normal in appearance, medium size; rind thick, coarse, color light green, rag abundant and very tough, juice scant, lacking in acidity, poor flavor, seeds few; rate of fruit growth very rapid, uniform; quantity of yield low with heaviest production during winter; commercial quality very poor.

The most striking characteristic that distinguishes the Collared from other strains of the Lisbon variety is the large proportion of long, collared fruits as shown in figure 15.

STRIPED STRAIN

Tree large, vigorous, spreading, semidense; trunk ridged; bud union overgrown on sour orange rootstock; branches semidense, thorns few, small; leaves abundant, medium size, mostly lanceolate, acuminate, crenate, light-green color; blossoms

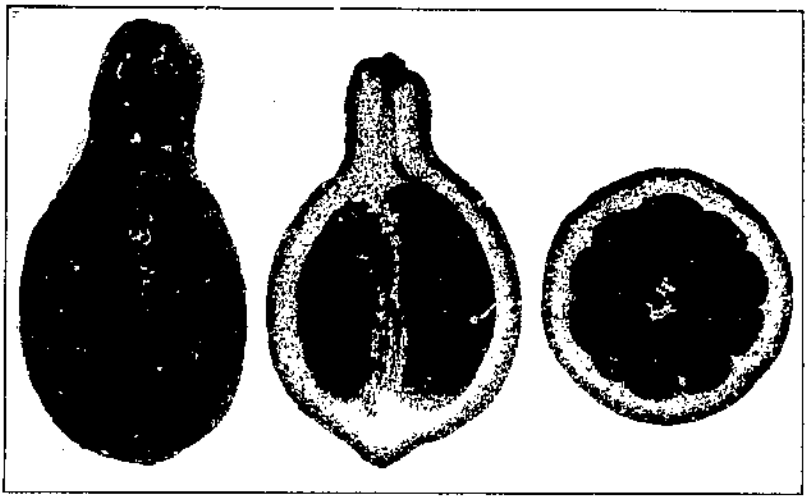


FIGURE 15.—Fruits of the Collared strain of the Lisbon lemon from a progeny tree propagated from a limb variation of this strain in the original Lisbon performance-record plot. Corona, Calif., April 1933.

few, large, weak, perfect, located mostly near tips of branches; fruits oval, medium size, rind sometimes ribbed or corrugated, striped alternate yellow and green with some specimens normal in character, rag abundant, coarse, juice abundant with high acidity, seeds medium number; rate of fruit growth medium, quantity of yield low with heaviest production during winter; commercial quality poor.

The striped fruits with alternate longitudinal yellow and green stripes are the most striking characteristics of this strain, as shown in figure 16.

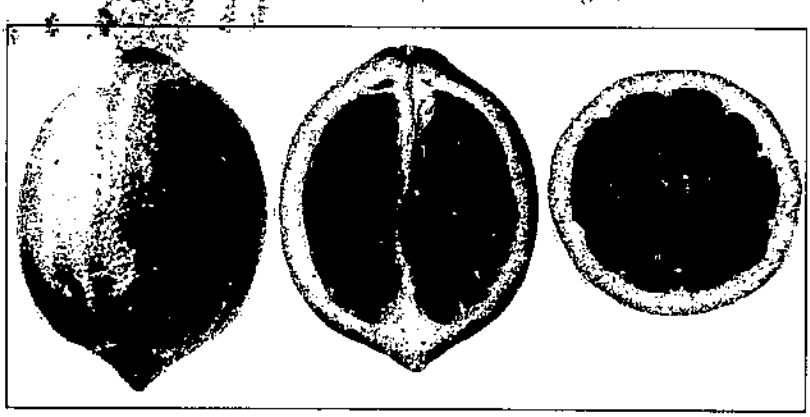


FIGURE 16.—Fruits of the Striped strain of the Lisbon lemon from a progeny tree propagated from a limb variation of this strain in the original Lisbon performance-record plot. Corona, Calif., May 1933.

THORNLESS UNPRODUCTIVE STRAIN

Tree large, vigorous, spreading and drooping, dense, susceptible to injury from wind and other stresses; trunk ridged; bud union overgrown on sour orange rootstock; branches dense, no thorns; leaves abundant, medium size, oval, acute to obtuse, deep-green color; blossoms few, small, many imperfect lacking pollen, located near tips of branches; fruits oblong, with blunt blossom ends, medium to small size, smooth, light-green color, rag medium amount, juice abundant with strong acidity, seeds none or very few; rate of fruit growth slow; very uniform

fruits, very few offtype; quantity of production low with heaviest crops during winter; commercial quality of fruit poor.

The outstanding characteristics of the trees of this strain are their thornless branches and weak and easily injured growth.

The Thornless Unproductive strain originated as a bud variation in an Unproductive strain tree that had many large, sharp thorns. It is of particular interest because it is the only one of the Lisbon strains under investigation in which the trees do not have thorns and that indicates the manner in which thornless vegetative strains arise.

OTHER STRIKING VARIATIONS

Variegated-branch variations of Lisbon trees have been observed that are quite similar in appearance to the variegated variations of the Eureka variety, but owing to limited planting space no attempt has been made to propagate them. There is every reason to believe that this variation of the Lisbon trees can be perpetuated through budding, as has been the case with the variegated Eureka variations.

Individual lemons having well-developed navels have been found from time to time in trees of both the Eureka and Lisbon varieties. However, no limb or entire tree bearing a number of navel lemons has been discovered in these investigations. The navel lemons studied do not differ materially from the normal fruits from the same parent tree except in the presence of the navels.

Lemons with longitudinal sections strikingly different from the normal in color, texture, and thickness of the rind, commonly called sectional chimeras, have been found rather frequently, but by reason of limited opportunities for studying such phenomena little attention has been given them. Some trees seem to produce more of such variations than others, and usually these trees are of the less desirable commercial strains.

One of the interesting vegetative variations in the Lisbon lemon is that of the number and size of thorns produced by the trees. The trees of some strains have many large, sharply pointed thorns which are dangerous to the fruits through scratches and punctures which result in blemishes and oftentimes lead to decay and loss of fruits on the trees or during storage and marketing. Such thorns are also a hazard to fruit pickers. The trees of other strains have usually but a few small thorns. In an instance previously mentioned a Lisbon tree of the Unproductive strain developed a thornless limb variation, in which the thorns are entirely absent. This occurrence of a thornless variation indicates the possibility of developing a desirable thornless strain in which the trees have very few and very small thorns.

Many other fruit and foliage variations have been observed in the parent and progeny lemon trees in these investigations, but on account of their minor commercial importance but little systematic study has been given them. It is probable that some of these variations may be of considerable interest in the investigation of the phenomenon of bud variation, and it is the intention to study them from this point of view when the opportunity is favorable.

PROGENY TESTS OF LEMON BUD VARIATIONS

In order to determine whether or not the characteristics of the limb and entire-tree variations discovered in the course of these investigations are perpetuated through budding, buds were obtained from

many of the variations in May 1916 and propagated at Riverside, Calif., in cooperation with and on the grounds of the Citrus Experiment Station of the University of California. Sour orange rootstock was used for these propagations, as it was the one commonly used in commercial operations at that time.

The resulting progeny nursery trees were transplanted in May 1918, one set of 471 being planted in the Citrus Experiment Station orchard at Riverside and another set of 1,146 on an 11-acre tract in the commercial orchard of the Jameson Co. in the Corona district. Charts of these two plantings are presented in figures 17 and 18.

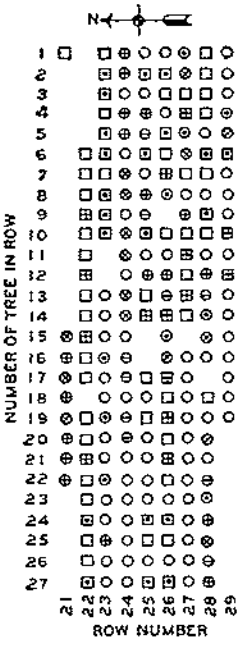


FIGURE 17.—Chart of the progeny lemon plot at Riverside, Calif., with trees of various strains indicated by symbols as follows: ○, Eureka strain, 72 trees; ⊙, Small-Open Eureka, 10 trees; ⊖, Pear-Shape Eureka, 10 trees; ⊕, Shade-Tree Eureka, 18 trees; ⊗, Unproductive Eureka, 16 trees; □, Lisbon strain, 42 trees; ⊡, Open Lisbon, 21 trees; ⊞, Unproductive Lisbon, 15 trees. The trees in the unmarked spaces were excluded from the general tabulated records for various reasons.

The two sets of progeny trees in different locations made possible the study of the performance of the progeny trees under somewhat different environmental conditions. The parent-limb and entire-tree variations were located in orchards in the Corona district, so it has been practicable to study the performance of the progeny trees in the same locality as that in which their parents were grown and under similar cultural conditions.

In the Citrus Experiment Station orchard the progeny trees were planted in rows spaced 20 feet apart and the trees in the rows were spaced 10 feet apart. The close planting in the rows provided for the planting of double the number of progeny trees otherwise possible and was done with the purpose of removing every alternate tree in the rows when the trees reached sufficient size to interfere with normal growth and fruiting. The taking out of the filler trees in this orchard was found necessary in 1923, at which time every alternate tree was removed. The arrangement in planting was such that the tree removals reduced by practically one-half the number of trees in each progeny test but did not reduce the number of progeny tests.

In the Jameson orchard at Corona the progeny trees were planted with the usual spacing for lemon trees in this orchard, the rows being spaced 22 feet apart with the trees 20 feet apart in the rows. In this larger planting a greater number of propagations of apparently commercially valuable variations were planted than could be included in the Citrus Experiment Station planting.

In both plots the progeny trees were planted on land where only unirrigated winter grain crops had been grown previously. The soils in both locations were typical of the districts in which the plantings were made. Very little fertilizer has been applied to the soil in either orchard, although it is believed that somewhat larger applications would have been beneficial through increasing the amount of fruit produced. The usual irrigation practices in these districts have been followed. The trees were protected from frost at critical periods by orchard heaters, but some loss of crop was experi-

enced through damage to the blossoms and small immature fruits by low temperatures. Fumigation was used in both orchards for the control of scale. The development of the trees in both locations has been about equal to that of the commercial orchards in these districts.

