CULTURE OF THE CITRUS IN CALIFORNIA

State Board of Horticulture

1902

WASHINGTON NAVELS—THE "KING OF ORANGES." (REDUCED.)

CULTURE

OF

THE CITRUS IN CALIFORNIA.

RESEARCH BY B. M. LELONG,

Assisted by Experienced Horticulturists.

REVISED BY

STATE BOARD OF HORTICULTURE.

SACRAMENTO:

A. J. JOHNSTON : : : SUPERINTENDENT STATE PRINTING.

1902.

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OFFICE OF THE STATE BOARD OF HORTICULTURE,
SACRAMENTO, CAL., May 24, 1902.

To His Excellency HENRY T. GAGE, *Governor of California:*

SIR: To meet the demands made by fruit-growers, the State Board of Horticulture has deemed it necessary to publish a second edition of the Culture of the Citrus in California. This second edition comprises nearly all of the subject-matter contained in the first, with the addition of new matter of importance to fruit-growers.

Respectfully submitted.

ELLWOOD COOPER,
President.

FRUITING BRANCH OF THE ORANGE (*Citrus aurantium*).

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THE CALIFORNIA FRUIT INDUSTRY.

The most important of all California's varied industries at the present day is fruit-growing. It has rapidly come to be a great productive industry, and has overshadowed all others in its extent and importance. Stock-growing, mining, agriculture, viticulture, have all been overtaken and passed on the road, and to-day the production, handling, and marketing of the various fruits of the State give employment to a larger number of people and have more capital invested in them than any other class of enterprises in California. Horticulture is the staple industry of the State, and everything that will affect it for either good or bad is watched with great interest. The condition of the weather in the Eastern fruit sections, the records of the thermometer in our own State, the climatic conditions affecting the bloom or the setting of the fruit, the coming and spread of pests or diseases, are all watched with the keenest anxiety, for they mean to the State at large good or bad times as the indications are favorable or otherwise. Out of this pursuit has grown numerous organizations having in view the advancement of the industry on various lines. These are both public and private. There are State and County boards of horticultural commissioners, whose duties are protective; fruit-growers' associations; coöperative associations for curing and marketing fruits; fruit exchanges and fruit unions; besides district and county horticultural societies. All these are the outgrowth of this industry and all are working to

advance it to the line of perfection as nearly as possible. One of the remarkable facts in connection with fruit-growing is the rapidity with which it has forced itself to the front. For, while fruit has been grown in California from the date of the first settlement, it is only within the past twenty years that the industry has come into any prominence. In that time it has become the great specialty of the State, so that California now boasts the proud distinction of being the orchard of the United States.

The climate and soil of the State render it especially adapted to fruit culture. In common with all our pastoral and agricultural pursuits, California owes the introduction of horticulture to the Mission Fathers, who first of all planted fruit-bearing trees on the Pacific shores. These plantings were small and of no great importance, except in so far as they proved that fruit would do well in California. Their orchards were planted with no regard to their commercial value, and the only object in planting them was to furnish the Fathers and their servants with fresh fruit. The best varieties then obtainable found their way here, but no effort was made to improve them. In fact, early horticulture in California, as with all other developments of agriculture, was very crude, and its products in no way comparable with those of the present age; but in the planting of their primitive orchards the Fathers laid the foundation for a gigantic industry and "builded better than they knew."

In 1767 the Jesuits were expelled from the missions in Lower California, their possessions were turned over to the Franciscans, and Junipero Serra was selected as President of the Missions. A dispute arose between the Franciscans and Dominicans over the division of the property. The latter claimed an interest in the mission work. In consequence of this a division was made, and in 1769 the Franciscans started northward, entering and occupying what is now the State of California. The avowed object of their establishment was the conversion of the savage races to christianity; but while devoting themselves to the harvest of souls the Fathers did not neglect the material interests of themselves or their establishments. The surrounding country was speedily subdued and the natives were changed from hunters to herdsmen and the flocks of the missions became numerous and of great value.

It was not thought possible in those early days that the vast plains of California would ever be available for other than grazing purposes. To the civilized world this State, together with the whole Pacific Coast, was known as the "great American desert." It was known that there were fertile spots, but these were regarded, like the oases in the Sahara, as but accentuating the aridity of the surrounding waste.

José del Galvez, "visitor-general" and secular head, with Father Serra, made arrangements for the establishment of settlements. Twenty-one missions were established, all but three of which had gardens and orchards. The mission orchards were very small, and some consisted of but few trees, but those trees played an important part in the horticultural advancement of the State, for they showed the possibilities in fruit culture, and furnished seeds, stocks, and scions for many orchards.

After the occupation of the southern part of the State by the Franciscans, the Russians, actuated by entirely different motives, penetrated from the north. The Mission Fathers were bent upon the spiritual conquest of the new land; the Russian traders, upon its commercial conquest; yet the efforts of both, diverse at first, converged in the conquest of the wild Pacific tribes to modern civilization, and both brought with them civilizing influences. The Russians who obtained a foothold here early in the nineteenth century planted an orchard of mixed deciduous fruits at Fort Ross, as early as 1812. The Russian orchards, like those of the Mission Fathers, were not planted from a commercial consideration, but to supply their respective owners with fruit for home consumption. However, like the corresponding industry in the south, it served to prove that fruit would grow in California, and thus became the pioneer of the present great wealth-producing industry of the State.

The fruits introduced into the two sections of the State were characteristic of the countries from which they were brought. The chief fruits brought by the Fathers were oranges, figs, grapes, and olives—all fruits of a genial southern clime. They met on common ground in California with those of the more rugged climate of the north—apples, pears, and cherries, introduced by the Russian pioneers. It speaks highly for the diversity of products to which this State is adapted that both once having obtained a foothold maintained it, and to-day we find the apple

of the north growing side by side with the orange of the south, while the pear and the lemon thrive together. The varieties of fruit grown in the missions of Lower California, whence the Franciscans derived their stock, were few in number and consisted of figs, citrons, oranges, pomegranates, plantains, olives, and dates. There were no fruits of the north temperate zone, unless it were a few peaches of very indifferent quality, which did not thrive well and were not regarded as worth much consideration.

As elsewhere related, the Franciscans made their first establishment at San Diego in 1769, and proceeded from that point northward, establishing altogether twenty-one missions; the last one being at Sonoma in 1823. Here they found the Russian settlements, and the horticultural products of the north and the south met and have grown together since. At each of their missions the Fathers established orchards.

Vancouver, in his memoir of the Pacific Coast, in 1792, describes an orchard which he found at Santa Clara in which were growing apples, peaches, pears, apricots, and figs, the trees all being thrifty and promising. He further details finding at the mission of San Buenaventura apples, pears, plums, figs, oranges, grapes, peaches, and pomegranates. The orchards connected with the Mission San Gabriel were among the most extensive of that early period, having, among other fruits growing, oranges, citrons, limes, apples, pears, peaches, pomegranates, and figs; grapes also grew in abundance.

No statistical accounts are extant recording the number of trees or the amount of fruit produced by the missions at the period of their greatest prosperity. Inventories of the mission properties were made at the time of their secularization in 1834. That of the Santa Ynez Mission recorded 987 fruit trees, valued at $1.00 each. San Fernando returned 1,600 fruit trees, valued at $1.50 each; San Gabriel, 2,333 fruit trees, upon which no valuation was placed; and San Diego returned 517 olive trees. Outside of the missions there were a few attempts at horticulture, which might be called the "prehistoric" orchards of the State.

From the period of the secularization of the missions the early fruit industry began to decline. In a few instances the orchards were kept up to their original standard of excellence, but these were exceptional cases, and when General Fremont

visited California in 1846, he wrote of them that "little remains of the orchards that were kept in high cultivation at the missions. * * * Fertile valleys are overgrown with wild mustard; vineyards and olive orchards are decayed and neglected."

While most of the orchards were thus allowed to fall into decay, a few still maintained their early vigor. Of one of these, General Fremont, in his "Geographical Memoir," says: "Among the arid brush-covered hills south of San Diego we found little valleys converted by a single spring into crowded gardens, where pears, peaches, quinces, pomegranates, grapes, olives, and other fruits grew luxuriantly together, the little streams acting upon them like a principle of life."

Some of the earlier settlers, with foresight enough to see that there was profit in fruit, secured some of the mission orchards, and under skillful treatment and fostering care these were made productive again by careful pruning, cultivation, and irrigation. These enterprising orchardists reaped a golden reward for their labor.

The early plantings in the north were generally in the vicinity of the mines and were small family orchards. But little care was bestowed upon them, as fruit-growing then was not the science into which it has since developed. All sorts of seeds were planted and these were allowed to grow and bear when and how they would. But as the demand for better varieties of fruit increased, efforts at improvement were made, and better stock was sought.

CITRUS CULTURE IN CALIFORNIA.

The discovery of the fact that citrus fruits could be produced successfully and profitably, gave an impetus to the growth of a most important industry in our State, and especially in the southern counties, which is almost unprecedented in the history of our Union.

California is essentially devoted to specialties, and while each of the numerous industries like the prune, raisin, peach, walnut, almond, etc., is pursued in the different sections, and while each of these industries is followed to a greater or less extent in the surrounding counties, so Southern California became the center of the citrus industry. Land which had

been regarded as worthless rapidly advanced in value as the industry grew, and as its possibilities began to dawn upon the knowledge of the grower, its value continued to increase. Cities, towns, and villages sprang up, whose birth, existence, and future depended upon the condition of the orange market. Extensive systems of irrigation were developed, and a large extent of territory which had at the commencement of this growth been regarded as a desert was converted into a vast orchard, filled with pleasant homes and a prosperous population.

While orange trees were among the earliest introduced into our State, having been brought here by the Mission Fathers, it may be said that orange culture is of very modern origin, and the industry has assumed commercial importance only since 1880.

The so-called citrus region is one of indefinite boundaries, and the question where oranges would or would not grow has given rise to much acrimonious discussion between various sections of the State. It may be set down as a fact that the orange will flourish in spots over the greater part of the State, the exceptions being in the extreme northern counties and the higher altitudes of the Sierra Nevada and Coast Range. The cultivation of citrus fruits has formed the chief horticultural industry of the extreme southern counties, and from this fact an impression has gone abroad that they would not flourish elsewhere. They are found in places along the entire length of the San Joaquin and Sacramento valleys, and very excellent fruit is grown as far north as Shasta. Of course this vast area is not all adapted to the culture of citrus fruits, in fact but a small proportion of it is so adapted, but enough has been done to prove that the climatic conditions required by the orange and lemon are to be found over a large part of California. While, too, the citrus fruit industry is the principal one of the southern counties, not all of the land in that section is suitable for the growth of citrus fruits.

Outside of the southern counties citrus fruits of exceedingly good quality are grown in the foothills of Kern County. In Tulare County there is a strip of land along the base of the foothills of the Sierra Nevada Mountains where oranges have been planted on a large scale, and they are grown very successfully both at the north and south ends of the belt. Citrus

fruits grown at Porterville and Lindsay are rapidly assuming a front position and share the honors in this line with other similarly favored sections of the south. Oranges thrive all along the foothills where water can be obtained. There are no damaging frosts or destructive winds. There are a number of fine orchards, and every year large areas of new land are being planted to citrus fruits.

Placer County has numerous citrus orchards, and the area in citrus culture is gradually extending, especially about Newcastle, Loomis, Rocklin, and Penryn.

In Sacramento County considerable attention is now devoted to the culture of citrus fruits, at Orangevale and Fair Oaks. In the former colony large plantings are to be seen and large shipments of this fruit are being made annually therefrom.

Citrus fruits do well over a large portion of Butte County, which county is entitled to the position of leader in the northern citrus belt. Prior to 1886, citrus culture was largely experimental, although even at that time the fact that oranges would grow there and could be made a profitable crop had gradually forced itself upon the attention of fruit-growers. The winning of the award at the Northern Citrus Fair in Sacramento that year, confirmed the belief of the citrus-growers there, and a great impetus was given to the new industry, until now Butte County is better known for her production of citrus fruits than for the growing of those which had so far proved of greater commercial importance. The colonies of Thermalito and Palermo have taken their chief impetus from the fact that oranges will grow there, and the planting of orange trees has not diminished, but rather increased with time. Wyandotte, adjacent to Palermo, is another favorite section where citrus fruits are grown successfully. The oldest orange tree in Northern California is at Bidwell's Bar (Butte County), where it may still be seen. This tree was grown from seed of an Acapulco orange planted by Jesse Morrill at Sacramento in 1855, and transplanted to its present site in 1859. (See illustration on next page.)

In Yuba County large tracts have been set out in orange trees, notably at Wheatland and Smartsville.

In Stanislaus County the area of citrus-growing is being rapidly extended. The orange has been successfully grown about Knight's Ferry for a number of years, but only recently

has the culture of this fruit been pursued on a large scale. Extensive plantings are being made about Oakdale.