The lemon progeny trees in both locations were used for two purposes: (1) a study of the heritability of the variations propagated from the parent-limb and entire-tree variations, and (2) the demonstration of the importance of the systematic selection of budwood in commercial nursery practice. These plantings have been visited

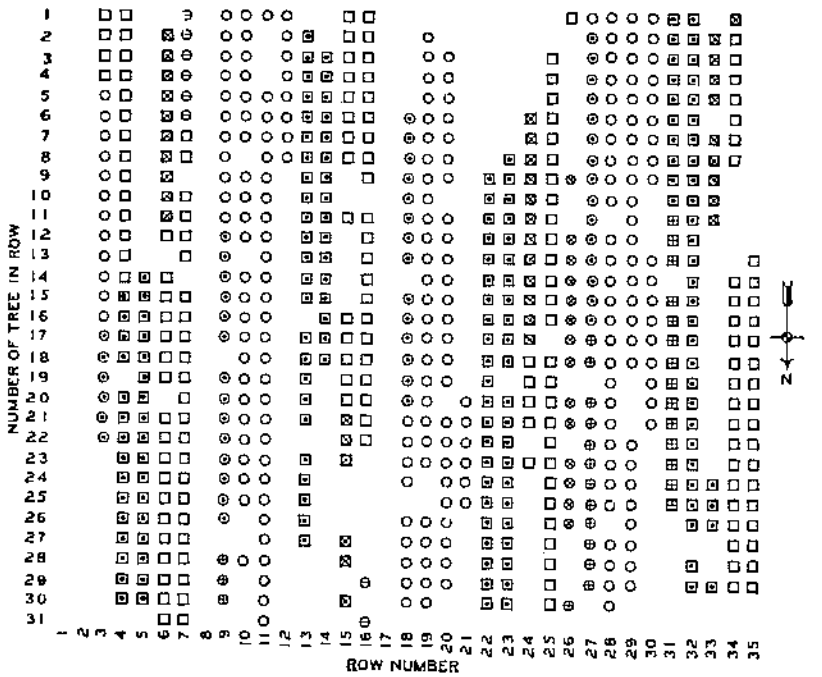


FIGURE 18.—Chart of the progeny lemon plot at Corona, Calif., with trees of various strains indicated by symbols as follows: ○, Eureka strain, 223 trees; ⊖, Small-Open Eureka, 49 trees; ⊜, Pear-Shape Eureka, 8 trees; ⊙, Shade-Tree Eureka, 16 trees; ⊗, Unproductive Eureka, 14 trees; □, Lisbon strain, 166 trees; ⊠, Dense Lisbon, 38 trees; ⊡, Open Lisbon, 158 trees; ⊟, Unproductive Lisbon, 14 trees. The trees in the unmarked spaces were excluded from the general tabulated records for various reasons.

by many citrus growers each year since they were planted and have furnished an important demonstration of the value of bud selection in the propagation of lemon trees and the economic production of the lemon crop.

PROGENY PERFORMANCE RECORDS

The performance-record data of progeny lemon trees reported in this bulletin include the continuous picking records of these trees for a period of years together with studies of the commercial quality of the fruit. These data are the basis from which conclusions have been drawn as to comparative strain and individual tree behavior. In addition, continuous observation of the trees and close contact with them during the performance-record period have led to an intimate knowledge of the fruit and foliage characteristics of the trees, which is important from the standpoint of these studies.

The progeny performance records were obtained by counting or weighing the fruits borne by each tree as they were picked. Where the actual weights were not obtained the fruits were counted as they were picked and their weight was determined from the average weight of typical samples of fruit of the same sizes.

The number of trees in each progeny was limited by lack of orchard space, but in the opinion of the writers enough trees were available for study so that reliable conclusions can be drawn from their records.

In commercial lemon handling the most desirable fruits are those that remain green in color until they have reached a certain determined picking size. Pickings are normally made 10 to 12 times a year, and the minimum size for green fruit at each picking is determined by seasonal and market conditions. Fruits that ripen on the trees are less desirable for commercial marketing than the green fruits, and they are usually picked when or shortly before they are fully mature, depending upon climatic and market conditions.

In the progeny plot in the Jameson orchard a uniform monthly picking size of $2\frac{8}{32}$ inches was used previous to October 1926. Since that date the same size has been used each time as was being used for the commercial picking on that ranch. In the progeny plot in the Citrus Experiment Station orchard the picking size was maintained at $2\frac{8}{32}$ inches throughout the performance-record period except for 2 months when certain conditions made it desirable to change this standard slightly.

In the progeny plots it was planned to make pickings at monthly intervals, as had been attempted in securing the data in the parent plots, and this practice was carried out except when rains or irrigations caused delays or omissions. In the plot in the Jameson orchard only five monthly picks were missed after the trees came into regular bearing, and only one was omitted in the Citrus Experiment Station plot. This practice of frequent picking resulted in the accumulation of a great amount of data from the studies of the progeny trees.

The performance records of all of the sets of progenies of the most important variations observed in the course of these investigations are summarized herein, and the entire data are available for study. Furthermore, the progeny plantings, the methods of obtaining performance records, and the living parent trees as well are open to observation and study by those interested in this subject.

PROGENY DATA ON EUREKA STRAINS

The average annual production and average total production per tree of the progeny trees of the five strains that were formerly most commonly present in commercial Eureka orchards are shown in table 1. These data cover the period from the first production of the young trees in the fall or winter of 1920–21 to December 1932, inclusive. It will be noted that the production rank of the various strains is the same in both progeny plots as it was in the parent plot for the earlier 6-year period, July 1911 to June 1917.

TABLE 1.—*Production of progeny trees of important strains of the Eureka lemon propagated in May 1916 from selected parent trees and planted in May 1918*

(The data show the average crop per tree for each year after they began bearing and for the total period 1921 to 1932, inclusive)

Strain	Plot	Trees	Production of lemons by progeny trees in years shown: 1921	1922	1923	1924	1925
		Number	Pounds	Pounds	Pounds	Pounds	Pounds
Eureka	Riverside	72	23.0±0.80	7.3±0.40	80.5±1.99	78.2±1.89	79.7±1.68
	Corona	223	10.1± .32	5.1± .16	39.6± .67	128.7±1.92	62.1±1.16
Small-Open	Riverside	10	21.2±1.73	5.4±1.02	70.6±1.59	61.2±3.85	78.0±3.31
	Corona	49	9.7± .53	5.1± .29	39.9±1.21	125.5±3.38	55.5±1.89
Pear-Shape	Riverside	10	6.7± .77	2.0± .25	31.4±2.77	69.5±3.28	42.3±3.34
	Corona	8	8.1± .94	3.0± .46	40.3±5.32	133.4±9.27	43.5±6.13
Shade-Tree	Riverside	18	7.9± .90	2.2± .25	51.1±3.56	45.0±2.00	67.6±3.78
	Corona	10	5.4± .50	1.2± .12	24.2±1.60	66.1±3.50	31.1±1.71
Unproductive	Riverside	16	8.0± .91	3.1± .48	48.0±4.68	40.0±2.10	64.6±4.01
	Corona	14	2.1± .38	1.5± .24	22.6±1.14	57.4±3.96	47.1±4.66

Strain	Plot	Production of lemons by progeny trees in years shown: 1926	1927	1928	1929	1930
		Pounds	Pounds	Pounds	Pounds	Pounds
Eureka	Riverside	236.0± 3.83	201.9± 3.15	148.9±2.79	245.4± 4.56	226.5±4.35
	Corona	170.1± 2.15	176.0± 1.90	86.0±1.32	161.2± 2.15	105.2±2.11
Small-Open	Riverside	179.4± 7.15	148.7± 8.54	110.4±6.55	195.0±13.66	175.9±8.56
	Corona	159.9± 4.10	163.7± 3.92	89.9±2.01	161.2± 4.37	120.9±3.51
Pear-Shape	Riverside	163.5± 6.46	94.0± 5.76	83.4±6.57	165.7±13.19	87.1±4.45
	Corona	141.1±13.80	127.4±14.30	45.9±4.63	166.5±17.32	68.9±6.63
Shade-Tree	Riverside	117.8± 4.43	74.1± 6.89	85.6±9.00	75.4± 4.74	89.7±5.71
	Corona	129.7± 5.51	115.1± 5.56	53.6±3.11	80.6± 7.35	77.4±5.04
Unproductive	Riverside	106.3± 4.61	66.8± 4.22	70.1±6.05	69.3± 5.60	81.4±4.69
	Corona	128.9± 6.08	90.1± 3.45	55.6±3.41	83.3± 7.25	82.6±5.25

Strain	Plot	Production of lemons by progeny trees in years shown: 1931	1932	Total, 1921-32	Rank in yield	Parent trees, Corona, Calif., July 1911 to June 1917: Number	Rank in yield
		Pounds	Pounds	Pounds			
Eureka	Riverside	251.9± 5.11	106.0±3.23	1,688.6±20.85	1	76	1
	Corona	190.1± 1.91	101.7±1.49	1,241.8±12.16			
Small-Open	Riverside	181.1± 7.76	68.0±6.47	1,265.1±47.10	2	10	2
	Corona	180.8± 5.38	107.7±2.76	1,229.9±26.29			
Pear-Shape	Riverside	169.2±12.44	55.0±4.67	909.4±40.11	3	2	3
	Corona	167.0±11.28	77.9±9.81	1,023.5±96.21			
Shade-Tree	Riverside	68.8± 9.20	36.3±2.71	723.5±32.52	4	17	4
	Corona	106.2± 4.52	52.6±4.45	743.5±29.65			
Unproductive	Riverside	50.1± 3.42	40.6±3.26	649.1±26.98	5	10	5
	Corona	106.1± 4.47	49.2±2.70	726.5±27.04			

Although lemons are grown at Riverside to only a limited extent it will be seen from this table that larger yields are recorded from the trees of the Eureka and Small-Open strains in the plot at Riverside than from those in the Corona plot. This is owing partly to the fact that in the Riverside plot the fruit that dropped from the trees between picking periods was recorded as a part of the tree yields during the entire record period, as had been done in the parent record plot, whereas in the Corona plot it was found impracticable to record the dropped fruit after the trees came into full production, because of the amount of additional work required in obtaining that data from the large number of trees. In general the type of fruit produced by the parent trees has been perpetuated very closely in the progeny

trees. Figure 19 shows fruits from a parent tree of the Pear-Shape strain and similar fruits from a progeny tree propagated from this same parent tree.

Table 2 shows data from the progeny plots for the percentages of

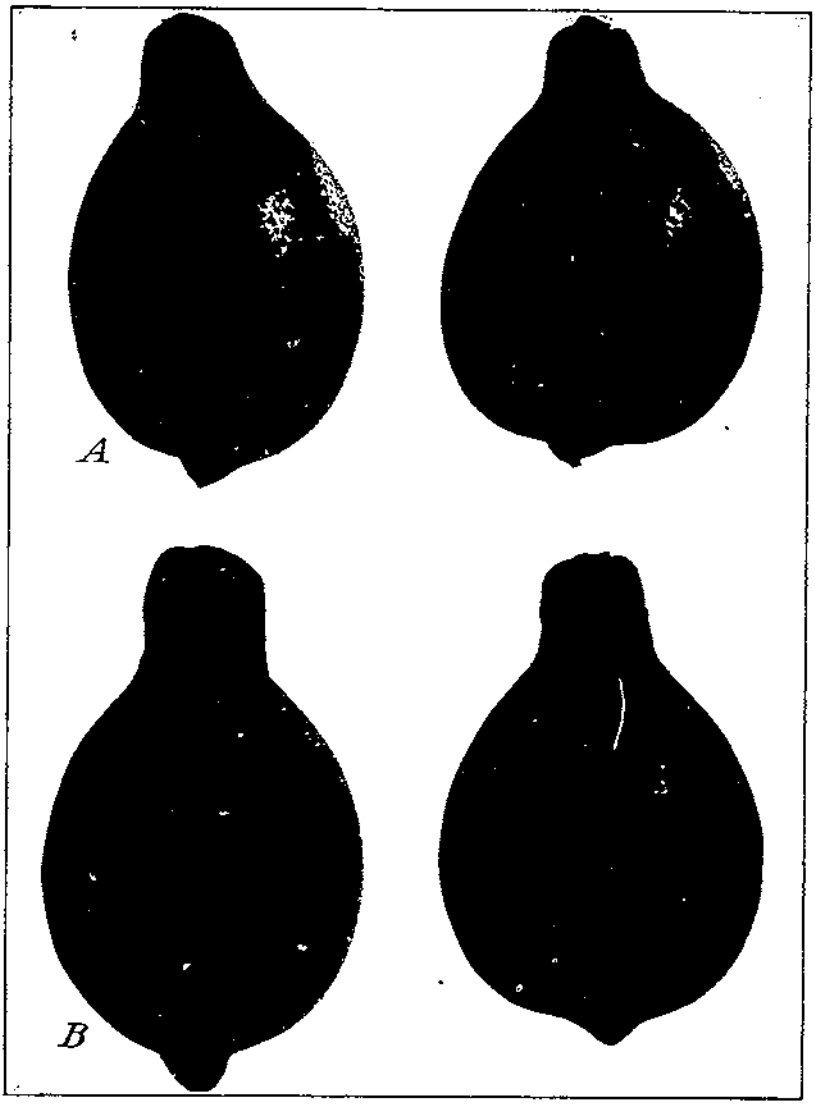


FIGURE 19.—Fruits of the Pear-Shape strain of the Eureka lemon from a typical tree of this strain in the original Eureka performance-record plot (*A*), and similar fruits from a progeny tree (*B*) propagated in 1916 from the tree that produced the fruits at *A*, showing perpetuation of the pear shape. Corona, Calif., April 1927.

green fruits (the most desirable part of the crop), the percentages of variable fruit, and the average number of seeds per fruit, for the most important Eureka strains, with similar data for the parent trees during the earlier periods in which they were studied. In all these characteristics the progeny trees and parent trees show very close agree-

ment except for the percentage of green fruit in the Riverside plot. All the strains showed a smaller proportion of green fruit at Riverside than at Corona, doubtless owing to climatic conditions which matured the fruit more rapidly, resulting in a lessened percentage of green fruit.

TABLE 2.—*Average percentages of green fruit and variable fruits, and number of seeds per fruit, in the crops of the progeny and parent trees of important strains of the Eureka lemon*

Strain	Green grade fruit			Variable fruits			Seeds per fruit	
	Progeny trees, 12 years, 1921–32		Parent trees, 6 years, July 1911 to June 1917, Corona	Progeny trees, 12 years, 1921–32		Parent trees, 3 years, July 1914 to June 1917, Corona	Progeny trees, 1 year, September 1932 to August 1933, Corona	Parent trees, 5 years, July 1911 to June 1916, Corona
	Riverside	Corona		Riverside	Corona			
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Number*	*Number*
Eureka	85.1	73.2	71.7	0.2	0.2	1.0	6.8	7.1
Small-Open	63.6	75.6	74.2	.8	.4	1.3	5.7	6.0
Pear-Shape	55.1	63.8	62.4	100.0	100.0	100.0	1.2	2.3
Shade-Tree	82.2	86.5	86.7	.8	.7	2.3	1.8	1.8
Unproductive	77.9	91.3	83.1	1.1	1.9	2.1	1.0	2.3

The seasonal yields of total crops are shown in table 3, in which the monthly percentage of fruit produced by the trees of each of the more important Eureka strains is tabulated. In general, the progeny trees in the Corona plot follow fairly closely the data from the parent trees during the earlier period. Variations in climatic conditions in the different years would have a considerable effect in changing seasonal production, so that no very exact similarity is to be expected in these monthly records over different periods. In the progeny plot at Riverside the variations from the parent-plot records are more marked, this condition doubtless being due to the greater climatic variations between the two districts. A graphic representation of the monthly percentage of production for the Eureka strain as shown in table 3 is presented in figure 20. This emphasizes the heavy proportions of fruit produced on the Riverside plot in the fall and winter months, which are usually

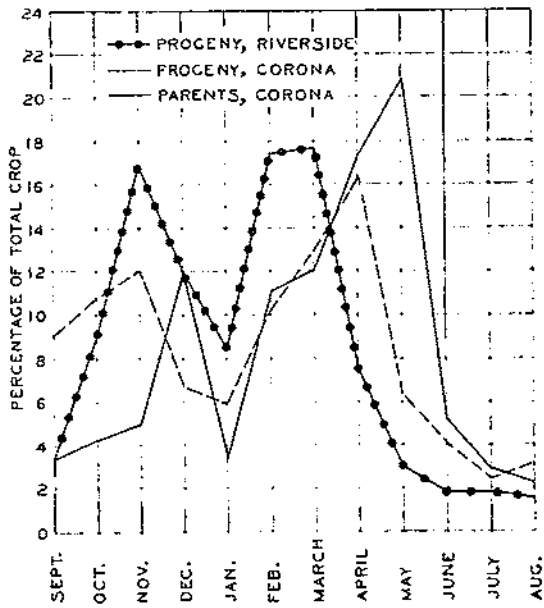


FIGURE 20. Percentages of the annual crops produced each month by trees of the Eureka strain of the Eureka lemon in the progeny and parent record plots. These data are taken from table 4 and cover the 12 years 1921 to 1932, inclusive, for the progeny trees and the 3 years from July 1914 to June 1917, inclusive, for the parent trees.

the seasons of least consumer demand and lowest market prices. This winter-bearing habit is an important reason why the Riverside district in general is not particularly favorable for lemon growing.

TABLE 3.—*Percentages of total annual production by months from trees of important strains of the Eureka lemon in progeny and parent record plots*

[The data for the progeny trees are for the years 1921 to 1932, inclusive; those for the parent trees cover the 3 years from July 1914 to June 1917, inclusive]

Strain	Plot	Trees	Percentage of annual production in—												
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	May–Sept.
		Number	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Eureka	Progeny, Riverside	72	8.4	17.1	17.7	7.4	2.9	1.8	1.8	1.5	3.4	8.9	16.8	12.0	11.4
	Progeny, Corona	223	5.9	10.3	13.0	10.3	6.4	4.1	2.4	3.1	9.1	10.7	12.0	6.7	25.1
	Parent, Corona	70	3.4	11.2	12.2	17.4	20.7	5.2	2.8	2.2	3.4	4.3	5.0	12.1	34.3
Small-Open	Progeny, Riverside	10	8.2	16.2	17.2	6.5	2.2	2.1	2.3	2.5	4.6	9.9	16.5	10.7	14.7
	Progeny, Corona	49	5.2	9.0	12.0	14.6	7.1	4.5	3.2	3.4	10.0	11.3	12.2	7.6	28.2
	Parent, Corona	10	3.5	11.3	12.6	15.7	19.7	5.7	3.6	2.5	3.6	4.2	6.0	11.7	35.1
Pear-Shape	Progeny, Riverside	10	10.4	22.1	19.0	5.0	2.0	.8	.6	.9	2.2	11.0	16.4	0.0	6.5
	Progeny, Corona	8	6.9	7.0	7.5	13.4	7.9	3.7	3.5	2.1	9.2	12.2	16.1	10.5	26.4
	Parent, Corona	2	3.8	6.4	4.8	5.9	10.7	6.2	2.9	4.6	8.1	7.8	11.4	27.2	32.5
Shade-Tree	Progeny, Riverside	18	7.5	12.5	9.5	4.4	3.5	4.1	6.6	5.5	7.5	12.4	17.4	0.0	27.2
	Progeny, Corona	10	5.9	7.1	8.4	9.2	5.8	6.9	7.0	5.5	12.2	11.2	13.8	7.0	37.4
	Parent, Corona	17	3.9	7.6	9.8	8.9	9.8	3.5	4.4	7.3	8.9	12.2	13.8	12.9	33.9
Unproductive	Progeny, Riverside	16	6.8	10.6	9.4	4.4	3.7	4.2	5.6	5.3	8.5	15.2	17.8	8.6	27.2
	Progeny, Corona	14	6.6	8.1	7.7	7.9	5.4	5.2	7.3	7.6	12.3	12.4	11.4	7.2	35.8
	Parent, Corona	10	3.8	7.7	6.6	9.2	14.2	5.7	4.6	7.1	9.1	9.4	11.2	11.4	40.7

The average circumferences of the trunks of the progeny trees of important Eureka strains in the Corona progeny plot at two periods 2 years apart are shown in table 4. These data show the Pear-Shape trees to be considerably larger than those of any other strain and indicate a lack of correlation of size of tree trunks and crop production for this strain. However, other studies have shown that within the separate strains there are rather high correlations for these characters.

TABLE 4.—*Average circumference, about 4 inches above bud union, of trunks of progeny trees of important strains of the Eureka lemon in the experimental plot in the Jameson orchard at Corona, Calif.*

Strain	Trees	Average circumference		Rank by size	Average increase, 2 years
		May 1931	June 1933		
	Number	*Cm*	*Cm*		*Cm*
Eureka	223	46.2	50.0	3	3.8
Small-Open	49	46.2	50.6	2	4.4
Pear-Shape	8	56.2	60.9	1	4.7
Shade-Tree	16	44.6	47.8	4	3.2
Unproductive	14	44.0	47.4	5	3.4

Records of the annual production of progeny trees propagated from several similar limb variations found in Eureka trees are given in table 5. All of these are forms that are of rather infrequent occurrence and of minor commercial importance, though they are of great scientific interest. Some of them are shown to have been unstable in their inheritance in varying degrees, while the Variegated strain as here studied was very stable. In the Crumpled-Leaf strain the fruits are normal in appearance, but the abnormal leaf character was very evident in the progeny trees.