The western portion of Amador County is admirably adapted to fruit-growing. The same citrus belt traverses this county that encircles the northern counties of Butte, Nevada, and Placer, and oranges and lemons of remarkable size and flavor have been produced there.

In Calaveras County citrus fruits have not been grown very extensively, but at Campo Seco there are orange trees over thirty years old, which bear good crops annually, as also in the citrus belt which embraces the northern part of the county.

The oldest orange tree in Northern California, at Bidwell's Bar, transplanted in 1859.

In Fresno County until recently very little attention was paid to growing citrus fruits. A few orange orchards in the foothill regions of the county showed the future possibilities of the section, and the acreage is now being rapidly extended. The oranges and lemons exhibited at the Fresno citrus fairs in the past four or five years compared favorably with those grown in other favored sections adjoining.

In Merced County the orange thrives best in the thermal belt of the Sierra Nevada foothills. There are numerous plantings in and about Merced City.

Fine fruit has also been exhibited at the Cloverdale citrus fairs held there for the past four seasons, showing the possibilities of that section in citrus culture.

It will be seen from these statements that the citrus belt of California is not confined within any mere geographical boun-

daries; that no compass and chain can separate the so-called southern from the northern citrus belt; that with proper conditions citrus fruits can be grown over a large area of the State; and that without proper climatic conditions they can not be grown successfully.

Primitive Orchards.—The most extensive orange orchard of early planting was at the San Gabriel Mission, in Los Angeles County, supposed to have been set out in 1804 by one "Father" Thomas Sanches. The first orange orchard of any note, outside of the missions, although small and intended for home use, was planted by Louis Vignes at Los

The once famous Wolfskill Orange Orchard—trees forty years old.

Angeles in 1834. The same year Manuel Requena also planted a small orchard. Other plantings soon followed, the most notable and important of which was that of the late William Wolfskill, at Los Angeles, consisting of two acres set out in 1841, and this was probably the first orange orchard planted in the State with a view to profit. In 1853 the Matthew Keller orchard, opposite the Wolfskill orchard, was planted. Another orchard was planted north of the San Gabriel Mission, now known as the Wilson orchard. These plantings did not immediately succeed each other, but a considerable period elapsed from the date of the setting out of the mission orchard, and even after the success of this latter orchard had been assured other plantings were slow and not extensive.

In 1857 a few trees were planted at old San Bernardino by L. Van Leuven from seed grown by him. He also the same year planted forty-five trees obtained from Los Angeles. About two hundred were planted at Crafton by Myron H. Crafts, about 1865. The first seeds were planted at Riverside in 1870, and the first trees in orchard, grown from these seeds, in 1872 and 1873. In 1869 Frank A. Kimball planted some orange and lemon trees at National City, San Diego County. At that time there were two old orange trees growing in El Cajon Valley. But little progress was made in orange culture from 1857 until 1862, at which date there were but twenty-five thousand trees in the entire State, and two thirds of these were in the Wolfskill orchard. From this date the planting of orange

Orange Avenue at San Gabriel—trees thirty years old.

trees increased, but not with any great rapidity until 1873, when the first impetus was given to the industry. Southern California was out of the reach of railroad transportation. Fruit for the market was hauled to Los Angeles in wagons and from there transferred to rail and steamer. This process was slow and expensive, and but a limited area, and that not the best land for the purpose, could be cultivated. The completion of the Southern Pacific line, however, gave superior transportation facilities, and at the same time opened up a new and better fruit region. Riverside had already started, having been settled in 1869, and a considerable area of orchard land was set to oranges. Shipments of fruit to San Francisco and the East commenced, and they brought good returns and encouraged the

growers. It was not, however, until the opening of the Atchison, Topeka & Santa Fé line that the highest development took place. From this time on there was a veritable boom in orange planting. Some of the returns from these orchards were almost incredible, as much as $3,000 from one acre having been reported, and $800 to $1,000 being no uncommon yield. Of course, an industry that would pay such profits was eagerly sought. Land suitable for orchards advanced rapidly in value; other lands advanced collaterally, and it became profitable to subdue them to this purpose. Land companies, irrigation companies, and planting companies were organized with sufficient capital to carry out their schemes, and the whole extent of a country which had been a forbidding waste was soon converted into a fruitful orchard. The very face of nature was changed, and in a few years Southern California became one of the most important sections of the State.

In 1862, H. M. White planted two orange trees in Frazier Valley, east of Porterville, Tulare County, which are still bearing and which formed the nucleus of a forty-acre orchard that now surrounds the original tree. At Plano, in the same county, Mrs. Gibbons, in 1863, planted some orange seed as an experiment, which proved successful. Other plantings followed, until the present citrus district of Porterville developed. The first orchard was planted in Porterville in 1883, by A. R. Henry. About the same date a small planting was made at Centerville, Fresno County. A few trees were planted by the agent of the Marysville and Oroville railroad as early as 1868, in his garden at Oroville, Butte County.

A small orange grove was planted by Nicholas Carriger in 1871, about two and a half miles west of the town of Sonoma. Mr. L. L. Lewis, the present owner, says: "These trees are now over three feet in circumference, and some of them will yield this season as high as twenty-five boxes of oranges."

Thus we find that, as early as 1870, small orange groves had been planted all along the foothills from San Diego to Butte County. Plantings in many of the valley counties had also been made up to this date. These latter have served to prove the inadaptability of the valleys to the growth of the industry, while along the foothills the small beginnings have developed into one of the most permanent and profitable branches of horticulture in the State.

Expansion of Orange Culture.—While oranges had been grown in the most favored sections of Southern California, and to a very small extent in other portions of the State, to Riverside is due the great impetus that brought the industry into national prominence. The twenty varieties of oranges that competed against the *world* at the New Orleans World's Fair, and to which was awarded the *gold medal* for their superiority, were grown at Riverside, and the fact was heralded the world over. It is also largely to Riverside that the orange industry is indebted for its present importance, from the success attained in the cultivation of the Washington Navel, an orange which achieved widespread fame for itself and the location (Riverside) where it was first successfully grown.

A Riverside Washington Navel Orange Grove.

The importation of the Australian ladybird (*Vedalia cardinalis*) gave another impetus to the industry, and the work of this little insect in this State can not be better illustrated than by the reported shipments of citrus fruits from Los Angeles before and after its introduction. For years Los Angeles was the leading shipper of citrus fruits, but the introduction and spread of the cottony cushion scale (*Icerya purchasi*) so affected the industry that it was on the verge of extinction. In 1890, San Bernardino County (now divided from Riverside), into which this scale had not forced its way, shipped 1,705 carloads of oranges, and Los Angeles 781. The Vedalia practically exterminated the cottony cushion scale, and the returns in 1891 were 2,212 carloads for Los Angeles and 1,708 for San Bernardino, an increase

of three carloads for the latter county, while Los Angeles advanced in one season from 781 to 2,212, an increase of 1,431 carloads. The increase of San Bernardino was a natural one, but that of Los Angeles was due to the advent of the Vedalia and not to the coming in of new orchards.

The latest tree census from returns made by County Assessors shows the number of orange and lemon trees in the State to be as follows:

	Oranges.	Lemons.
Bearing Trees	3,132,785	805,084
Non-bearing Trees	1,837,695	504,272
Totals	4,970,480	1,309,356

It is notorious that the returns of assessors are underestimated, many orchardists reluctantly giving the full number, fearing it might entail additional taxation. If twenty per cent were added to the above, it would approximate more nearly to the true number. By such addition we would have 3,759,342 bearing and 2,205,234 non-bearing orange trees. Of lemon trees we would have 966,101 bearing and 605,126 non-bearing. The total number would be 5,964,576 orange trees and 1,571,227 lemon trees, and a combined total of 7,535,803 orange and lemon trees. Averaging 100 trees to the acre, would give 75,358 acres devoted to this culture. As it is estimated that there are about 1,500,000 acres in the so-called Thermal Belt extending from San Diego to Tehama County suitable for the cultivation of citrus fruits, the foregoing data show what room there is for the expansion of this industry.

CALIFORNIA ORANGE AND LEMON SHIPMENTS.

From California Fruit-Grower.

Season.	Carloads.	No. of Boxes.
1892-93	5,871	1,972,560
1893-94	5,022	1,687,500
1894-95	7,575	2,545,200
1895-96	6,915	2,323,500
1896-97	7,350	2,469,600
1897-98	15,400	5,174,400
1898-99	10,875	3,654,000
1899-00	18,400	6,624,000
1900-01	24,900	8,964,000

Of the 24,900 cars, or 8,964,000 boxes, of citrus fruit shipped during the season of 1900-01, 3,200 cars, or 992,000 boxes

were lemons. As the average net value of a carload of oranges and lemons to the producer for the season of 1900–01 was about $350, the total value of the shipments amounts to $8,715,000. About as much more money was disbursed for cultivation, packing, and freight, making a grand total for that season of about $17,430,000. The above only represents the actual amounts that were moved to markets.

Especially Favorable and Dangerous Localities.—All along the belt of country from Tehama County to San Diego there are especially protected or favored localities where the orange and the lemon grow to perfection, and also localities where it would be unsafe to attempt citrus fruit culture as a commercial enterprise. This is caused by the local topography of the country and does not depend much on the altitude. Wherever cold currents of air from high altitudes flow to the valley without interruption, it will not be safe to attempt citrus culture at any elevation within the sweep of these currents. On the other hand, wherever these descending currents are cut off or turned aside by spurs of the mountains, leaving the warm atmosphere of the days undisturbed during the nights, there orange and lemon culture may be engaged in without danger from frost. In other words, the eddies of air currents must be selected and the main flow of these currents must be avoided.

Every one who has traveled along these Sierra foothills parallel with the valleys, particularly in the winter season and at night, will recall his surprise at the sudden changes of the temperature of the atmosphere within short distances. He may also remember to have noticed tender plants and shrubs seared and frost bitten, while just over a ridge or cone the same plants and shrubs were in full leaf and growing luxuriantly. Want of attention to these facts has caused many a disastrous failure in the cultivation of citrus fruits in California.

It may be here observed that these peculiar natural phenomena are more striking and their lessons are more imperative north than south of the Tehachapi pass—for the reason that south of that point the coast range of mountains is broken up into fragments, and the tempering influences of the waters and breezes of the ocean are more direct and powerful

than farther north, where this range is practically unbroken and the citrus belt is farther inland. These disadvantages of the northern section are, however, somewhat counteracted in the fact that the drier and warmer summer atmosphere is a greater guarantee against the spread and ravages of insect pests. The more elevated and inland localities in the south have this same advantage over localities nearer the coast.

There are orange and lemon trees growing in nearly all of the counties of the State not exclusively in the mountainous sections, and many of these trees are bearing more or less fruit of very fair quality. For climatic reasons, however, the citrus fruit industry is and must be confined to a belt of country lying along the foothills of the Sierra Nevada Mountains. This belt is called the "Thermal Belt." It stretches from San Diego to Tehama County, a distance of over seven hundred miles, and varies in width from three or four miles to twenty-five or thirty. In this belt it is estimated there are about 1,500,000 acres of land adapted to the safe cultivation of citrus fruits on a commercial basis.

The altitude ranges from 30 to 1,800 feet above sea-level. The mean summer temperature of this belt is somewhat higher in the northern portion than in the southern, but the mean winter temperature is higher in the southern than in the northern portion. The mean temperature for the year does not vary more than four degrees throughout the whole belt.

POLLINATION—HYBRIDS.

The mixing of the pollen among the flowers of the species has given birth to innumerable hybrids, distinguished as such and designated as varieties, by their remaining constant, *i. e.*, not reverting to the mother type after continuous propagation. With the constant multiplication of varieties it would be difficult to trace to what species many hybrids belong. Many partake of the lemon, the orange, and the citron.

The flower of the orange is nothing but a transformed branch, coming out of either the axilla of an ordinary leaf or from that of an abortive leaf, usually called a bract. This transformed branch, or flower, in the orange, consists of several whorls or transformed leaves, viz: the calyx whorl, the

corolla whorl, the stamina whorl or whorls, and ovary whorl or whorls. The latter, in the citrus fruit, consists ordinarily of two distinct whorls—the outer or rind whorl, and the inner or pulp whorl. The flowers of the greater number of species are single—possessing an abundance of pollen. Double flowers are often produced by the growth of additional whorls or petals.

Double flowers have a tendency to fruit-doubling. The peculiarity of these fruits exists in the ovary before fertilization, and the fruit exhibiting it may develop without having been fertilized. It has rarely any seeds, and when present are very small and imperfect. Such instances of seedless fruit plainly show that the so-called superfœtation could not have been the result of excess fertilization, as there are no germs to be fertilized, and even if there are any, they must be so imperfect that no fertilization can take place. This result might also occur from imperfection of the sexual organs.