TABLE 5.—*Records of annual production of progeny trees propagated in May 1916 from several limb variations of minor strains in trees of the Eureka strain of the Eureka lemon*

Progeny tree no.	Source of buds		Fruits produced by progeny trees													
	Parent tree no.	Limb or tree	Character	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	Total
				Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
21–51	238	Limb variation in tree of Eureka strain	Variegated	0	0	0	0	17	5	(1)							
21–52	238	do	do	0	22	2	16	57	20	554	494	456	470	192	462	143	2,888
21–53	239	Tree previously top-worked from above limb	do	4	7	2	3	15	8	(1)							
21–54	239	do	do	4	26	8	33	86	53	495	508	255	310	122	533	75	2,508
22–1	240	Striped limb variation	Striped	30	8	1	122	61	43	181	90	145	124	267	115	56	1,243
			Normal	12	22	9	291	233	286	920	796	771	1,042	1,067	1,034	495	6,978
			Total	42	30	10	413	294	329	1,101	886	916	1,166	1,334	1,149	551	8,221
22–2	240	do	Striped	1	6	0	63	34	5	(1)							
			Normal	0	17	0	40	59	17								
			Total	1	23	0	103	93	22								
22–5	242	Ribbed limb variation	Ribbed	1	30	17	251	203	310	556	634	547	644	616	619	350	4,778
			Normal	0	3	5	12	15	12	36	24	38	84	91	110	57	487
			Total	1	33	22	263	218	322	592	658	585	728	707	729	407	5,265
22–6	242	do	Ribbed	0	17	1	162	119	77	(1)							
			Normal	0	3	0	15	17	8								
			Total	0	20	1	177	136	85								
1–18	237	Corrugated limb variation	Corrugated	0	0	0	0	0	3	16	175	14	218	53	136	134	749
			Normal	0	0	0	0	0	2	7	7	5	6	15	15	5	62
			Total	0	0	0	0	0	5	23	182	19	224	68	151	139	[2]811
1–19	237	do	Corrugated	0	0	0	0	0	0	1	80	10	103	50	123	193	560
			Normal	0	0	0	0	0	0	0	4	8	3	1	5	29	50
			Total	0	0	0	0	0	0	1	84	18	106	51	128	222	[2]610

See footnotes at end of table.

TABLE 5.—*Records of annual production of progeny trees propagated in May 1916 from several limb variations of minor strains in trees of the Eureka strain of the Eureka lemon*—Continued

Progeny tree no.	Source of buds		Fruits produced by progeny trees														
	Parent tree no.	Limb or tree	Character	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	Total
				Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
21-49	237	Corrugated limb variation	Corrugated	1	65	1	123	205	34	(1)							
			Normal	0	8	0	18	9	7								
			Total	1	73	1	141	214	41								
21-50	237	do	Corrugated	4	105	30	305	310	211	824	859	681	719	425	977	260	5,710
			Normal	2	4	3	11	18	22	38	26	19	20	10	15	11	199
			Total	6	109	33	316	328	233	862	885	700	739	435	992	271	5,909
22-3	241	Crumpled-Leaf limb variation	Normal [3]	0	30	7	58	86	210	508	546	304	712	594	358	279	3,692
22-4	241	do	do	0	9	0	31	54	17	(1)							
22-7	243	do	do	2	17	5	179	124	563	339	264	146	369	427	221	128	2,784
22-8	243	do	do	12	12	2	140	88	22	(1)							

[1] Tree removed in May 1925 because of too close planting.
[2] The light crop on this tree was due to competition of neighboring street trees.
[3] The fruits of this variation are similar to those of the normal Eureka strain.

PROGENY DATA ON LISBON STRAINS

The average total production per tree for the progeny trees of the most important Lisbon strains is presented in table 6. The rank of these strains by yield is the same as in the parent record plot except for the two highest, the Lisbon and the Dense strains, and the difference between these is small for a 12-year period. In the parent plot the difference between these was only 9 pounds per year in favor of the Lisbon strain, or about 1½ percent greater, and the data included the dropped fruits. The Lisbon strain trees have more drops than do the trees of the Dense strain, and if these drops had been recorded during the entire period of the progeny records it is probable that the totals for the Lisbon and Dense trees would be more nearly equal than is shown by the data.

TABLE 6.—*Production of progeny trees of important strains of the Lisbon lemon propagated in May 1916 from selected parent trees and planted in May 1918*

[The data show the average crop per tree for each year after they began bearing and for the total period 1921–32, inclusive. No trees of the Dense strain were planted in the progeny plot at Riverside]

Strain	Plot	Trees	1921	1922	1923	1924	1925
		Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Lisbon	Riverside	42	4.1±0.33	7.5±0.40	50.7±2.65	131.5±3.12	87.0±2.61
	Corona	166	1.3± .09	.6± .04	27.0± .75	97.5±1.54	124.0±2.38
Dense	Corona	38	1.4± .19	.4± .07	28.5±1.38	110.7±3.51	137.0±4.93
Open	Riverside	21	5.2± .63	10.5±1.14	45.3±3.46	120.0±6.43	69.1±3.20
	Corona	158	1.6± .09	1.0± .05	25.5± .59	103.9±1.77	80.4±1.76
Unproductive	Riverside	15	0	0	.6± .13	3.0± .56	3.5± .51
	Corona	14	0	0	.2± .05	1.9± .32	4.1± .40

Strain	Plot	1926	1927	1928	1929	1930
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Lisbon	Riverside	271.4±5.50	275.9±7.56	167.8±7.46	434.3±11.91	105.7±6.34
	Corona	224.6±2.80	289.8±3.54	121.2±2.52	361.3± 3.89	43.0±1.37
Dense	Corona	250.7±5.78	321.1±7.11	133.3±1.16	376.3± 9.24	41.7±3.23
Open	Riverside	246.3±8.37	235.6±7.81	112.3±6.37	347.1±12.33	138.4±7.95
	Corona	146.4±2.70	269.7±5.02	87.6±2.68	294.8± 2.72	33.6±1.19
Unproductive	Riverside	13.7±1.72	17.0±1.97	5.7± .97	90.0± 9.83	13.0±2.05
	Corona	19.2±2.55	9.6±1.76	8.1±1.17	67.4± 4.22	23.3±2.47

Strain	Plot	1931	1932	Total, 1921–1932	Rank in yield	Parent trees	
						Number	Rank in yield
		Pounds	*Pounds*	*Pounds*			
Lisbon	Riverside	603.7±14.77	239.5±5.56	2,370.0±16.59	1	22	1
	Corona	295.1± 1.96	284.0±4.60	1,870.0±18.07	2		
Dense	Corona	309.7± 8.00	317.0±7.14	2,027.0±55.57	1	11	2
Open	Riverside	320.8±13.23	153.8±5.51	1,793.3±43.44	2	77	3
	Corona	251.6± 2.02	110.0±2.32	1,319.8±14.28	3		
Unproductive	Riverside	10.8± 2.82	15.5±7.36	212.8±21.72	3	8	4
	Corona	39.6± 6.10	68.8±4.17	222.3±16.31	4		

The similarity of type of fruits in the parent and progeny trees is shown in figures 21, 22, and 23, illustrating fruits from parent and progeny trees of the Lisbon, Dense, and Open strains.

The percentages of green fruit and of variable fruits, with the average number of seeds per fruit, from the progeny trees of the im-

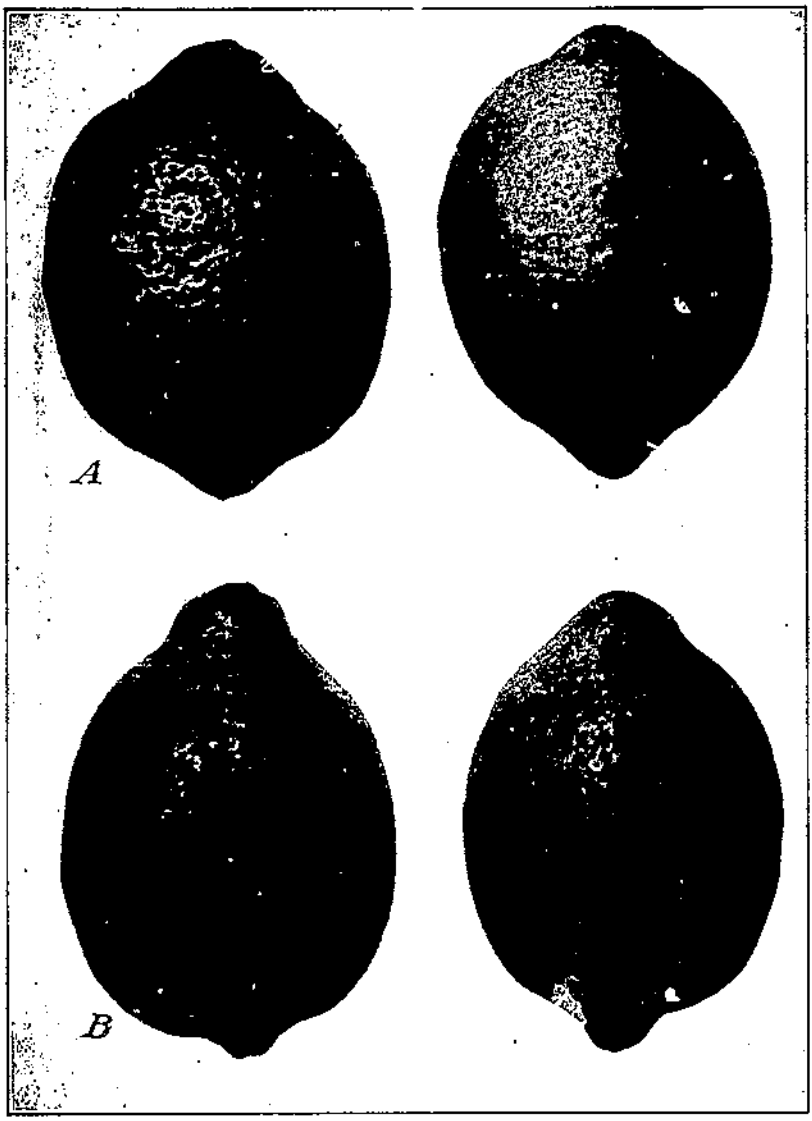


FIGURE 21.—Fruits of the Lisbon strain of the Lisbon lemon from a typical tree of this strain in the original Lisbon performance-record plot (*A*) and similar fruits (*B*) from a progeny tree propagated in 1916 from the tree that produced the fruits at (*A*), showing similarity to fruits of parent tree. Corona, Calif., April 1927.

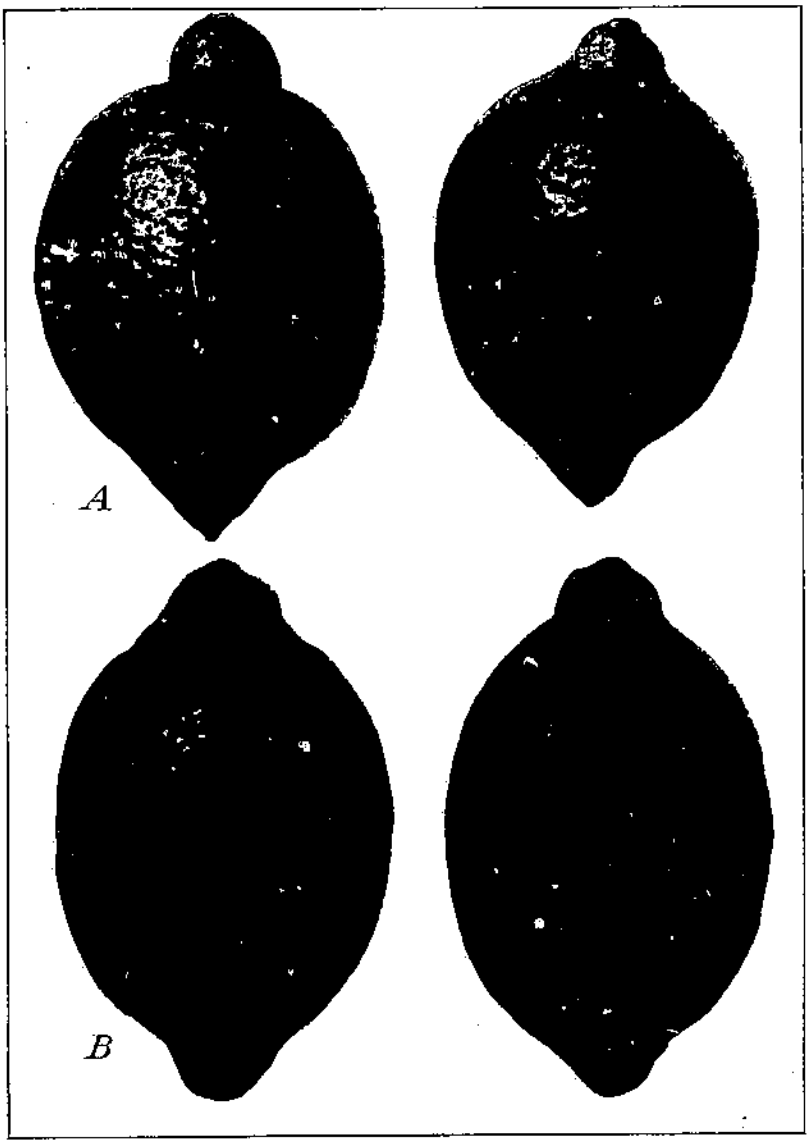


FIGURE 22.—Fruits of the Dense strain of the Lisbon lemon from a typical tree of this strain in the original Lisbon performance-record plot (*A*) and similar fruits (*B*) from a progeny tree propagated in 1916 from the tree that produced the fruits at *A*, showing perpetuation of coarse texture and undesirable shape. Corona, Calif., April 1927.

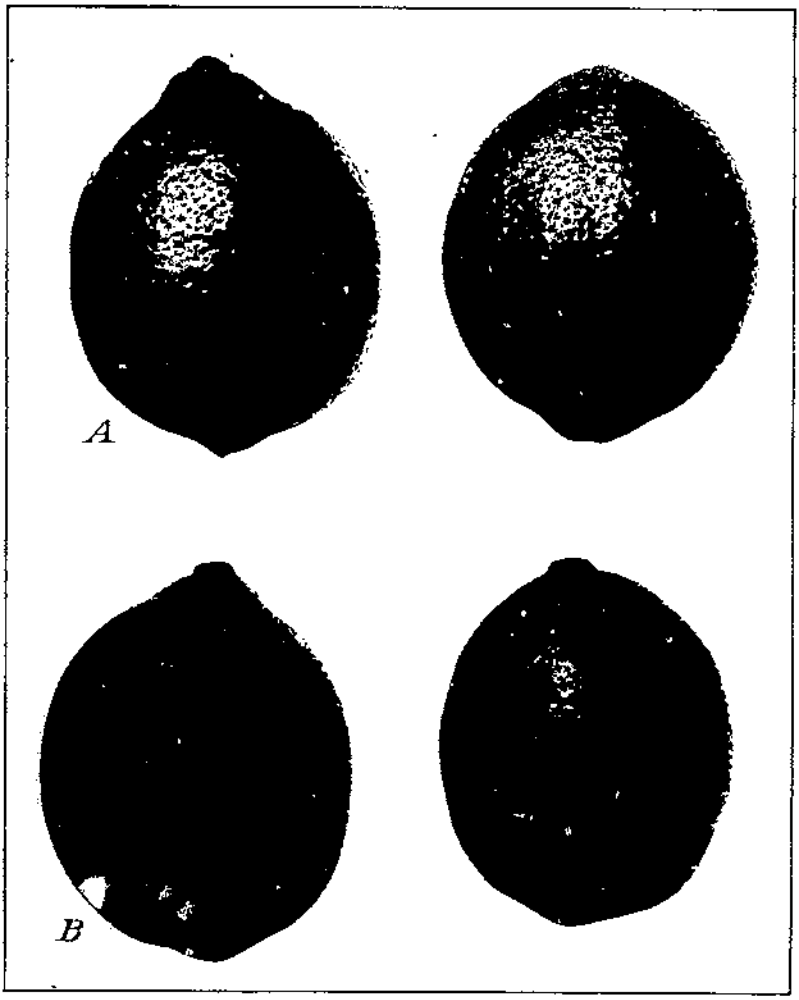


FIGURE 23.—Fruits of the Open strain of the Lisbon lemon from a typical tree of this strain in the original Lisbon performance-record plot (*A*) and similar fruits (*B*) from a progeny tree propagated in 1916 from the tree that produced the fruits at *A*, showing perpetuation of oval shape and smooth texture. Corona, Calif., April 1927.

portant Lisbon strains are shown in table 7. These data show a fairly close agreement between the progeny and parent trees except for the low percentages of green fruit at Riverside, and that condition is similar to the records for the Eureka strains as shown in table 2.

TABLE 7.—*Average percentages of green fruits and of variable fruits and number of seeds per fruit in the crops of the progeny and parent trees of important strains of the Lisbon lemon*

[No trees of the Dense strain were planted in the progeny plot at Riverside]

Strain	Green grade fruit			Variable fruits			Seeds per fruit	
	Progeny trees, 12 years, 1921–32		Parent trees, 4 years, July 1913 to June 1917, Corona	Progeny trees, 12 years, 1921–32		Parent trees, 4 years, July 1913 to June 1917, Corona	Progeny trees, 1 year, September 1932 to August 1933, Corona	Parent trees, 3 years, July 1913 to June 1916, Corona
	Riverside	Corona		Riverside	Corona			
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Number*	*Number*
Lisbon	70.7	85.1	86.2	0.3	0.8	1.2	5.8	4.4
Dense		83.9	92.3		3.4	1.5	5.0	4.2
Open	93.6	70.0	72.9	.1	.3	.0	5.3	5.1
Unproductive	51.7	82.3	95.5	100.0	100.0	100.0	2.7	1.7

The monthly yields of total crops are shown in table 8, in which the percentage of fruit produced by months is shown for the important Lisbon strains. The progeny trees in the Corona plot follow fairly closely the production of the parent trees, even though the data for the two plots cover entirely different periods and monthly production is influenced to a considerable degree by climatic conditions. In the progeny plot at Riverside the heavier production in February and March was similar to the production trend in the Eureka strains, as shown in table 3 and figure 20, and is doubtless caused by climatic variations between the two districts. A graphic representation of the monthly percentage of production for the Lisbon strain is shown

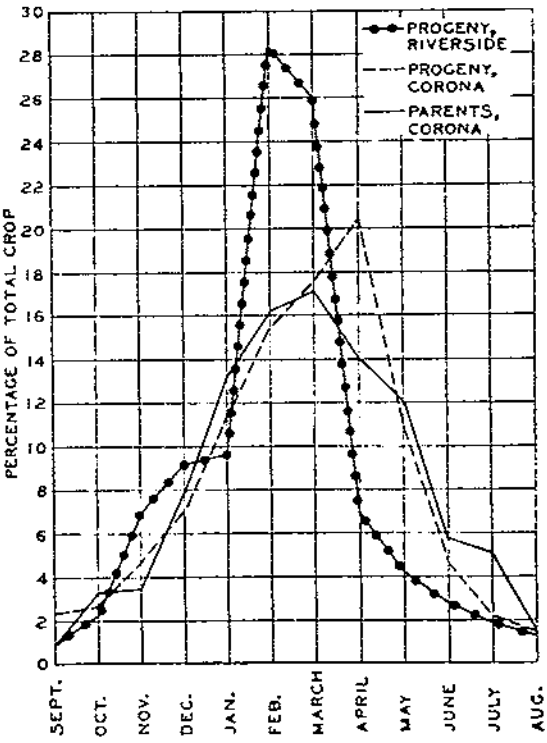


FIGURE 24.—Percentages of the annual crops produced each month by trees of the Lisbon strain of the Lisbon lemon in the progeny and parent record plots. These data are taken from table 8 and cover the 12 years 1921 to 1932, inclusive, for the progeny trees and the 3 years from July 1914 to June 1917, inclusive, for the parent trees.

in figure 24. This emphasizes the variation between the Riverside and the Corona progeny plots and the close agreement between the Corona progeny plot and the parent plot, which was also at Corona.

TABLE 8.—*Percentages of total annual production by months from trees of important strains of the Lisbon lemon in progeny and parent record plots*

[The data for the progeny trees are for the years 1921 to 1932, inclusive; those for the parent trees cover the 3 years from July 1914 to June 1917, inclusive]

Strain	Plot	Trees	Percentage of annual production in												
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	May-Sept.
		Number	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Lisbon	Progeny, Riverside	42	0.6	28.3	25.9	6.9	4.2	2.7	1.8	1.2	0.9	2.3	7.0	9.2	19.8
	Progeny, Corona	166	11.3	15.5	17.4	20.3	10.8	4.6	2.1	1.3	2.3	2.7	4.7	7.0	21.1
	Parent, Corona	22	13.2	16.2	17.1	13.9	12.1	5.7	5.0	1.4	.9	3.3	3.4	7.8	25.1
Dense	Progeny, Corona	38	11.2	15.4	16.4	20.5	12.1	4.8	2.3	1.1	2.3	2.7	4.2	7.0	22.6
	Parent, Corona	11	17.0	13.6	13.2	10.4	4.4	4.1	1.3	.9	1.2	9.2	9.6	15.2	14.9
Open	Progeny, Riverside	21	0.3	21.7	25.6	7.9	5.2	3.6	2.3	1.6	1.7	4.8	9.9	5.5	14.4
	Progeny, Corona	155	6.5	13.6	16.4	20.8	12.8	5.2	2.3	1.9	4.7	5.1	8.0	4.7	26.9
	Parent, Corona	77	7.6	11.9	15.7	17.4	14.4	9.5	5.8	4.0	2.5	2.5	1.9	3.9	30.2
Unproductive	Progeny, Riverside	15	5.7	12.5	29.4	11.6	17.2	7.8	2.6	2.9	.9	1.5	2.8	6.7	31.1
	Progeny, Corona	14	13.7	13.8	15.4	18.0	8.6	10.5	1.9	.7	2.1	3.6	4.1	7.6	23.8
	Parent, Corona	8	16.0	14.5	9.7	10.1	7.5	2.2	2.0	.1	1.2	10.9	10.0	15.8	13.0

The average circumferences of the trunks of the progeny trees of important Lisbon strains in the Corona plot at two periods 2 years apart are presented in table 9.