The orange within an orange is nothing but a doubling of the fruit or ovary whorls. It is the result of the doubling of the flower. Gallesio says: "Certain varieties, like the double-flowered bergamot, when not highly cultivated and left to themselves, lose by degrees the character of giving double flowers and bear only single ones."

Artificial fecundation whenever applied has given varying results, and when the action was effected upon the ovules the fruit was not modified, but the ovules grew into seeds, which when planted produced trees and fruit entirely distinct from the parent trees.

Fecundation is effected naturally among pollen-producing flowers by insects, birds, the wind, and by friction. The moment the flowers reach maturity and are ready for fecundation the stigma of the pistil appears as if gummed with a honey-like substance, and serves to retain the dust-like pollen when applied to it. The flower with which to effect fecundation must be taken when nearly ready to bloom, must be thrifty, the corolla removed, and the anthers rubbed upon the stigma to be fructified. The operation is repeated until the stigma assumes its normal state, and care must be exercised not to miss the moment of blooming in the pistil.

Varieties of the orange are innumerable, and have of late

years been imported from all over the globe. While many of these possess good qualities, the majority lack the most essential characteristics to be worthy of culture for profit. Attempts to improve upon the varieties now fruiting have been made by cross pollination, but without results of much value, although numerous varieties possessed of some merit have been thus originated. The best results have been through Dame Nature, and chance seedlings of high merit have been produced without the aid of man. But while some of these imported sorts and home-grown seedlings have been planted quite largely throughout the State, the fruit, being devoid of special characteristics through which their qualities could be known to the trade and distinguished from the ordinary common seedling, often sell for no more, if as much.

The only variety produced by what may be termed a peculiar method of propagation is an exceptionally fine type of Navel by A. C. Thomson, of Duarte. The process, which is mentioned by ancient writers upon agriculture, was first applied in this State by Mr. Thomson, and was performed by a close intermarriage of the wood of several varieties, which, by growing together, resulted in a combination of the characteristics of the various factors. The secret of the operation lies in the matching of two half-buds of the same size and of different sorts.

The process Mr. Thomson describes as follows: "The bud is composed of two half-buds of the same size put together and inserted as one, waxed over, after being concaved to fit the convex side of the stock, and concaved a little also in the split so as to bring both edges of the germ together closely. This has to be done of course with a very thin, sharp knife. Now say, for instance, that one of the half-buds is a Washington Navel and the other half a St. Michael. These grow together and form one shoot. From this shoot next season take buds, and from Malta Blood take buds of equal size and maturity; split and unite these halves as one bud, fit them well and neatly together, wax over lightly, and cover with a wax wrapper; string will not do, as the buds would dry out. Next season again take these buds from this new growth and halve them with half-buds of Mediterranean Sweet. Here, then, you get a growth which includes all the varieties named. At

the end of three weeks from budding, the wrapper has to be removed and the buds examined with a magnifying glass. If the union is complete at the crown of the germ return the wrapper, to exclude sun and air until the bud starts to grow. Sometimes only one-half of the bud starts to grow; all such should be cut out and the budding done over again. Sometimes both halves die, or both halves grow separately. Then it has to be done over again on a new place in the stock. There ought to be at least fifty buds of each combination put in at the same time to cover failures."

Mr. Thomson has distributed a great many buds and trees among his neighbors and in other sections of the State. The trees have invariably continued to produce a thin-skinned orange and seemingly remaining constant. Many have claimed that the variety has not produced fruit as grown on the original trees, but Mr. Thomson says this has not been on trees which he has supplied. The buds then must have come from other trees that are not the true "Improved Navel."

METHODS USED IN HYBRIDIZING PLANTS.*

The process of hybridizing plants is in itself neither difficult nor mysterious, it being simply necessary to understand the general structure of the flower to be used. The flowers of the tomato, pear, and orange may be taken as illustrating the common forms, although, of course, very many modifications occur. The envelopes of these flowers, as in the case of the flowers of most cultivated plants, consist of two whorls of modified leaves. The outer whorl, which is known as the calyx, is commonly green like the foliage and is divided into several distinct or more or less united lobes, or sepals; while the inner whorl, or corolla, is usually of some bright color other than green, and its different divisions or lobes are known as petals. In some cases, as in the lily, the calyx and corolla are of the same color, so that they are not easily distinguishable; while in still other cases, as in oaks, walnuts, etc., the corolla is entirely wanting.

The essential, or sexual, organs of the flower, the stamens

*By Walter T. Swingle and Herbert J. Webber, Special Agents Department of Agriculture. Yearbook 1897, p. 385.

and pistils, are found inside the calyx and corolla, and it is with these organs that the hybridizer is most concerned. The stamens, or male organs, of the plant are usually several in number, and are composed of an upper swollen portion, the anther, which is borne on a more or less slender stalk called the filament. In some flowers, as in those of the tomato, the filament is very short, and in others is entirely wanting, the anthers being borne at the base of the corolla. The very numerous small, yellow, powdery grains of pollen, which constitute the male fecundating elements, are borne in sacks in the anthers. When the anther matures, these sacks burst open and the pollen is exposed. A quantity of this pollen must be transferred, either by natural or artificial means, to the stigma of the female organ in order to insure fecundation. The application of pollen to the stigma is designated pollination, and successful pollination—that is, the application of pollen to the stigma, followed by fecundation—is termed fertilization.

The pistil or pistils, which are the female organs, occupy the center of the flower and are surrounded by the stamens. The upper portion of the pistil is usually somewhat swollen and more or less rough. It is on this portion of the pistil, known as the stigma, that the pollen must fall to produce fecundation.

In the majority of plants the stamens and pistils are produced in the same flower, as in the tomato and orange, but in certain plants they are produced in different flowers on the same plant, as in walnuts, castor beans, etc., or on different plants, as in the willow, poplar, etc.

In undertaking to hybridize plants artificially, it is well to remember that in many plants the stamens and pistils when in the same flower mature at different times—a provision to insure cross-pollination (the application of the pollen of one flower to the stigma of another). In a large majority of such cases the stamens ripen first, discharging their pollen before the pistil is receptive. The most important feature in the work of crossing is to exclude from the stigma all pollen except that which it is desired to use. The prevention of self-pollination (the transfer of pollen to the stigma of the same flower) in perfect flowers—that is, flowers containing both stamens and pistils—necessitates the careful opening of the flowers intended for hybridization while they are still immature, and the cutting or

pulling off of the anthers before they burst and allow the escape of the pollen. This process is termed emasculation. * * *

In the manipulation of orange flowers mature buds nearly ready to open are selected and the tips of the corolla carefully pried apart until the stamens are exposed. In these flowers the anthers are attached to the filaments by very slender threads, which are easily broken, so that the simplest method of removing the stamens is to pull them off with fine-pointed forceps. The latter may also be conveniently used in prying apart the corolla lobes of the bud. During the process of emasculation in this and all other cases great care must be exercised not to open the stamens and accidentally pollinate the flower. All insects must be watched and carefully excluded. Fig. 3 shows an emasculated flower ready to bag.

FIG. 1—Orange flower bud, showing stage which should be selected for emasculation. (Natural size.)

FIG. 2—Mature orange flower. (Natural size.)

FIG. 3—An emasculated orange flower; *a*, shows where anthers were detached. (Natural size.)

(After Swingle and Webber.)

After emasculating the flower, a bag of some closely woven cloth or of paper should be carefully passed over the twig bearing the flower and tied around the stem below the flower in such a manner as to effectually exclude all insects and foreign pollen. The manila paper sacks used by grocers are employed almost exclusively for this purpose. In a few days after emasculation and bagging, when the pistils have had time to mature, the sacks must be removed and the pistils pollinated, after which the sacks should be replaced as before and allowed to remain until fecundation has taken place and all danger from the action of foreign pollen is over. In most cases the sacks should then be removed, as they are likely to injure the development of the fruit. In some cases, as in the orange, where the pistil is nearly mature when the bud is opened, the pollen may be applied to the stigma when the flower is emasculated, thus avoiding the trouble of opening the bag later.

The flowers selected for emasculation and hybridization should be full-sized, perfect in all respects, and conveniently situated. Those on the end of a twig frequently set fruit best. All the flowers on the branch which are not used should be cut off. Frequently several flowers of the same age can be selected on the same branch, emasculated, and inclosed under the same bag.

In hybridizing, many different methods are followed in applying the pollen. In most cases where an abundance of pollen can be secured the freshly burst anthers from one plant may be taken with fine-pointed forceps and rubbed over the stigma of the other until sufficient pollen has been transferred. This is probably the easiest and safest method in most cases. Some hybridizers transfer the pollen with a small ladle or camel's-hair brush, and occasionally this method may be found somewhat convenient, especially where the pollen is brought from some distance and has largely escaped from the anthers.

After each pollination it is of the utmost importance to label the bag in such a way that there will be no question as to what it contains. These labels should be allowed to remain after the bag has been removed. As fruits, like oranges, etc., approach maturity it is very desirable that they be inclosed in gauze bags firmly tied to the branches. Such bags allow the normal development of the fruit, protect it from being picked accidentally, and in case the fruit falls prematurely preserve it in connection with the label.

WHAT ARE HYBRIDS? *

The term hybrid is by many applied only to the offspring obtained by crossing two plants or animals sufficiently different to be considered by naturalists as distinct species, while the terms mongrel and cross are used to designate the offspring of two classes or varieties of one species. It was formerly supposed that all hybrids were more or less sterile, in contradistinction to mongrels, which were believed to be very sterile. It has been found, however, that many hybrids, in the narrow sense, are very fertile, and that some mongrels are nearly sterile. Since it is impossible to indicate by any two words, such as hybrid

* By Walter T. Swingle and Herbert J. Webber, Special Agents Department of Agriculture. Yearbook 1897, p. 384.

or mongrel, the various degrees of difference of the forms crossed, the word hybrid is here used, conformably to the Century Dictionary, as a generic term, to include all organisms arising from a cross of two forms noticeably different, whether the difference be great or slight. Adjectives are sometimes used to indicate the grade of the forms crossed, such as racial hybrid, bigeneric hybrid, etc. Where a hybrid of two species is crossed with a third species a trispecific hybrid results.

The offspring produced by the union of two plants identical in kind, but separated in descent by at least several seed generations, is often called a crossed, cross-fertilized, or cross-bred plant, but it is not a hybrid, as the essential character of a hybrid is that it results from the union of plants differing more or less in kind; or, in other words, is the result of a union between different races, varieties, species, genera, etc. On the other hand, flowers impregnated with their own pollen, with the pollen of another flower on the same plant, or even with pollen from another plant derived from the same original stock by cuttings, grafts, etc., are said to be self-fertilized, and the offspring resulting from such unions are also termed self-fertilized plants. With some plants, such as tobacco and wheat, self-fertilization is the rule. In many cases, however, the flowers are so constructed that cross-fertilization is necessary, all possibility of self-pollination being precluded, as in the case of hemp and other plants having the male and female flowers on separate individuals.

PURPOSE AND GROWTH OF PRIMAL TYPES.*

Nature, unaided by animate creatures, sets her aim and degree of excellence around one central purpose. It is to produce a germ to perpetuate her products, a seed, and within that seed a cluster of highly organized cells, that possess within themselves an impulse, and a power, under favorable conditions, to produce a type nearly identical with the parent.

We can not comprehend the structure of this tiny association of cells, the delicate adjustment of its parts which give us the variety of the orchard, the latent impulse that has been imparted to this wonderful unit of growth. It is that enigma

*By Wm. C. Fuller, of Colton, Cal.

SEEDLING TAHITI ORANGE—PRIMAL TYPE. (REDUCED.)

of life, co-equal and co-splendent with the human soul, the analysis of being.

It is a necessity with nature that every precaution of protection should surround this seed in its growth, to guard it against destruction, and to complete its perfect development.

The law of man's self-existence is, that when the seed becomes his food whereby he lives, every effort of nature must be seconded to make a perfect seed protection. When the seed is not his food, then we must change, or entirely eliminate, one or more of these natural guards, and allow other qualities to displace these protective qualities.

If wild areas were occupied by a species where the varieties could not mix by pollination, those varieties that developed vital seeds would thrive by perpetuating a race only slightly at variance with the primal type.

If the area was occupied by mixed varieties, those having the most virile pollen, or those the best sexed, would conquer in the race for existence, and only that variety remain which would be surrounded by the greatest protection against all possible enemies.

This would be accomplished by a change in each generation of seed, imparted to it by pollen possessing the greatest strength and enduring qualities. The growing plant from such a seed, having more resistance to climatic changes, more strength of root to forage in the soil, and more power of leaf to elaborate its fruit, would produce, first, intermediate varieties, and, finally, occupy the whole area with a variety indistinguishable from the strongest type.