TABLE 9.—*Average circumference, about 4 inches above bud union, of trunks of progeny trees of important strains of the Lisbon lemon in the experimental plot in the Jameson orchard at Corona, Calif.*

Strain	Trees	Average circumference		Rank by size	Average increase, 2 years
		May 1931	June 1933		
	Number	*Cm*	*Cm*		*Cm*
Lisbon	166	51.5	55.6	2	4.1
Dense	38	54.3	58.1	1	3.8
Open	158	50.0	53.7	3	3.7
Unproductive	14	49.3	52.5	4	3.2

Records of the annual production of progeny trees propagated from several similar limb variations which were found in Lisbon trees are given in table 10. These are all variations of minor commercial importance though they are very striking in character and of great scientific interest and value. Most of these forms show an unstable inheritance; i. e., the progeny trees produce both normal fruits and those like the limb variation (fig. 25) and with greatly varying proportions of the abnormal fruits.

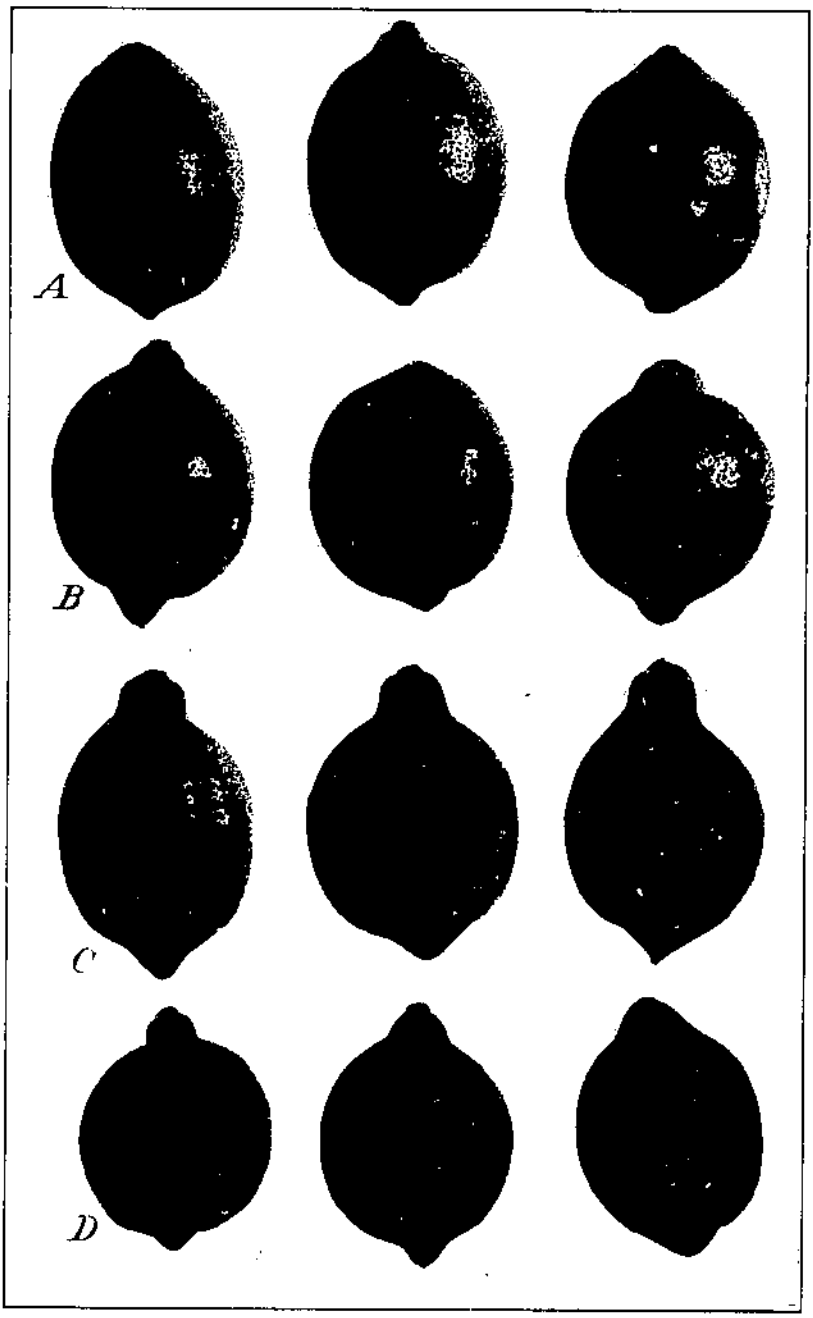


FIGURE 25.—Fruits of the Lisbon strain of the Lisbon lemon from a tree of that strain in the original Lisbon performance-record plot (*A*) and fruits of the Ridged and Collared strain from a limb variation in the same parent tree (*C*), with similar fruits of both the Lisbon (*B*) and Ridged and Collared (*D*) strains from a single progeny tree propagated in 1916 from the normal part of the tree that produced the fruits at *A* and *C*. Corona, Calif., April 1927.

TABLE 10.—*Records of annual production of progeny trees propagated in May 1916 from limb variations of some of the minor Lisbon strains*

Progeny tree no.	Source of buds: Parent tree no.	Source of buds: Limb	Character	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	Total
				No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
2-4	224	Striped variation in tree of Unproductive strain.	Striped	0	0	0	139	82	426	785	194	997	41	445	358	3,467
			Dense Unproductive	1	0	1	35	82	107	12	23	134	21	101	99	616
			Total	1	0	1	174	164	533	797	217	1,131	62	546	457	4,083
2-5	224	do	Striped	1	0	0	138	63	417	809	266	1,083	73	637	334	3,821
			Dense Unproductive	1	0	1	66	90	44	8	35	205	13	175	114	752
			Total	2	0	1	204	153	461	817	301	1,288	86	812	448	4,573
21-28	224	do	Striped	0	3	41	464	181	323	864	328	1,810	150	605	857	5,626
			Dense Unproductive	0	1	11	59	13	41	81	47	192	17	63	57	582
			Total	0	4	52	523	194	364	945	375	2,002	167	668	914	6,208
2-16	218	Pear-shaped variation	Pear-Shape	21	7	113	419	101	1,070	748	497	1,492	60	1,204	1,201	6,933
2-17	218	do	do	10	11	40	528	77	725	806	493	1,459	23	853	869	5,894
			Total	31	18	153	947	178	1,795	1,554	990	2,951	83	2,057	2,070	12,827
2-12	220	Variation bearing pear-shaped, ridged fruits	Pear-Shape	1	1	7	10	1	6	2	7	7	0	1	0	43
			Normal	0	0	28	336	205	857	978	700	1,435	147	1,297	947	7,020
			Total	1	1	35	346	206	863	980	707	1,442	147	1,298	947	7,063
2-13	220	do	Pear-Shape and Ridged	0	1	32	146	140	624	589	438	869	58	561	364	3,822
			Normal	0	0	21	351	117	607	326	151	814	24	559	287	3,257
			Total	0	1	53	497	257	1,231	915	589	1,683	82	1,120	651	7,079
21-20	220	do	Pear-Shape and Ridged	1	1	70	552	206	427	786	234	868	156	1,051	(1)	4,352
			Normal	0	1	18	41	27	43	34	25	4	5	23	....	221
			Total	1	2	88	593	233	470	820	259	872	161	1,074	.....	4,573

2-20	216	Variation bearing long-collared fruits	Long-Collared	0	0	38	84	162	573	605	306	1,140	59	1,220	749	4,936
			Normal	0	1	8	13	27	88	59	57	47	52	57	48	457
			Total	0	1	46	97	189	661	664	363	1,187	111	1,277	797	5,393
2-21	216	do	Long-Collared	0	0	29	122	131	520	526	418	1,275	70	1,204	741	5,039
			Normal	0	0	5	11	15	24	34	24	93	6	104	191	507
			Total	0	0	34	133	149	544	560	442	1,368	76	1,308	932	5,546
2-22	215	Ridged variation	Ridged	0	0	2	1	0	3	7	22	166	90	450	631	1,372
			Normal	0	0	21	82	62	241	117	177	734	54	166	50	1,704
			Total	0	0	23	83	62	244	124	199	900	144	616	681	3,076
21-12	215	do	Ridged	3	5	66	252	126	475	664	437	2,199	269	1,679	1,710	7,885
			Normal	1	3	6	20	28	45	89	12	200	10	55	170	639
			Total	4	8	72	272	154	520	753	449	2,399	279	1,734	1,880	8,524
2-8	222	Variation bearing ridged and collared fruits	Ridged-Collared	4	0	82	237	218	1,046	990	748	1,973	121	921	823	7,163
			Normal	6	0	11	63	64	38	134	36	26	12	67	59	516
			Total	10	0	93	300	282	1,084	1,124	784	1,999	133	988	882	7,679
2-9	222	do	Ridged-Collared	0	0	15	203	202	1,012	604	617	1,756	151	1,249	736	6,545
			Normal	0	0	3	45	93	14	52	12	22	21	83	61	406
			Total	0	0	18	248	295	1,026	656	629	1,778	172	1,332	797	6,951
21-21	222	do	Ridged-Collared	46	83	215	950	238	1,531	1,720	303	3,188	147	4,256	1,117	13,824
			Normal	1	14	14	30	53	52	27	13	48	8	57	19	336
			Total	47	97	259	980	291	1,583	1,747	316	3,236	155	4,313	1,136	14,160
12-18	222	Normal limb in same tree as above	Normal	7	3	90	280	317	832	1,270	504	1,714	67	1,335	1,411	7,860
12-19	222	do	do	4	2	136	525	570	916	1,242	308	1,851	165	1,695	1,346	8,760
12-20	222	do	do	0	1	44	254	456	901	1,205	205	1,759	81	1,834	1,136	7,876
21-2	222	do	do	26	10	207	250	268	1,563	1,415	1,242	1,990	747	3,810	2,049	13,583
2-6	223	Ribbed variation	Ribbed	0	0	79	152	61	445	1,262	227	(3)	------	------	------	------
			Normal	0	0	3	5	40	22	28	28	------	------	------	------	------
			Total	0	0	82	157	101	468	1,290	255	------	------	------	------	------
2-7	223	do	Ribbed	1	0	41	183	112	346	1,221	436	1,206	18	461	554	4,579
			Normal	0	0	1	25	5	43	41	36	18	1	48	60	278
			Total	1	0	42	208	117	389	1,262	472	1,224	19	509	614	4,857

See footnotes at end of table

TABLE 10.—*Records of annual production of progeny trees propagated in May 1916 from limb variations of some of the minor Lisbon strains*—Continued

Progeny tree no.	Source of buds: Parent tree no.	Source of buds: Limb	Character	Fruits produced by progeny trees: 1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	Total
				No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
21-26	223	Ribbed variation	Ribbed	1	3	48	236	46	528	407	238	1,055	241	956	475	4,234
			Normal	0	0	21	58	31	22	17	11	38	6	15	9	228
			Total	1	3	69	294	77	550	424	249	1,093	247	971	484	4,462
21-10	214	do	Ribbed	9	51	31	451	40	391	704	331	945	23	67	(3)	3,046
			Normal	4	7	6	32	27	17	25	40	26	3	8	.....	195
			Total	13	61	37	483	67	408	729	371	971	26	75	.....	3,241
2-26	213	Ribbed variation in tree of Dense strain	Ribbed	0	0	0	2	0	6	11	6	21	3	7	3	59
			Normal	6	1	68	198	85	653	607	417	953	62	1,684	919	5,053
			Total	6	1	68	200	85	659	618	423	974	65	1,691	922	5,112
2-27	213	do	Ribbed	0	0	0	0	0	25	18	5	56	3	12	18	137
			Normal	0	0	17	202	205	718	574	409	914	31	886	1,049	5,005
			Total	0	0	17	202	205	743	592	414	970	34	898	1,067	5,142
21-8	213	do	Ribbed	0	18	70	226	193	789	381	91	705	41	528	787	3,932
			Normal	8	41	117	324	280	400	921	451	1,747	308	2,127	671	7,398
			Total	8	59	187	650	473	1,189	1,308	542	2,452	349	2,655	1,458	11,330
2-28	212	Corrugated variation in tree of Dense strain	Corrugated	0	0	0	0	23	258	102	165	371	19	342	488	1,768
			Normal	0	0	5	21	23	50	30	1	16	8	40	11	205
			Total	0	0	5	21	46	308	132	166	387	27	382	499	1,973
2-20	212	do	Corrugated	0	0	0	0	11	254	161	30	174	31	265	410	1,336
			Normal	0	0	3	26	12	87	8	2	9	7	21	47	222
			Total	0	0	3	26	23	341	169	32	183	38	286	457	1,558

21-6	212	do	Corrugated	0	3	68	103	191	709	627	533	1,521	502	1,059	1,061	6,377
			Normal	0	6	15	6	29	15	21	9	14	5	23	17	160
			Total	0	9	83	109	220	724	648	542	1,535	507	1,082	1,078	6,537
12-15	212	Normal limb in same tree as above	Corrugated	3	0	47	323	97	433	674	201	1,004	58	437	1,101	4,378
12-16	212	do	do	1	0	65	266	186	418	648	353	964	73	601	1,138	4,713
12-17	212	do	do	1	0	33	170	213	457	757	274	983	67	624	1,116	4,695
			Total	5	0	145	759	496	1,308	2,079	828	2,951	198	1,662	3,355	13,786
21-11	212	do	Corrugated	0	0	0	0	0	0	0	5	0	0	1	0	6
			Normal	1	0	125	495	748	1,207	1,483	674	2,099	192	1,192	1,682	9,898
			Total	1	0	125	495	748	1,207	1,483	679	2,099	192	1,193	1,682	9,904
21-12	212	do	Normal	9	0	131	367	602	1,308	1,441	453	1,936	87	1,474	1,306	9,114
21-13	212	do	Corrugated	0	0	31	269	330	640	402	459	1,070	140	536	1,031	4,908
30-28	212	do	Normal	6	1	128	451	679	1,160	917	495	2,120	48	1,490	1,306	8,801
			Total	15	1	290	1,087	1,611	3,108	2,760	1,407	5,126	275	3,500	3,643	22,823
30-29	212	do	Corrugated	0	0	0	0	0	1	0	0	1	0	0	0	2
			Normal	0	6	85	230	483	852	995	467	1,550	160	1,172	1,051	7,051
			Total	0	6	85	230	483	853	995	467	1,551	160	1,172	1,051	7,053

[1] None of the fruits on this tree were ridged.
[2] Tree removed early in 1934 because it was diseased.
[3] Tree died in January 1929.

The trees listed at the end of table 10 are of special interest because it was a propagation of a similar nature to this (fig. 25), early in the study of the inheritance of lemon variations, that showed the importance of avoiding, in commercial propagation, the use of budwood from any part of a tree that bore an undesirable limb variation. Trees 2–28, 2–29, and 21–6, recorded near the end of table 10, were propagated from a Corrugated limb variation, bearing only Corrugated fruit, in a tree of the Dense Lisbon strain, and are shown to be unstable in inheritance, producing a large proportion of Corrugated strain fruits with some normal fruits. The last eight trees listed in this table were propagated at the same time as the three just mentioned, but the budwood for their propagation was taken from a limb on the opposite side of the parent tree from the Corrugated limb, and it was bearing only normal Lisbon strain fruits and had produced only normal fruits during the 2 preceding years, during which performance records had been secured from it. Two of the eight progeny trees from this normal propagation, 21–12 and 30–28, are shown to have borne nothing but normal Lisbon fruits, as they would commonly be expected to do; four of the eight progeny trees from this same propagation, 12–15, 12–16, 12–17, and 21–13, have borne nothing but Corrugated fruits like those produced on the limb variation in the parent tree; and two of the eight progeny trees, 21–11 and 30–29, have produced both Corrugated and normal Lisbon fruits, as did the progeny trees propagated from the Corrugated limb variation. In commercial propagations it is of course desirable to produce only typical trees of the desired variety. The possibility that abnormal trees may develop from normal budwood from a tree that has an abnormal limb, as happened in the case just described, shows the importance of taking commercial budwood only from trees that have been studied carefully and found free from any undesirable limb or single fruit variations.

PERPETUATION OF VARIATIONS IN QUANTITY OF CROP

The important strains of both the Eureka and Lisbon lemons produce characteristically different amounts of fruit annually under comparative cultural conditions, as shown by records of the progeny trees in tables 1 and 6. In some instances the strains having abnormally high or low yields have foliage characteristics that are apparently correlated with the quantity of production, such as density, shape, or color of the leaves and vigor or habit of growth of the trees.

COMMERCIAL QUALITY OF CROPS OF DIFFERENT STRAINS

In some instances the lemons produced by the various entire-tree and limb variations and the progeny trees propagated from these variations differ in commercial quality to a marked degree; in other cases they are so similar in appearance as to be indistinguishable. The most striking and clearly apparent of such characteristics include the shape, size, and color of the lemons, the thickness, texture, and smoothness of the rinds, the amount of rag, the abundance and acidity of the juice, and the number of seeds.

The oblong to oval shape of typical Eureka and Lisbon strain lemons is considered to be best suited for packing and handling operations. The pear, bottle-neck, round, or other abnormal shapes that are

characteristic of typical fruits of some of the variations of the normal strains are less desirable than the oblong to oval shape both from the standpoint of packing and of other phases of handling.

As lemons are picked when they reach a predetermined size, there is ordinarily little danger of obtaining fruits that are too large for market purposes. However, the trees of certain strains tend to produce a considerable proportion of fruits that do not grow sufficiently large for the best results. While the development of undersized lemons is largely due to unfavorable climatic, soil, or cultural conditions, the inherent tendency of certain strains to produce small lemons has also been proved as a result of these progeny tests.

Fruits that reach picking size while still green in color are the most desirable ones. It has been found in these studies (tables 2 and 7) that some of the variations tend to produce a larger proportion of deep- or light-green fruits than others.

SEASON OF MAXIMUM PRODUCTION IN DIFFERENT STRAINS

The tendency of the trees of all of the lemon strains in these investigations is to develop the maximum amount of bloom during the months of March, April, and May. The trees of a few strains bloom to a greater or less extent during all seasons of the year, so that blossoms and small and large fruits are to be found on the same trees at all times. However, there is a rather marked varietal difference in the season of maximum production of fruits of picking size, and similar marked differences characterize several of the strains.

The trees of the Eureka strain of the Eureka variety and the Open strain of the Lisbon variety, as shown in tables 3 and 8, tend to produce lemons throughout all seasons of the year, although the largest proportion of the bloom and set of fruit occurs during the spring months. The trees of the Shade-Tree and Unproductive strains of the Eureka variety tend to bloom heavily during both the spring and autumn seasons, but many of the blossoms are imperfect and do not set fruits. The fall blooms of these trees are the ones that ordinarily develop the crops produced during the fall of the year following the blooming.

The trees of all the strains of the Lisbon variety, except those of the Open strain, tend to produce their crops most heavily during late winter and spring.

Differences have been observed in the season of blooming and of maximum fruit production of individual trees of a strain and to a less extent of different branches on the same trees. An investigation as to the possibilities of perpetuating these characteristics through budding is being made, but the available data are considered to be insufficient at this time to warrant final conclusions.

RELATIVE INHERENT STABILITY OF DIFFERENT TREES

The performance records of progeny propagations of carefully selected lemon trees have shown that the characteristics of some of the parent trees have been perpetuated much more uniformly than others. Where buds have been taken from normal branches of parent trees having one or more limb variations the progeny trees have shown great variability in fruit and foliage characters, as shown by the records of progeny trees from parent tree 212 in table 10. In a few instances the progeny trees of apparently normal parent trees have

been quite variable, indicating that the parent trees were inherently unstable.

As a rule, parent trees having limb or individual fruit variations are almost certain to transmit tendencies to such variations to the progeny trees that have been propagated from the normal parts of such parents, whereas the progenies of parent trees having no marked variations of fruit or foliage tend to be uniformly like the parent trees. Such uniform progenies are considered to be inherently stable, and when the quantity and commercial quality of their fruits are superior to the average for the variety they are suitable for commercial propagation.

The progeny test of selected parent trees is a reliable method of determining their relative inherent stability. While it is oftentimes possible to estimate the inherent stability of selected trees through a study of their performance records for a period of years and from a study of the fruits on the trees, the progeny test reveals the actual relative inherent stability of the parent trees as well as of the progeny trees. The most serious objection urged against the use of the progeny test in commercial bud-selection practice is the length of time required to obtain necessary data and information from which safe conclusions can be drawn. In some instances this period can be materially shortened through top-working established older trees, using buds from the selected parent trees for this purpose. With nursery progeny trees, performance records covering a period of 4 or 5 years of orchard growth and production are ordinarily thought to be adequate for most purposes.

ISOLATION OF INHERENTLY STABLE STRAINS

The isolation and propagation of inherently stable and superior strains of the commercial varieties of lemons is an important factor in profitable lemon growing. The studies that have been carried out in this investigation indicate that through the selection of budwood from parent trees found through progeny tests to be inherently stable, such as are shown in figures 21, 22, and 23, it is commercially practicable to isolate and propagate strains in which the trees strongly tend to the production of uniformly desirable lemons. In this fundamental way the proportion of first-grade fruits can be increased without any added cost of production.