Continuous cross-pollination would, with each generation, tend to eliminate the weaker variety, while seedless varieties would be destroyed immediately.

It is this known law in its action, in natural selection and adaptation, that the *Citrus vulgaris* var. *bigaradia*, or the sour-bitter orange, may be regarded as the primitive type of many of the California oranges. Whether or not this is the germinal and historic species from which the historic varieties came, it is *the natural protective type* to represent the purpose of nature in the production of seed.

Citrus Vulgaris, var. *Bigaradia*.—If nature had marked this tree and fruit with the sign "Touch not, taste not," she could

not have fulfilled her purpose in perpetuating its life better than she has with the disagreeable qualities and outside aids with which she has surrounded it.

The tree habits and fruit-growth differ from other varieties in many particulars. The tree is low for a standard, rarely reaching over thirty feet in height. This habit guards it from the effects of high winds and allows it to get the greatest benefit from the radiated heat, when the direct rays of the sun are spent. By its low, conelike growth the lower fruit is produced having great strength and character, allowing a small compact cell to do an immense work, in the leaf and root. The leaf is winged; the large petioles below the articulation act as a protection and help, in case of injury to the blade of the leaf by degrees of heat or cold, or lack of nutrition and moisture. The flowers are shortened, thick petaled, and diffused with color ranging from white to pink. The little investigation that has been given to the study of the nectaries, and their sweet contents, of the orange forbids a comparison with other varieties. As in this family of plants this characteristic is a staminal or male development, and by analogy with the known habits of wild flowers it is certain that the sour orange has large, well-filled nectaries, aiding, as does the color of its petals, the distribution of its pollen by insect agencies. While these organs may not be regarded as protecting the individual, as the thorns and bitter of the fruit, yet to the species and staminal varieties it is one of the essential means of self-protection in pollination by the aid of insects. The fruit is unsightly and rough, bitter and acrid. The oil is pungent and the fragrance heavy, as are the oils of the leaves and flowers. The pulp is sour and partakes of the bitterness of the rind. The oil cells are concave. The tree carries well-formed thorns distributed to the ends of the branches, and the fruit when ripe has strong germinating seeds for reproduction. Every quality and development of the tree is protective, and these staminal qualities have guarded its life, under adverse conditions, for centuries from destruction by birds, animals, and mankind.

The characteristics of the bitter orange are given in detail, as this orange, highly sexualized, and strong in its staminate and pistillate power, is a type for all, and has imparted some of its qualities to all the varieties of our orchards. How has

this orange with its combination of disagreeable qualities been changed and modified, and some of its qualities eliminated, to give us the Konah, the St. Michael, the Washington Navel, and other meritorious varieties?

Staminal or Male Characteristics.—By the law of vegetable growth, plants construct and form themselves; they increase and multiply themselves. The orange multiplies by the root growth of adventitious buds, that eventually form perfect trees; by cuttings; by the development of buds in the limb, that grow to branches and fruitfulness; and by a seed embryo developed in the ripened fruit. The adventitious bud in the root, and the branch bud are the result of the *sex impulse distributed through the entire tree structure.* The embryo of the seed is the result of special adaptations in the structure of the leaf. The perfect development of the nucleus of the seed is the strength of the united reproductive functions of the entire tree, and although the root and branch buds are liable to "sport" and give new or modified varieties, it is to the staminate and pistillate modifications that we must look for the primary changes in the fruit and tree habits of growth.

The least modification impressed upon the pollen impulse, and the receptivity of the ovarian cell, will change, modify, or eliminate some habit of the tree, or quality of the fruit, in the embryo and bud.

It is apparent that in the bitter orange of the *bigaradia*, the male or *staminal power is in the ascendancy.* The whole tree, in all its manifestations, is suffused by this power. It primarily affects the cell of the leaf, the branch, and root. It influences the vitality, the strength, and the compactness of the protoplasmic unit in the pollen germ. It is manifested in the heavy compact limb, the stout effective thorn, the resistant and strong terminal root growth, the thick leaf, the pungent oils, the bitter compounds of the rind and cells of the carpel, and in the capacity to resist the elaboration of sugar from the fruit acid, compelling the slow development of a strong germinative and generative seed.

Modifications in the Pollen Impulse.—Either by nature or cultivation the strength of the pollen impulse was changed. The staminate or male power of the bitter orange was acted upon,

and its supremacy destroyed. When that was accomplished, those qualities that nature used to protect the seed were either without necessity or modified to the changed habits of the new tree. As these changes were produced, the whole tree was acted upon to adjust a correlated growth. The germ cells were changed in their capacity to produce a constant type. The vegetative functions were immediately increased, and those parts of the tree impulse put forth a growth modifying those protective growths built upon the defense and perpetuity of the seed. As an immediate result of the loss in the pollen impulse, the leaf increased in surface. The root cells were enlarged and enabled to absorb liquids to meet an increase of leaf evaporation. The whole tree acquired a greater heat range and became more tropical. These modifications of the microscopic pollen cell in its constructive energy to maintain a permanent type are seen in the habits of growth and fruit of the sweet orange (*Citrus aurantium*) of our orchards.

Citrus Aurantium.—This orange is in such marked contrast to the bitter orange that eminent authorities have debated its origin, and have considered it a species equal with the bitter orange, and awarded to both the ancestry of whole groups of varieties. It carries a strong though weakened reproductive function. Its departure from the type of the bitter orange is in the loss of staminal power. The pistillate or vegetable growths have increased by a readjustment of plant energy in the floral branch which has weakened the virility of the pollen impulse.

When the two varieties are compared, the necessity for a different parentage does not appear. The lines of modification follow the generative impulse, and this possibility of the germ type to variation gives the key to unlock the cause of seed and bud variation in the great number of varieties and monstrosities. The generative force broken in the *type unit*, the combinations of its qualities were resolved into groups. The *type unit* being impossible, the *group unit* appears in the pollen, the seed, and the bud, giving us the varieties of the orchard, each having one or more characteristics of the historic type.

The sweet orange is intermediate between the bitter orange and the seedless varieties. In comparison with the bitter

orange the pistillate impulse has displaced the staminate impulse, which appears in a weakened reproductive function. The vegetative growths have increased; the leaf is larger and has lost its relative thickness, and except in new and rampant growths is nearly wingless. The thorns have lost much of their protective qualities and are easily changed to a branch, and in rare cases develop a sessile floral branch which tips the thorn with a flower. The changes in the fruit are marked. The oil cells of the rind are convex, and have lost the pungent oils, becoming more delicate in fragrance. The same comparative delicacy in the oils is seen in the leaf and the blossoms. The bitter compounds are freed from the inner cells of the carpels, and are only feebly present in the rind. The power to produce acidity is impaired, and the vegetative functions cause the tree to shorten its season of fruit-ripening by the aborted development of its seed.

In this comparison of the two varieties of oranges, the bitter and the sweet, we see the positive staminal qualities of the bitter orange are in the sweet orange either entirely eliminated, weakened, or replaced by the growth of negative qualities that could not be observed in union with the overpowering staminal qualities. We see that the sweet orange does not represent the complete unit of nature, but consists of a division of qualities, comprised in a large group only. However marked this change, our California seedling still retains the largest group of qualities representing the type of our orchard varieties.

Tendency of Orange Culture.—The tendency of orange culture in California is to displace, as far as possible, the type of varieties, as represented by the bitter and sweet oranges, and to extend the orchard growths in the direction of the variety that eliminates the seed growth and possesses only a small and sometimes feeble group of inherited qualities. This tendency arises from a desire to grow a sweet orange, and to a great extent is a misunderstanding of those qualities which, in combination, make a model fruit.

Variety Groups.—In the St. Michael we have a group of qualities that intensified the staminal impulse of the sweet orange, as shown in the production of seeds. It retains the

quality of late ripening of the bitter orange, and possesses a citrus quality of great merit associated with a heavy, compact cell growth.

In the Homosassa (or a variety known as the Homosassa), a Florida variety, we have a staminate group of qualities, giving to the fruit a high color, tending to seedlessness and an early ripening of the fruit. As we should expect from its tendency to depart from the development of seed, it is not possessed of the citrus quality of the St. Michael.

The Tardive, or Hart's Late, is an orange late in ripening, and with a feeble or impotent pollination. It is practically seedless. The rich coloring of the flesh, united with its slow maturity, allows this fruit to be picked in different stages of acidity. When well colored the citrus quality is past.

The Ruby Blood is an orange with a fluctuating group of qualities. It is deeper flushed than the Maltese Blood, sweet and early. It develops the navel mark like the Washington Navel, and then is of marked sweetness and has a freedom from seeds.

In the Sweet Seville, an orange unworthy of cultivation in California, we see the curious phenomenon of a division of the impulse of ripening. The cells of the flesh almost exhaust the acidity by its elaboration to sugar, while the cells of the rind are immature and green. When the rind is colored the fruit is insipid and worthless.

The Washington Navel, the great seedless orange of California, is the popular variety and its plantings exceed any other. Keeping in view the natural law, that a type must possess many qualities to develop and protect a seed germ and bud integrity to perpetuate itself, that these qualities must be the result of the staminal impulse imparted by the pollen to the perfected seed, and that a pervading staminal strength must be diffused in the entire tree structure for bud growth and development, we see in this orange from Bahia how far it is possible to change from the purpose of nature. We see a small group of negative qualities wrested from a natural type. The displacement of its parts, culminating in the markings at the apex of the fruit, and from which it has acquired its popular name, is constant. As an inconstant habit it is not uncommon. All the varieties have occasional developments of the navel mark. It is often observed in the common seedling, and is

very common in the Ruby Blood. It has been popularly believed, when seen in other varieties, to be the result of cross-pollination from the Washington or some other variety of Navel. In the light of recent investigations this is deemed impossible. Experiments the coming season will undoubtedly be made to substantiate this view. I am inclined to think that this was among the first changes in the bitter orange, to destroy the staminal supremacy of that fruit. Whenever a fruit carries this mark it produces less seed and carries greater relative sweetness to its acidity. The original plants were received at Washington from Bahia, Brazil, and a number were sent by the Government to Florida and California for cultivation. The different results of cultivation and environment in the two areas show marked tendencies in tree development and fruitfulness. These questions arise: Were those plants of uniform excellence? Did the Florida plants possess the same inherited qualities that the California plants possessed? Did the trees received at Riverside each possess equal excellence as a budding stock, and does the tree now in Washington possess the average inherited qualities of those in California and Florida? Satisfactory answers to these questions have an important bearing in solving the cause of the different developments of the variety as grown in the two areas. If there were inherent qualities of variation in the plants distributed to the two areas, the difference in the habits of tree growth and fruitfulness would be in part accounted for. If plants of known purity of strain were exchanged by the two sections, Florida and California, consisting of well-developed buds, on both the sour and sweet stocks, and planted in average climatic conditions in the two areas, should show a tendency to change their habits of growth and fruitfulness, then climatic conditions would be considered a cause sufficient for these effects and the question of type inheritance be answered. Buds from the tree at Washington distributed to the two sections and treated as those exchanged by the two producing areas would further simplify the solution of inherent qualities.

Navel Unfruitfulness.—The orange-growers of Florida observed the unfruitfulness of the Navel, in that State, early in its history. This seemed to show itself in the young trees as well as in the older orchards. The absence of pollen was noticed, and its

unfruitfulness was attributed to this unsexed development of the navel bloom. Professor Webber, of the United States Sub-Laboratory, was led to believe that the Navel in California produced an abundance of well-developed pollen, which was the cause of its fruiting in this State. Professor Cook observed, some time since, the absence of pollen in the navel bloom in California. This discovery established the *normal* unsexed quality of the Navel, in both the great areas of Florida and California. The staminate, or male, impulse is aborted and fails to produce developed pollen grains, or if it occasionally appears, is a lingering impulse belonging to an incidental floral leaf. The impulse still exists to produce a weakened staminal bud development. As this development is arrested in the stamens and is only feebly present in the bud, just sufficient to cause the growth of the floral whorl bearing an anther without pollen, it would seem as though the staminal impulse was a quality pertaining to the root and in nowise dependent on the vegetative processes of the leaf, and in the Navel it is as though nature had almost withdrawn this force from the Navel tree and dissipated it in a vigorous root growth.

When it was known that the Navel was not self-pollinated, it was affirmed that it was fruitful from the action of pollen from other varieties planted in close proximity. The proof of this was asked by Professor Webber and the question was submitted to Mr. E. W. Holmes and Mr. J. H. Reed of Riverside, where large areas were planted far from pollen varieties. These able observers, aided by other horticulturists, have failed to detect any difference in the fruitfulness of the Navel when grown far from other varieties and outside the area of mixed pollination.

Mr. B. M. Lelong, along the same line of investigation, says: "Cross-pollination only tends to the production of seeds, and can not in any way increase the production of fruit." Professor Webber says to the same effect: "That we should not take means to secure the cross-pollination of our Navel trees, hoping thereby to secure a larger crop of fruit. The effect of the cross-pollination apparently being the production of seedy fruit, but not necessarily more fruit."

From these experiments and observations we may conclude that in the two great areas of Florida and California, the Navel

will fruit without pollination, and that fecundation will not increase fruitfulness in either area, but simply cause the development of the embryo into rudimentary or perfect seeds.

Professor Webber, in a series of experiments in artificial pollination of the Navel, proved by them that some of the pistils of the Navel could transmit the impulse of the foreign pollen to the ovules of both the Washington and the Parson Navel, and that the embryo developed into full and perfect seeds, carrying a marked individuality, so apparent that from photographs of these seeds their form and appearance indicated the variety of pollen experimented with.

We can infer from this how few are the qualities and how small the group is that remain of this variety to represent a type. This shows the Navel to be very sensitive to climate and treatment. The climate of Florida destroys its profitable bearing in that State. Its fruitage, as a profitable orange in Arizona, from information received from that Territory, is an experiment which indicated that it will not be profitable to cultivate it there. Its area of fruitage is therefore confined to California, as the only area in the United States where the conditions exist for its development, and in many locations and areas in this State where planted conditions will be found as unsuitable to its best growth. Its fruitfulness and habits are too sensitive to climatic changes and treatment to sustain the universal confidence reposed in it as a variety to plant in all conditions and soils. The orchardist should be enlisted to plant more sexualized varieties to guard his future interests.

Results of Experiments.—These experiments and observations are valuable, showing—

(1) That the Washington Navel is without staminal development of pollen.

(2) That it fruits without the aid of foreign pollen.

(3) That pollination would not increase its fruitfulness.

(4) That the pistillate, or female quality, exists in the capacity to produce seeds, but is modified and fails to impress its growth and transmit to it its own characteristics.

(5) That the readiness of the pistil to respond to artificial pollination, and its absence from seeds where an abundance of free foreign pollen has been distributed, show a weakness in the pistil to exude the adherent solvents to attach the pollen

germ and excite germination, or a weakness of the nectaries to furnish sweets to attract the natural insect aids.

(6) That the capacity of the Navel to produce pollen is an inherent weakness of the staminal impulse in the tree and is not dependent upon climatic conditions. This removes the Navel from the varieties that can be modified by germinal changes in the embryo or seed, and classifies it with those varieties which will show modifications by adaptation in their bud development only. That if the same inherent bud qualities were possessed by the parent trees of Florida and California, unfruitfulness of the Navel variety may be expected to appear in the orchards of California.

Adaptability.—The great questions of profitable and successful orange culture in California are the adaptability of each variety to an area that will produce, as far as possible, a perfect fruit, and the selection of such groups of qualities that will meet a market demand during the season.

That one principal variety, like the Washington Navel, can fulfill these conditions is impossible. Several well-chosen varieties will meet the market demand.

If a relatively sweet orange for the early market is desired we should choose one in which the processes of fruit growth hasten the period of ripening, as in the Washington Navel and Homosassa—one the great seedless orange of California, and the other a modified staminal type. This caution should be given as to the Navel and all seedless varieties.

There is a subtle and delicate citrus quality that must be associated in all the qualities of an orange. It can only be described by saying that it appeals to the intellectual perceptions, as that natural goodness and excellence inherent in the choice products of nature. This can be eliminated from the orange and render the fruit insipid and valueless. We must be careful in the selections of stock and bud so that we will draw toward this noble fruit and gift of nature the happy union of staminate and blended qualities that awards this halo of ambrosial excellence.

If we select the late varieties—the St. Michael and the Tardive—we will have in the first a strong late orange, and in the last a seedless orange, both of good qualities. Could we add a seedling, a medium early, sweet, with few seeds, and a

fine citrus quality, we will have oranges that will supplement the Navel with comparative excellence and meet all market demands.

With the varieties modified and adapted to the best climatic areas to produce the best fruit, and perpetuated in bud and seed by scientific direction to respond to normal productiveness, growth, and longevity, a foundation will be laid to rear a great and glorious State.

PERIOD OF FRUITFULNESS.

There seems to be quite prevalent a belief or impression that the period of profitable production of the Washington Navel orange ceases after the seventh or eighth year.

*"It is not claimed that our trees are short lived, but that their period of fruitfulness is to be short, and that the budded varieties differ materially from the seedling in this regard. But has such a difference been shown to exist in their actual periods of fruitfulness? Let us make a comparison. In the first place the Navel and seedling are both upon the same root, and therefore start out in life upon the same footing. For the first seven or eight years the seedling tree draws upon its plot of ground for such elements of plant-food only as will produce growth of leaf, limb, and root, asking for no fruit-forming material, as it has made no fruit. It then begins to use sparingly of its reserve materials, and within the next seven or eight years it will so nearly have exhausted the fruit-forming elements in the natural soil that it no longer produces profitable crops, they being small in quantity and inferior in quality. Now, in the case of the Navel tree, you have taken a bud from a precocious variety of tree, and by uniting it with a seedling root have produced the most ravenous feeder of the citrus family, and also the most perfect machine for making superb fruit yet known to the business. It is not content with the slow, plodding habit of the seedling tree, but even in its second year begins to dig up the necessary materials for constructing fruit, and it will continue to do so in an increased ratio until about the same length of time occupied in the process of the seedling, when it too will have used up so much of its available

*C. E. Bemis, in essay read at Farmers' Institute, at Covina, November, 1899.

material that it can no longer increase its output; the difference, if any, in the time occupied being easily explained by the superior texture and greater amount of nutriment contained in the Navel over the seedling fruit."

THE AGE OF CITRUS TREES.*

Apparent Deterioration in Old Navel Orchards—Due to Improper Management.

The questions I here present are, then: Is there a lack of vitality in the tree as it grows old? If there appears to be, what is the cause, and can we remove it?

I find that there is a radical difference in the condition of the oldest groves. Some are marvelously beautiful and productive, and others are light of color and scant of fruit. In some fairly good orchards there are sections in which the trees are unhealthy, and this to an extent to reduce the yield to an unsatisfactory figure. The fact that the good and bad orchards, and the large number which are neither very good nor very bad, are located under practically identical conditions of soil, climate, and irrigation facilities, is proof enough that the cause of unsatisfactory conditions of tree and product is not due to any constitutional weakness of the tree, but to differing methods of treatment.

I am thoroughly convinced that the tree is above the average in vitality, and that there is no justification for the belief that it is to become nonproductive as it grows old.

It is a fact which can not be denied that many of the oldest orchards are yielding light crops, and that their foliage lacks that dark rich green characteristic of the thoroughly healthy orange tree. But I am satisfied that the fault is not with the tree, but with the owner. It is true that the young bearing orchards average better crops than do the old ones. But it is also true that the very best trees, the richest foliaged and heaviest bearing, are the oldest in the valley. These facts seem to point clearly to causes outside the tree itself for the

*Extracts from report of E. W. Holmes, of Riverside, who, at the request of the Riverside Horticultural Club, made an investigation regarding the alleged tendency of the Washington Navel orange tree to fall off in productiveness with the approach of age. In "Press and Horticulturist," January 6, 1900.

unsatisfactory condition of many orchards; and, having satisfied myself that many of the oldest orchards are the best, I have thought it well to endeavor to discover why it is that orchards adjacent to those which are most healthy and prolific are sometimes either a burden to their owners, or, at best, return but very moderate dividends.

It can not be doubted that to three or four causes is due the failure of many groves. I do not mean absolute failure in all cases, but failure as compared to the best. I do not think the average orchardist will admit his fault in the matter. I find a majority deny conditions in their groves which are apparent enough to an unprejudiced investigator. I am convinced that:

First—We do not feed the trees sufficiently. The Navel bears every year, and sooner exhausts the soil of the essential elements than such trees as rest from time to time.

Second—We do not stir the soil to a sufficient depth, nor do we take all the pains we should to pulverize it finely. In rich, red, clayey soil, most prized because it produces the highest colored and best keeping fruit, there is invariably a tendency to form a crust of somewhat impervious soil below the depth regularly reached by the plow and cultivator. This is hardly "hardpan," such as is found in some sections. It will allow the roots to penetrate, and softens into cultivable shape if irrigation is long continued. But it is sufficiently hard to prevent the penetration of ordinary irrigation, and to prevent the soil from receiving the full benefit of the soluble fertilizers applied. It prevents the aëration of the soil, without which the essential process of nitrification is impossible. In nine out of ten of the orchards examined I find evidence that its presence has rendered partially useless much of the fertilizer, water, and labor used.

Third—The disposition is to economize by delaying the application of water in the hot season until the tree plainly manifests its need. This policy, at least in a soil like that of Riverside and Redlands, is a mistake. I admit that by the use of manures which lighten the soil it can be made to absorb and retain water and fertilizer, and that such treatment is a valuable aid where water is scant; but I find the best results obtained where no attention is paid to the theory of infrequent irrigation, and water is regularly supplied.

A fact to which I wish to call your attention is that in every

one of the healthy and productive old orchards these three points of treatment are faithfully attended to, while I find not one of the ordinary or inferior orchards in which either one or two, and sometimes all three, are disregarded. I do not mean that they are intentionally ignored in the latter class. The owner hasn't the means to properly manure his orchard. He follows the conventional method of cultivating, and would be surprised if one should intimate that his work was lacking in thoroughness. He runs water in abundance, and often enough, but the shallow stirring of strong soil prevents its proper penetration. It has been a surprise to myself to find that I have failed in thoroughness, and I am sure that if others shall examine they will find that there is need of improvement. Old orange groves will not be profitable unless we use intelligent methods.

Where unhealthy trees exist because of a shallow soil, or where the rise of surface water has made the locality unfit for citrus fruits, or where the frost too often does injury, what I have said does not apply. Such conditions it is impossible to overcome.

No man can study the condition of our older orchards without having proof supplied of the truth of the scriptures to the effect that "To him who hath shall be given." Men of wealth who dare to invest heavily in fertilizers every season, and whose orchards want neither for intelligent labor nor for irrigation, are the ones whose dividends are assured and regular. Handicapped with a heavy mortgage, the intelligent and shrewd orchardist may be forced to try to extract profit from his grove with the least possible annual expenditure, and may make thorough cultivation and faithful attention serve fairly well with a scant supply of fertilizer. But he can not attain the results achieved by him who adds to these methods the ability to furnish the fertilizing elements needed.

I have pointed out the fact that certain old orchards have maintained health and productiveness, while others, having equal if not superior natural conditions, have proved either only moderately profitable or a source of loss to their owners. Many of the less successful groves have not apparently been neglected, and, it may be, have failed to use only one of the three essentials to success. It is possible that the calling of the attention of their growers to the practices which have won most marked success may lead them to appreciate the need of

improving their methods, instead of drifting along in the easier, conventional way which is common. Young orchards generally pay while the soil is virgin and its abuse has not begun to affect the product. It will be well if the conceit which has always characterized the residents of each young fruit settlement shall be eliminated before its orchardists discover that to maintain the reputation of their horticultural youth there is need of constant and faithful labor, and a generous feeding of the soil before its best elements shall have been extracted. Providence has given to each orchardist, in the natural fertility of his soil, a little capital with which to work. He can not draw upon it without loss, and permanent prosperity depends upon maintaining it. It is because this is gone that we hear of the decadence of the older orange trees, and to nothing else. The pioneers have had some expensive experiences, and it will be well if the later comers shall benefit by them.

General statements regarding my conclusions may have more force if I give brief reference to the methods of successful growers. There are few orchardists in Southern California who are better known for the quality of their fruit than W. H. Backus. Though he has never aimed to unduly force his trees, he has had uniform success in securing regular crops of fine-textured fruit. His orchard is one of the very oldest, and his trees have the disadvantage of having been planted only a rod apart. The soil is heavy. If there were anything in the claim of the deterioration of the Navel tree it should find justification here. And yet the trees are generally fine in color, and always well loaded with fruit. What methods have maintained the uniform excellence of this orchard? Mr. Backus has always used fertilizers generously, always given from a ton to a ton and a half to the acre. He says he made the mistake of using a smaller quantity than usual last year, and applied it too late, and is satisfied he is a loser by so doing. He thinks it is a serious mistake to wait until the trees show need before giving water. To allow the soil to bake once is to make all subsequent irrigation less effective. He has always cultivated deeply, and considers this one of the fundamental causes of his success. Mr. Backus has never failed of good results with any of the high-grade manufactured fertilizers, and he will continue to use them.