Studies of second-generation progenies that were propagated from the best producing trees of superior progenies indicate that continuous improvement of the population of lemon strains is possible through the systematic selection of budwood based upon the performance records of inherently stable progeny trees and the use in commercial propagation of buds from only the best progeny trees.

ELIMINATION OF INHERENTLY INFERIOR STRAIN TREES

The results of the lemon progeny tests reported in this bulletin, as well as others that are being carried on by growers, indicate that through careful bud selection based upon the performance records of progeny trees it is practicable to avoid the propagation of trees of inferior strains.

In established bearing orchards the inferior-strain trees can be eliminated profitably through top-working or replanting. Both of these methods have been described in a previous publication (*17*).

The elimination of inferior-strain trees results in increased and improved production and reduces the losses due to the work of assorting and disposing of the undesirable fruits that are borne by such trees.

COMMERCIAL IMPORTANCE OF LEMON BUD SELECTION

Without careful and systematic bud selection in propagation, commercial lemon plantings tend to become inefficient through the presence of trees of inferior strains that have been unintentionally propagated from undesirable limb and tree variations. This condition is due to the fact that without the intelligent selection of propagating material from superior parent trees undesirable limb and tree variations are likely to be perpetuated to an ever-increasing degree in young orchards, so that the proportion of the trees of these inferior strains may soon become sufficient to impair seriously the efficiency of the varieties for profitable lemon production.

The trees of certain strains of the established lemon varieties are better adapted to the local environmental conditions of some citrus districts than are those of other strains. In commercial propagation it is important to select budwood of the particular strains best adapted for culture under the conditions where the trees are to be planted.

As a result of tree records obtained in these investigations it seems probable that scions from the trees of some of the strains make a more congenial bud union with certain rootstocks than is the case with the scions from the trees of other strains. Therefore it is important to use rootstocks that are known to make satisfactory bud unions with the particular strains to be propagated.

The adoption of the varieties now used for the production of the lemon crop in the Southwest resulted from long-continued commercial experience. These proved varieties constitute an invaluable asset of the lemon industry, and the maintenance of their efficiency for lemon production is a matter of primary importance. In a like manner the use of the best strains of these varieties, the trees of which are particularly adapted to local soil, climatic, rootstock, and other environmental conditions, is a matter second in importance only to the adoption of the most suitable varieties. These results can be most economically and certainly achieved through the use of buds for propagation that have been selected from the best parent trees of the superior strains known to be suitable for the locality where the resulting orchard trees are to be planted. At the present time the commercial supply of selected buds used for the propagation of lemon trees in the Southwest is secured largely through cooperative organizations of growers, and to a less extent from large individual growers and nurserymen.

SUMMARY

The lemon industry is a rather recent commercial citrus development in the Southwest. Two varieties are grown in this district, the Eureka and the Lisbon, the former having originated from a selected lemon seedling in Los Angeles, Calif., in 1877, and the latter being an introduction from Australia with importations in 1874 and 1875.

Bud variations in the trees of these varieties have been found to occur more frequently than is commonly supposed, and the uninten-

tional propagation of some of these variations has led to the development of a number of strains that differ in habit of growth and foliage characteristics of the trees and in the quantity and commercial quality of the fruits.

These bud variations have been found to occur as individual fruit, limb, and entire-tree variations. Progeny tests of limb and entire-tree variations have been carried out to determine whether or not their characteristics are perpetuated through bud propagation. Performance records of the progeny trees have been obtained continuously since they began bearing. These individual-tree records and systematic notes on vegetative characters provide a reliable basis from which conclusions can be drawn as to the degree of heritability of the parent bud variations. The data obtained in these individual progeny tree-performance record studies, together with a discussion of the results, are presented in this bulletin.

The progenies of the limb and entire-tree variations have been showing consistently large or small yields, depending upon the relative quantities of fruits borne by the parent limb or entire-tree variations. The trees of the high-yielding progenies have shown moderate vegetative growth with an abundance of oval-shaped, deep-green leaves.

The trees of some of the progenies have tended to bear most of their fruits during the spring, others during autumn, while in other instances there has been a rather marked tendency to the production of more uniform quantities of lemons throughout the entire year.

The commercial quality of the lemons produced by the different progenies, including their shape, size, texture and thickness of rind, juiciness, and acidity of the juice, has been very similar to that of the fruits borne by the parent variations.

The progeny trees of the limb and entire-tree variations have produced uniform crops of fruit in those cases where the parent variations bore uniform lemons, while those that were propagated from variations that produce valuable fruits have borne crops with about the same degree of variability as the parent variations. The uniform parent variations have been considered inherently stable ones, whereas those that are variable have been classified as inherently unstable ones.

The results of the progeny studies strongly indicate that through bud selection based upon performance records it is possible to isolate and propagate inherently stable and commercially superior strains of the Eureka and Lisbon lemon varieties.

The elimination of the commercially inferior and inherently unstable strains can be accomplished through systematic bud selection and the use of buds in propagation from only the inherently stable and superior parent trees as shown by progeny tests. In established orchards the inferior strain trees can be replaced with desirable strain trees through top-working or replanting.

The results of these investigations show that the heritability of observed variations in the fruit or vegetative characteristics of lemon trees can be definitely determined through the use of the progeny-test method.

The individual progeny tree-performance record studies are of value in the consideration of the degree of inheritance of the characters of the parent variations and are sometimes of commercial importance through obtaining reliable information as to sources of inherently stable and commercially superior budwood for propagation.

LITERATURE CITED

(1) Pomeroy, C. S.
1915. BUD SPORTS IN AGRICULTURE. Calif. Fruit Growers' Conv. Proc. (1914) 45: 253-257, illus.

(2) ———
1915. THE VALUE OF INDIVIDUAL-TREE PERFORMANCE-RECORDS. Fla. Grower 11 (29): 10, 35-37, illus.

(3) ———
1922. CITRUS BUD SELECTION. THE IMPORTANCE OF USING CAREFULLY SELECTED BUDWOOD IN THE PROPAGATION OF TREES. Citrus Leaves 2 (3): 1-3, 8, 24, illus.

(4) ———
1923. BUD SELECTION IN PROPAGATION. THE TRANSMISSION OF PRODUCTION TO PROGENY TREES. Citrus Leaves 3 (3): 8-9.

(5) Shamel, A. D.
1911. A STUDY OF BUD SELECTION IN CITRUS FRUITS. Calif. Fruit Growers' Conv. Proc. 39: 89-107.

(6) ———
1911. A STUDY OF THE IMPROVEMENT OF CITRUS FRUITS THROUGH BUD SELECTION. U. S. Dept. Agr., Bur. Plant Indus. Circ. 77, 19 pp., illus.

(7) ———
1912. BUD SELECTIONS AS A MEANS OF IMPROVING CITRUS AND OTHER FRUITS. Amer. Breeders Assoc. Ann. Rept. 8: 497-503.

(8) ———
1912. BREEDING CITRUS TREES. Calif. Comm. Hort. Monthly Bull. 1: 441-478, illus.

(9) ———
1914. IMPROVEMENT OF CITRUS FRUITS BY BUD SELECTION. Calif. Cult. 43: 516-518, 548-549, 580-581.

(10) ———
1915. IMPROVEMENT OF LEMON VARIETIES BY BUD SELECTION. Calif. Fruit Growers' Conv. Proc. (1914) 45: 257-266, illus.

(11) ———
1916. SOME RECENT OPERATIONS AND EXPERIMENTS WITH BUD VARIATIONS. Calif. Citrogr. 2 (1): 14-16, illus.

(12) ———
1916. METHODS FOR SECURING IMPROVED PRODUCTION OF THE WASHINGTON NAVEL ORANGE. Calif. Fruit Growers' Conv. Proc. (1915) 47: 158-175, illus.

(13) ———
1917. CITRUS-FRUIT IMPROVEMENT: HOW TO SECURE AND USE TREE-PERFORMANCE RECORDS. U. S. Dept. Agr. Farmers' Bull. 794, 16 pp., illus.

(14) ———
1917. BUD VARIATION IN LEMONS. Jour. Heredity 8: 75-81, illus. Also in Calif. Citrogr. 2 (4): 6, 7, 16, illus.

(15) ———
1920. COOPERATIVE IMPROVEMENT OF CITRUS VARIETIES. U. S. Dept. Agr. Yearbook 1919: 249-275, illus.

(16) ———
1932. A PINK-FRUITED LEMON. Jour. Heredity 23: 23-27, illus.

(17) ——— Pomeroy, C. S., and Caryl, R. E.
1925. CITRUS FRUIT GROWING IN THE SOUTHWEST. U. S. Dept. Agr. Farmers' Bull. 1447, 42 pp., illus.

(18) ——— Scott, L. B., Pomeroy, C. S., and Dyer, C. L.
1920. CITRUS-FRUIT IMPROVEMENT: A STUDY OF BUD VARIATION IN THE EUREKA LEMON. U. S. Dept. Agr. Bull. 813, 88 pp., illus.

(19) ——— Scott, L. B., Pomeroy, C. S., and Dyer, C. L.
1920. CITRUS-FRUIT IMPROVEMENT: A STUDY OF BUD VARIATION IN THE LISBON LEMON. U. S. Dept. Agr. Bull. 815, 70 pp., illus.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	HENRY A. WALLACE.
Under Secretary	REXFORD G. TUGWELL.
Assistant Secretary	M. L. WILSON.
Director of Extension Work	C. W. WARBURTON.
Director of Finance	W. A. JUMP.
Director of Information	M. S. EISENHOWER.
Director of Personnel	W. W. STOCKBERGER.
Director of Research	JAMES T. JARDINE.
Solicitor	MASTIN G. WHITE.
Agricultural Adjustment Administration	H. R. TOLLEY, *Administrator.*
Bureau of Agricultural Economics	A. G. BLACK, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Biological Survey	IRA N. GABRIELSON, *Chief.*
Bureau of Chemistry and Soils	HENRY G. KNIGHT, *Chief.*
Commodity Exchange Administration	J. W. T. DUVEL, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Chief.*
Forest Service	FERDINAND A. SILCOX, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Bureau of Plant Industry	FREDERICK D. RICHEY, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Soil Conservation Service	H. H. BENNETT, *Chief.*
Weather Bureau	WILLIS R. GREGG, *Chief.*

This bulletin is a contribution from

Bureau of Plant Industry	FREDERICK D. RICHEY, *Chief.*
Division of Fruit and Vegetable Crops and Diseases.	E. C. AUCHTER, *Principal Horticulturist, in Charge.*

U. S. GOVERNMENT PRINTING OFFICE: 1933

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 10 cents

END