Another old Navel orchard is that of Ernest Meacham. He has five acres of trees, twenty-two years of age, planted a rod apart. He has attained results so much superior to some of his neighbors that his methods are worth considering. Having considerable livestock, he uses his stable manure by making a dead furrow across the regular irrigating lands, into which he puts it while fresh, three to five feet to the tree, immediately covering it with the plow. In the course of the year he gets over the whole place in this way. This sends the nitrogenous matter deep with the rains and irrigating water, and the soil is made mellow by its presence. In the late winter he applies ten to twelve pounds of guano, with which is mixed three per cent of potash and five per cent of sulphate of iron. He irrigates thoroughly every thirty days in summer, and his appliances of his own devising for deep furrowing and thorough cultivation close up to the trees, while his team walks in the center of the land, are worth examining. These trees are exceptionally fine in color, and the quantity and quality of the fruit are remarkable. There isn't a sick tree in the lot, except one or two attacked by gophers. For several years this five-acre orchard has yielded between three and four thousand boxes of oranges, running perhaps ninety per cent fancy. This orchard most effectually demonstrates the vigor and productiveness of the old Navel tree when properly cared for.

Everybody knows the Barny orchard, the largest of the original Navel orchards. It has always had the best of care, and, if anything, has been over-fertilized at times; and yet, in spite of the harm the terminal branches got from the April frost of two years ago, is marvelously beautiful to-day, with its dark green foliage and heavy crop of splendid fruit. It has water regularly, and is always thoroughly cultivated.

I might multiply such evidences of the effect of proper treatment, in every one of which the three points I have referred to are those in which they differ from the less successful.

It is, however, proper to give a type of another class of orchards in which success has been attained where no special effort at ideal cultivation and irrigation has been attempted. Such a one is that of D. P. Chapman. It is an old orchard of ten acres and has yielded from four thousand to seven thousand boxes annually for many years. I can find no other cause for its superior and constant yield but the fact that its owner never

loses a chance to apply any kind of manures, natural or artificial, which he believes good. Such applications, with average treatment as regards soil and water use, have proven a good investment. If there is a criticism due here, it is that excessive use of nitrogen may have caused rather more than the usual scab among the trees.

Another experience, valuable as illustrating the effect of the best treatment upon a comparatively young Navel orchard that had suffered from the March frost, is that of A. P. Johnson. In spite of the fact that a large proportion of the bearing wood had been removed, a heavy application of fertilizer, properly applied, brought not only a very profitable crop the following winter, but, with a later generous application, a crop the present season, which, for uniform excellence, it is hard to excel. Mr. Johnson's old seedlings, upon which he has put, perhaps, seventy-five cents' worth of fertilizer to the tree, appear to have twenty to twenty-five boxes of fruit each at the present time.

But the transforming effect of heavy fertilizing is more conclusively shown in the old Kearn place, which, starved and neglected in past years, had a crop last season not worth the cost of picking, while to-day, as the result of expending ninety cents to the tree for fertilizer last year, there is a transformation in appearance and a crop which will give a handsome dividend. I mention this not as directly bearing upon the main topic we are discussing, but as showing the effect of generous expenditures in restoring the health of an orange grove. The cure for tree weakness and nonproduction is simply proper tree food in ample quantity, timely irrigation, and deep and thorough cultivation.

THE ORANGE.

THE SWEET ORANGE.

Citrus aurantium dulces, Linn.

The sweet orange belongs to the natural order *Aurantiacæ*, and the origin of the different members of this citrus family is extremely doubtful, having been cultivated from a remote period of antiquity, but is supposed to belong originally to

A. Compound unifoliate leaf of the orange (*Citrus aurantium*). 1. Point of union, marked by an articulation; 2. Petiole, winged on both sides; 3. Lamina; 4. Flowering branch of *Citrus bigaradia*; 5 and 6. The fruit; 7. Flower complete: 8. Pistil; 9. Transverse section of ovary. (After Haldane.)

China and India, and was not taken to Europe until centuries after the Christian era. Its cultivation has been confined to the countries adjacent to the Mediterranean, for only there is the climate suitable for its best development. Seedling trees under favorable conditions have lived for centuries. At the convent of St. Sabina, at Rome, there is a tree 32 feet high which is

said to be over 600 years old; and another at Hampton Court, grown under glass, over 200 years old. Spain and Sicily also have trees of great age. At Versailles there is a seedling planted in 1421. At Nice there is a tree 50 feet high, with a trunk over 3 feet in diameter, which is said to produce 6,000 to 7,000 oranges in a year.

The flowers are white, the leaves lanceolate or oblong. The petiole is not so markedly winged as in the bitter-sour orange, but is always present to a greater or less degree. The fruit is generally an oblate sphere, pyriform or elliptical, of a golden color when ripe, and full of delicate pulp and sweet, refreshing juice.

Seedlings of *Citrus aurantium dulces*—yearling plants.

SEEDLINGS. — *Primary root* stout, tapering, twisted, furnished after a time with a few lateral rootlets, longitudinally ridged and furrowed, at least when dry.

Hypocotyl subterranean, short, stout, curved, longitudinally ridged, colorless, 2–3.5 mm. long.

Cotyledons two, opposite or frequently alternate, colorless, fleshy, not leaving the testa, but very often compressed and shapeless, owing to the presence of two, three, or four embryos in the seed.

Stem woody, erect, terete (striate when dried and somewhat twisted), pale green, glabrous or minutely pubescent; first internode 2.5–4 cm. long; second, and sometimes the third and fourth undeveloped, or the third 3 mm. and the fourth 2.25 mm. long.

Leaves simple, cauline, alternate, exstipulate, petiolate, evergreen, shining, coriaceous, thickly dotted with immersed glands, strongly odoriferous when bruised, glabrous.

Nos. 1 and 2. Generally opposite by the nondevelopment of the internode, more or less obliquely obcordate and appearing deformed; very shortly petiolate.

Nos. 3 and 4 (in specimen examined). Alternate, elliptic, obtuse, obso-

letely serrate, minutely emarginate, with alternate, ascending lateral nerves; petioles channeled above, narrowly winged, articulated with the stem below and the leaf above.

Ultimate leaves oblong-ovate, acuminate, emarginate, minutely and obsoletely serrate, pellucidly punctate, with a thin marginal line of larger glands; lamina articulated with the winged petiole, which is ovate in outline, with a short, stout, not winged base.—Sir John Lubbock, "Contributions to Our Knowledge of Seedlings," Vol. I, 1892.

ORANGE TYPES—VARIETIES.

(*a*) Seedlings* that have lost their parental characteristics through degeneration;

(*b*) Modified Seedlings, types produced by chance, through natural intermixing of pollen, with characteristics unlike their parent, remaining constant, but with tendency to revert to the mother type;

(*c*) Hybrids.

(*a*) SEEDLING TYPES, produced by chance.

Mayberry's Premier.—Originated at San Gabriel.

Cooper's Seedling.—Originated at Santa Barbara.

Kercheval's Queen.—Originated at Los Angeles.

Baldwin's Favorite.—Originated at San Gabriel.

Nicaraguan.—Originated at Los Angeles.

Tahiti.—Originated at Los Angeles.

IXL.—Originated at Los Angeles.

Eureka.—Originated at Los Angeles.

Acapulco.—Originated at Los Angeles.

(*b*) MODIFIED TYPES, produced by chance, the embryo in the seed having been influenced by natural cross-pollination and remaining constant.

Wolfkill's Best.—Originated at Los Angeles; fruit somewhat flattened and medium to large, deep orange red, fine grain and pulp; ripens early.

Konah.—Originated at Los Angeles. Fruit large, rough and thick-skinned; tree very thorny; ripens early.

Joppa.—Originated at San Gabriel. Fruit medium to large: oblong, and uniform.

Wilson's Best (syn., Lake Vineyard).—Originated at San Gabriel. Fruit medium to large: tree handsome grower.

(*c*) HYBRIDS.

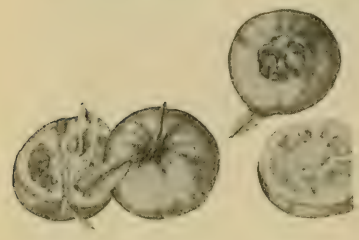
*The term "seedling" is applied to any type of orange reared indiscriminately from seed.

Navel Type.

WASHINGTON NAVEL.—This variety is the most widely known and is properly styled the "king of oranges." The fruit has proved of such exceptional quality and is in such general favor that its production overtops all other varieties.

The name "Washington Navel" was applied to this variety in California, to distinguish it from the "Australian Navel," a shy bearer with a similar peculiar mark, and because it was received from Washington, having been imported from Brazil by the Department of Agriculture. It was for a time called "Bahia" (place of origin), also "Riverside Navel," denoting the locality where the first trees were planted, and which are the parents of all trees of this variety in the State.

The first orange shipments consist of the Washington Navel, which constitute over one half of the output, but it is shipped later in the season, extending into June and July.



First picture of the Navel orange on record.

Fruit large, highly colored, solid and heavy, skin smooth and of a very fine texture, very juicy, highly flavored, with melting pulp, seedless (except occasionally—evidently the result of pollen influence). Tree semi-dwarf, good and prolific bearer, medium thorny, a rapid grower and early bearer. Foliage deep green, heavy and compact, leaves large and prominently winged. Branches deep green and smooth, inclined to roundish. Stock sturdy, with well-balanced limbs. The blossoms are double (having a secondary blossom within), and rarely have any pollen. Ripens early.

Most of the early publications of Brazil mention the *Lavanja de ombigo*—Navel orange. The first illustration of the Navel orange appears in a volume, "Table XVI—Historiæ Naturalis de Arboribus et Fructibus, Libri Decem. Johannis Jonstoni, Medicinæ Doctoris. Francofurti o/m, MDCLXII" ("The Natural History of Trees and Fruits, Ten Books. By John Johnson, Doctor of Medicine. Frankfort on Main, 1662"), referred to as *Aurantium fœtiferum*. The accompanying illustration, photographed from the original plate in the library of Prof. Edw. L. Greene, of the Catholic University of America, at Washington, D. C., was secured through the kindness of Wm. A. Taylor, Assistant U. S. Pomologist, to whom the writer is

CLUSTER OF WASHINGTON NAVELS—"KING OF ORANGES." (REDUCED.)

indebted for assistance. Although no description of the Navel orange appears in the text, this is the earliest reference known.

M. George Gallesio, Auditor of the State Council and Sub-Prefect of Savona, in a treatise on the citrus family, written early in the last century, makes mention of a variety of orange, double flowered. The author describes the *Aurantium fœtiferum* as presenting a superfœtation, an imperfect development of many germs inclosed within another or united under the envelope or an exterior germ. Those descriptions undoubtedly refer to the Navel orange. Thus it would seem that the navel formation is of great antiquity. The navel mark shows in the fruit as early as it can be examined, which in its development the *navel* is itself a secondary orange, in some specimens having a distinct skin surrounding it.

Mr. Wm. Saunders, of Washington, D. C., to whom the world is indebted for the introduction of the Washington Navel orange.

History of the Introduction of This King of Citrus Fruits.—*"During the Civil War a woman who had been sojourning in Brazil told Mr. Saunders that she knew of an orange at Bahia, Brazil, that excelled any other variety she had ever tasted or heard of. He sent there and had twelve trees propagated by budding and sent to him, in 1870. They all grew, and some of them are yet bearing fruit in the orange house at Washington. None of the original trees was sent out to the public, but all were there used as stock from which to propagate by budding. Many young trees were budded from them and sent to Florida and California. Early in 1873 Mrs. Tibbets was in Washington, just previous to going to her new home at Riverside, California. Mr. Saunders offered to give her some trees of this new and untried orange and she most gladly accepted two trees. She and her aged husband planted them beside their cottage, and when they bore fruit it was

*Prof. H. E. Van Deman, in "Rural New Yorker," June, 1899.

found to be equal to the most extravagant reports of its quality and size, and the trees were very prolific in that section. The trees sent to Florida produced equally good fruit, but they did not bear well. This is why many fruit-growers thought there was more than one variety in the lot of trees imported from Brazil; but the difference in fruitfulness came from climatic causes, as has been most thoroughly proved by many years of experience in all the orange-growing sections of the country. It has also been said that there was only one tree at the Tibbets place, and that it was unlike the other trees bearing the

LUTHER C. TIBBETS AND WIFE.
The parents of the Washington Navel orange industry in California.

same name. But this is a mistake, for I have gathered and eaten fruit from these two trees and had their history direct from Mr. and Mrs. Tibbets, also from Mr. Saunders. Besides, I have critically examined the trees of Bahia in bearing in many parts of Florida and California, and compared them and their fruit in many ways, and found them to be identical, except in variations caused by climate, soil, and culture. The orange is truly seedless and utterly devoid of pollen, and the pistils are also deformed in such a way as to render seed production from the pollen of other varieties an impossibility, except in a few *very* rare cases in which seeds have been found. It is this malformation of the pistils or embryonic ovaries that

causes that peculiar umbilical mark, either large or small, which gives the name 'navel,' by which this orange is commonly known."

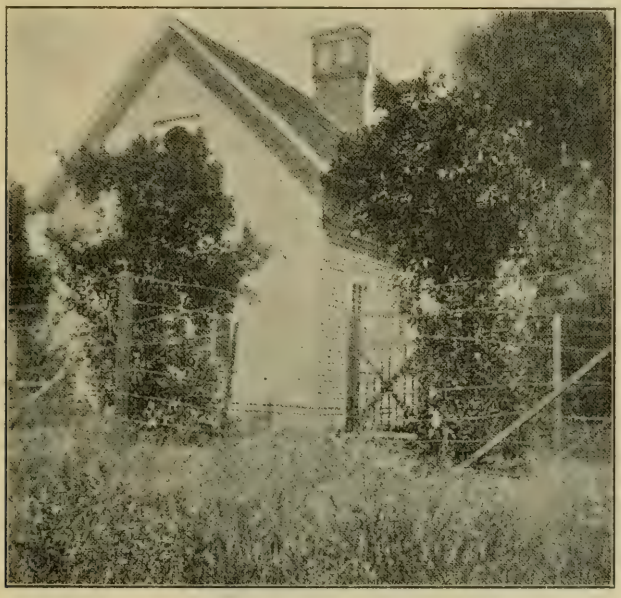
*"The first fruit brought to general notice was at a citrus fair in Riverside, in 1879, where it received prompt recognition. From that time forward its propagation was rapid, until to-day vast areas are devoted to its culture. The trees originally imported from Brazil still stand in the greenhouses at Washington, but those that were sent out to the growers of the citrus-producing sections of the United States were small stocks budded directly from the imported ones. It is worthy of most careful

Most remarkable orange "sports" on record. A "Navel" with a perfect orange outside its fruit bud; and one with a perfect orange, skin and all, inside it.

note that the valuable qualities which make the Navel the greatest of oranges developed in their entirety only upon the Pacific Coast. The peculiarity from which this orange derived its name is a navel seal, or trademark, of great importance to its grower—an unmistakable protuberance at the apex or blossom end of the fruit, not unlike the navel of the human body. In a seeming effort to break forth from its confinement, the bud often takes the form (especially in late blooming) of a diminutive orange. This mark varies greatly in size from a dim outline to oftentimes a monstrosity, readily distinguished in the accompanying engravings from nature. Besides these normal developments specimens are sometimes found with a section of the fruit in a raised or sunken panel, with pro-

* Herman H. Monroe, in "Land of Sunshine," May, 1899.

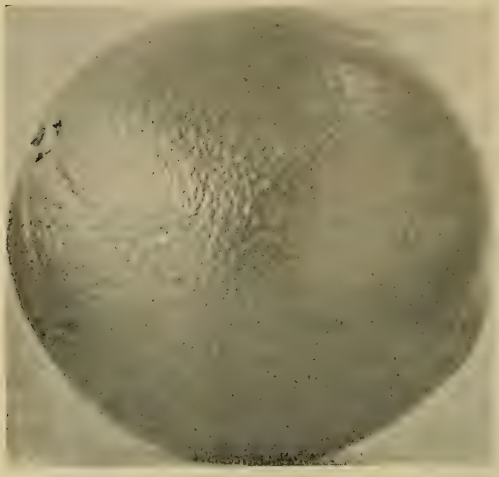
nounced difference in coloring. While some are disposed to believe that through its golden-bronze skin shines the lighter blood of a remote ancestry, others in turn find an excuse for its sporting in the theory that adjacent trees bearing fruit of a different variety may by pollination stamp upon it the insignia of their species—for the Navel is more susceptible to change than any other type. From reports of the United States consuls in the orange-growing countries of the entire world, it is clear that in no other country on the face of the globe is the



Original Washington Navel orange trees, at the Tibbets homestead, Riverside, Cal. [Removed April 25, 1902, to the head of Magnolia Avenue.]

culture of the orange so successful as in the Golden State, where the climatic conditions and soil are so well adapted to its perfection of character. There are two colossal old trees, 'Los Migueletes,' in Mairena del Alçon of Seville, which are recorded to have borne each thirty-eight thousand oranges in a single season, and those in the garden of the Alcazar, at Seville, said to have been planted at the time of King Pedro I., and others whose hollow trunks still support luxuriant foliage, which might have afforded shade for Charles I., for they date back three hundred and forty years. While the original Cali-

fornia pair may not command the admiration that do the historical ones cited, they should merit the fostering care of a grateful people, for they revolutionized the orange industry in its infancy throughout California, and made possible great profits in the development of an orange which is unsurpassed in the world. To-day, these trees, whose progeny has amassed millions, stand apart from their fellows, receiving meager attention, but still producing 'golden apples' in limited quantities—one which I was allowed to pluck showing a measurement of twelve inches in circumference and weighing a trifle over a pound."



Thomson's Improved Navel—reduced.

Cross-section of Thomson's Improved Navel—reduced.

THOMSON'S IMPROVED NAVEL.—Originated by A. C. Thomson, of Duarte. Fruit large and solid, juicy and sweet, of very fine texture. Rind very smooth, oil cells small. Tree is very prolific, and bears early.

AUSTRALIAN NAVEL.—Fruit seedy, varying in size from large to small, and splits at the navel, which is usually large and prominent. Tree strong grower, but a very shy bearer.

River's Navel.—Fruit medium, ripens late. Tree large and productive. Grown extensively by A. S. Chapman, at San Gabriel, who considers it one of the best varieties to grow.

Double Imperial Navel.—Imported from Florida; inferior.

Whitney's Seedless.—Florida.

Atwood's Seedless.—Florida.

Ormand's Prize.—Florida.

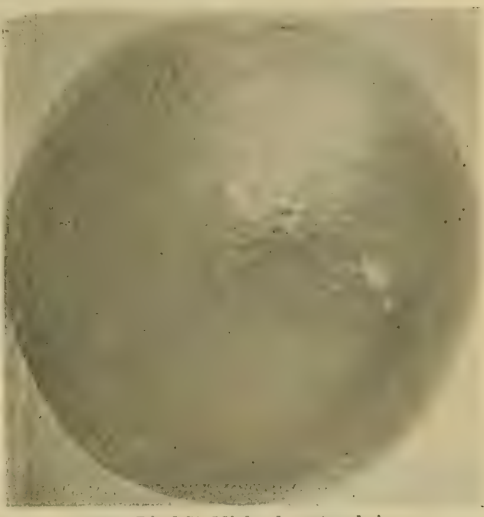
Sanford's.—Pink-tinted flesh; Florida.

Navel Blood.—Florida.

Brazilian Navel.

St. Michael Type.

Paper-Rind St. Michael.—Fruit small, round, very firm, and very juicy; pale, thin skin; grows uniformly in size. Ripens late and keeps well on the tree. Tree of a semi-dwarf habit, medium thorny, a good bearer. This is the thinnest-skinned orange grown, and is very popular.



Paper Rind St. Michael—natural size.

Small St. Michael. Fruit very small; has thick, coarse skin; inferior.

Large St. Michael. A variety without possessing the St. Michael characteristics. Fruit large and coarse; tree thorny.

Azorean St. Michael.—Fruit medium to large, solid, pulp fine and melting, medium thin rind,

Cross-section of Paper Rind St. Michael—natural size.

flattened, few seeds. Ripens early and keeps well on the tree. Tree is a rapid grower and a prolific bearer.

St. Michael's Egg.—Florida.

Valencia Late.

Cross-section of Valencia Late.

Valencia Late (California's favorite late orange).—Fruit medium size, oblong, tapering toward calyx. Few seeds, pulp very fine, skin smooth, flavor subacid. Ripens late. Tree thrifty grower and prolific bearer. This is the latest variety known in the State, rarely becoming sweet before May or June, and will hang on the tree through the summer. It has often been kept on the trees until Christmas.

HART'S TARDIVE.—(See Valencia Late, which seems identical.)

WHITE ORANGE.—Fruit large, round, light yellow, flesh white, like a lemon, very sweet, texture fine, ripens late. Tree a dwarf.

Blood Type.

MALTA BLOOD.—This is a popular variety. The fruit has a red blush on the surface, which gives it a delightful appearance not possessed by any other fruit. Fruit medium size, oval, has a fine texture and flavor, and is sweeter and earlier than the Maltese Blood. The pulp is marked as if streaked and mottled with blood; has very few seeds. The tree is of a dwarf habit and has a peculiar character of growth, very readily distinguished.

MALTESE BLOOD.—Fruit oval in shape, medium in size, pulp marked a vinous red. Ripens later than the Malta Blood.

RUBY.—Resembles the Malta Blood, and the pulp is marked a vinous red. The tree is a good grower and prolific bearer.

MEDITERRANEAN BLOOD.—Florida.

PIERCE BLOOD.—Florida.

LARGE BLOOD.—Inferior.

NICARAGUAN BLOOD.—Inferior.

Standard Varieties with No Distinctive Mark.

RIO.—Fruit and tree resemble the Mediterranean Sweet (see page 63), but the fruit is much larger, and has a thick skin. Ripens late and uneven.

HOMOSASSA.—Fruit deep orange red, flesh melting and juicy, seeds, thorny. Ripens early.

PARSON BROWN.—Fruit medium, oblong, and slightly flattened at the stem end, smooth skin, juicy and sweet; is sweet from the time it commences to turn. Tree medium thorny, a fair grower and a good bearer. Ripens early.

ASHER'S BEST.—A strain of the Mediterranean Sweet, which it resembles in both growth and fruit.

MAJORCA.—Fruit medium size, nearly round, smooth, juicy, and few seeds.

Jaffa—natural size.

JAFFA.—Fruit medium size, heavy and juicy, thin skinned, also very smooth. A remarkably handsome grower and nearly thornless.

Cross-section of Jaffa—natural size.

MEDITERRANEAN SWEET.—Fruit medium size, pulp and skin of very fine texture, solid and with few seeds; ripens late. This variety seems to require special climatic conditions and soil for

Mediterranean Sweet orange tree, showing habit, productiveness, etc.

its successful fruiting. At Colton the tree is a good grower and ranks with the semi-dwarfs. Tree thornless, and one of the most beautiful.

Tangierine—Mandarin Type.

Citrus aurantium, var. *Nobilis*, Linn.

Of Japanese and Chinese origin. The fruit is generally small, deep red without and within, skin loose and easily detached, containing sweet juice, quite depressed. Leaves of most varieties vary, but most are somewhat linear and unarmed. On account of the foliage being of a

Tangierine fruit and branch—reduced

weeping habit the best results have been attained by budding on large stocks, quite high from the ground, allowing the branches to form a large and compact head. By this method the trees become more fruitful and uniform in shape. This tree requires little or no outside pruning and grows very symmetrical.

Broad-Leaf Mandarin tree.

SATSUMA (Unshiu and Oonshiu).—Japan. Fruit of medium size, flattened, rind easily detached, of exceedingly fine texture, sweet and nearly seedless. Tree dwarf and remarkably hardy, especially when worked on the *Citrus trifoliata*—the deciduous orange.

KING.—Siam. Fruit large, very rough rind, segments cleave when fully ripe, very highly flavored. Tree a handsome grower, very thorny.

DANCY TANGIERINE.—Fruit small, much flattened, pulp very sweet and fragrant, color deep red, nearly seedless. The foliage closely resembles that of the sweet orange. Tree thorny and an upright grower.

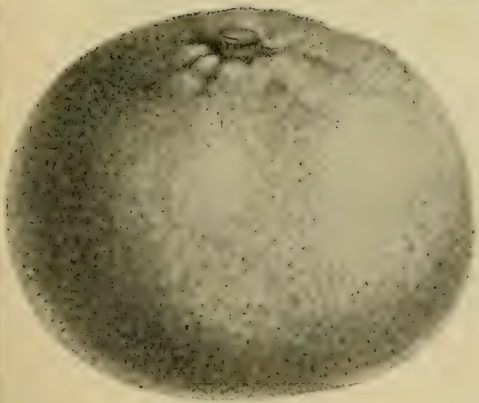
STEVENS.—Japan. Bears two crops a year, maturing in summer and winter. Tree of dwarf, bushy growth; thornless. Fruit pale yellow; juice subacid, delicious. Grown by Mrs. L. C. Stevens, of Santa Barbara.

KINNELOA.—Fruit large, depressed, flattened, few seeds, quite juicy. Skin very easily detached and fragrant. Tree good grower, very productive.

Tangierine—Dancy—natural size.

Mandarin—King—natural size.

Mandarin—Kinneloa—natural size.



Stevens—natural size.

Willow-Leaf Mandarin—natural size.

VARIETIES OF THE "CITRUS AURANTIUM NOBILIS."

Broad-Leaf Mandarin.—Japan. Ornamental only; fruit of no commercial value.

Other Varieties.—Bitter Loose Jacket, Cleopatra, Dr. Cogill's Tangierine, Paragon Tangierine, China Sweet, Mary Bremont, Narrow-Leaf Mandarin, Thorny Mandarin, Emperor Mandarin, China, Coolie, Canton, Willow-Leaf Tangierine, Broad-Leaf Tangierine.

Seedling Tangierine tree in A. S. Chapman's orchard at San Gabriel, showing habit of growth, etc.

Miscellaneous Japanese Citrus Fruits.

The following varieties of miscellaneous citrus fruits have been introduced from Japan, and after being thoroughly tested were found to lack the essential qualities required for their culture on a large scale, although many possess considerable merit:

Natsu-Dai-Dai.—A species of pomelo; coarse.

Dai-Dai.—Very thick rind; coarse.

Yuma-Buki-Mikan.—Greenish color; rind thick; coarse.

Shirawa-Koji.—Small; very thick rind and many seeds.

Beni-Koji.—Very highly colored; thin rind and few seeds.

Satsuma—Unshiu Mikan—natural size.

Broad-Leaf Mandarin—natural size.

VARIETIES OF THE "CITRUS AURANTIUM NOBILIS"

KIN-KUNENBO.—Thin rind and few seeds.

IUKO.—Small, with very thin rind and full of seeds.

TOKO-IUDZU.—Very small; a species of Bergamot lemon.

JAGATARA-MIKAN.—A species of pomelo; very coarse.

MARU-BUSHIOKAN.—A species of citron.

TO-MIKAN.—A rusty brown orange; very thick rind and full of seeds.

KINU-GAWA-MIKAN.—Very large and bitter.

BUSHIU-KAN.—Fruit unsightly, resembles a bunch of fingers; said to possess medicinal qualities.

Bushiu-Kan—The fingered citron of Japan. Used for medicinal purposes.

TO-DAI-DAI.—Rusty brown; very coarse and bitter.

BENI-MIKAN.—Very small; thin rind, with few seeds.

KAWAHI-MIKAN.—A species of Mandarin.

KINOKUNI-MIKAN.—A species of Tangierine.

KOJI.—Rusty brown; very thin rind; bitter and full of seeds.

IUDZU.—Very thick rind; coarse and bitter.

MARUMI-KINKAN.—The Kumquat.

KABUSA.—Pulp fine, seeds few, rind thick, pulp white.

NARUTO-MIKAN.—Rusty brown; inferior.

AMA-DAI-DAI.—Rusty brown; medium thin rind, pulp white, few seeds, bitter.

Olive-Shaped Kumquat—natural size.

Kumquat Type.

Citrus aurantium, var. *Japonica*, Thunberg.

OLIVE-SHAPED.—Fruit very small, olive-shaped, rind thick, yellow, smooth, sweet-scented, very little pulp, contains many seeds. Tree dwarf (a bush), four to six feet; a very prolific bearer. The fruit is edible whole; the rind has a pleasant aroma. Valuable for preserves and marmalades.

Round Kumquat—natural size.

ROUND.—Smaller than the Olive-shaped; fruit round, somewhat acid.

KINKAN.—Fruit very small; sweet juice.

THE SOUR ORANGE.

Citrus vulgaris, var. *Bigaradia*, Risso.

From the species *vulgaris* all others are supposed to have sprung, which are sub-species proper.

The fruit of the *Bigaradia* and its many decendants is of a red orange color, with a rugged skin, rough and porous. Pulp yellow, and the juice extremely bitter. Leaf large and petiole

Sour Orange (*Citrus vulgaris*, var. *Bigaradia*).

highly winged. Flower large and highly perfumed. There are many varieties of this species, and the fruit of some is used in making marmalade and preserves, and the flowers for the manufacture of perfumery.

This species does not grow as high nor as robust as the sweet orange, but on account of its hardiness and exemption from

disease much attention has been given to its culture for stocks. While the sweet orange requires good soil and high, dry elevation, the sour orange seems best adapted to low, wet soils, such as it is grown in in Florida, known as "hammocks," and along the margins of swamps. But those kinds of land do not exist in our State, and while the sour orange stock is hardy beyond question and thrives in our dry soils under entirely different conditions, it has not superseded the sweet orange stock or Tahiti Seedling, as was predicted it would, and perhaps never will. Trees grown on sour stocks, of the same age, show a marked difference of growth in almost every section of the State. The trunks are not as large as those on sweet stocks, and show less expansion of root system. The influence of the stocks on the bud is also traceable. Those on sweet root show a darker foliage, with a tendency to improvement in the quality of the fruit. The trees become of extraordinarily large size, and the product twice or more as large. The susceptibility of the sweet stock to the gum disease is obviated by the care bestowed upon it, which is now practiced and thoroughly understood.

Types, Sub-Species, or Varieties of C. Bigaradia.

The following types, sub-species, or varieties of *C. bigaradia* are grown in Florida. Occasionally some are met with here, but rarely:

Bitter Sweet.—Medium size, juicy, sweet, inner rind bitter. Tree indistinguishable from the Sour. Native wild orange of Florida.

Bitter Sweet (Philip's).—An improved variety of the Bitter Sweet.

Sour.—Native wild orange of Florida; fruit large, coarse; juice acid, inner rind bitter.

Sour (Italian).—Tree thornless and vigorous.

Willow-Leaf (Italian).—Resembles the Italian Sour.

Variegated (Sour).—Very ornamental; leaves and fruit mottled with white.

Variegated (Bitter Sweet).

Tarsus Sour.

Melangolo Sour.

Sour Sweet.

THE BITTER ORANGE.

Citrus aurantium, var. *Bergamia*, Risso.

The flowers of the Bergamot orange are small, white, and highly scented. Leaves oblong, elongated, acute or obtuse, the under side pale. Petiole more or less winged. Fruit pale yellow, pyriform or depressed, the oil-vesicles concave, pulp acid, and the whole highly perfumed. The tree is of semi-dwarf habit, and very hardy. There are a great many varieties of this species, some bearing large fruits, the majority of which are worthless, and some bearing small fruits, only valuable for the manufacture of orange and essential oils. The peel of the bitter orange is used in medicine as an aromatic tonic, and the fruit is also used in making marmalade and preserves. Many of these are grown in Europe for the essential oil they contain, from which is made a substance known as bergamot camphor. In this State varieties of this species have only been grown for ornament, to which purpose they are well suited.

Varieties of C. Bergamia.

Bergamot.—Fruit large, rough, flattened, very aromatic. Flowers large, double, and very fragrant.

Bouquet.—Flowers double and very fragrant. Leaves large and glossy. Fruit bitter.

Double-Flowered.—Large double flowers, very aromatic; highly prized for the bloom.

Large Marmalade.—Grown in Florida; highly prized.

Sweet Seville.—Grown in Florida.

Philip's Bitter Sweet.

MYRTLE-LEAF TYPE.

Citrus aurantium, var. *Myrtifolia*, Gallesio.

Tree very ornamental, dwarf, foliage densely packed together, leaf small, like the myrtle. Flowers small, pure white, and very fragrant. Fruit bitter.

Myrtle Leaf.—Yellow fruited.

Myrtle Leaf.—Red fruited.

Myrtle Leaf.—White fruited.

THE SHADDOCK.

Citrus aurantium, var. *Decumana*, Willd.

SEEDLINGS.—*Hypocotyl* very short, subterranean.

Cotyledons subterranean, and remaining in the seed till they decay, oblong-elliptic, obtuse, plano-convex, fleshy, sessile, and both directed to one side,

Fruiting branch of Shaddock (*Citrus decumana*)—reduced.

greenish-yellow above, yellowish beneath, somewhat falcate, 13 mm. long and 6 mm. wide.

Stem, soon becoming woody, covered with a short, very fine pubescence; first internode 5–5.5 cm. long; the one to three following ones suppressed, or from two to four of the leaves on the same level; succeeding ones again elongated.

Leaves as in *C. aurantium*.

First pair opposite, orbicular, emarginate, subsessile, not articulated. Petiole crenate.

Second pair often on the same level as the first two, so that there is a whorl of four. When distinct, oblong or elliptic, obtuse, otherwise like the two preceding.

Fifth leaf (where the first four are whorled) elliptic, cuneate at the base.

Sixth leaf obovate-elliptic, more elongate and cuneate at the base, with a swelling of the midrib some distance above the base, corresponding to articulation.

Seventh leaf ovate, bluntly pointed, articulated with an oblanceolate winged petiole, obsoletely crenate.—LINNÆUS.

Modified type of "Citrus Decumana"—A hybrid. (Reduced one half.)

Fruit mostly pyriform, very large, pale yellow, with rugged skin, very thick and bitter; pulp in some sorts white with green tint, in others dark green. Fruit contains many large seeds, and very little juice, which is bitter acid. The tree is a rapid grower and very ornamental, but the fruit is of very little value, except for decorative purposes. It is greatly

sought by the Chinese during their New Year celebrations to ornament their homes and joss-houses, and many thousands are annually imported by them from China for this purpose. The fruit is called by the Chinese *yu shu* and *gon lack*. The rind and flowers are said to furnish an essential oil of considerable value, and the skin is used in the manufacture of bitters.

The propagation of the shaddock is very simple. It comes "true" from seed, or mostly so; is budded on almost any kind of citrus stock, orange preferred; the tree requires less care than any tree of the citrus family.

Pomelo tree in fruit.

Varieties.

China. — Fruit very large, pyriform; tree large grower.

Blood. — Fruit very large with pink flesh.

Forbidden Fruit. — Fruit very large, pyriform.

Mammoth. — Fruit extraordinarily large, pyriform, pale yellow.

THE POMELO.*

Citrus aurantium, var. *Pomelanus*, Willd.

Leaves large, very dark green, somewhat lanceolated and notched at their edges. Leaf stalk markedly winged. Flowers

*The name "grape fruit" has been applied by common consent to this fruit, from its habit of growing in clusters, but such name is wrong and misleading. It should be known solely as *Pomelo*, which is popular and botanically correct.

white (like the orange), large and fleshy (like the citron), and arranged in large clusters. Fruit of most varieties extraordinarily large, round or pyriform, with a smooth yellow skin. Tree a rapid grower and prolific bearer, with short and often flattened branches.

Owing to the incomplete research and lack of knowledge of the species *Pomelanus*, a hybrid, botanists have confounded it with *Decumana*, and have joined the two under the latter name, but it has no place there. That *Pomelanus* (pomelo) was confounded with *Decumana* (shaddock) was no doubt on account of its having sprung from the latter and on account of both species bearing fruits of extraordinary size; *decumana* (Latin for huge) has been indiscriminately applied to both.

The chief characteristics of all these fruits, distinguishing them from the different varieties of the orange, are associated with their size and color. They are all, or nearly all, larger than the largest orange, and are uniformly of a pale yellow. In texture the rind may be smooth or even polished; it is seldom rough, nearly always firm, and not very thick. The pulp is pale yellow or greenish white, sometimes pink or crimson; the vesicles (juice bags) of the pulp are more distinct than in the orange; very juicy, somewhat sweetish, with a distinct but agreeable, bitter flavor. The pith surrounding the segments possesses more of the bitter than the pulp, but it is less agreeable, and on that account is never eaten. In shape these fruits vary a good deal. Some are quite globular, others somewhat flattened at the top and tapering below, forming a pear-shaped body. Even in the globular fruits the top is more or less flattened. There are none, we believe, pointed at both ends.

The special alkaloid of most varieties of the pomelo contains a bitter principle, which, while its medicinal virtues are conceded, has not yet, I regret to say, been defined by chemical examination. Neither is it safe to consider it quinine, for there are scores of vegetable bitters which are not quinine. The presumption therefore is, that it is a unique bitter principle peculiar to this fruit.

Observations made by William C. Fuller, of Colton, and myself show that large confluent and well-defined oil cells in the *citrus* indicate *sweet fruit*, and especially does this law of energy follow when applied to the pomelo. Considering the purpose for which the demand for this fruit comes, tendency

to undue sweetness should be avoided and varieties producing fruit with a delicate bitter should be sought.

Within the past five years a good deal of interest has been manifested in this State respecting the pomelo.

For medicinal purposes it leads all the citrus fruits, and its value from this point of view is as yet unknown. Invalids find it just the thing to tone up their system; it is a sure preventive of that languid feeling so prevalent in spring; when used in fevers it is fully as beneficial as quinine without the deleterious effect of that drug, and is one of the finest tonics in the world. Women find it exceedingly valuable. A German physician pronounces it a cure for incipient consumption and kindred lung troubles. It is a well-known fact that people with weak lungs wintering in Florida have derived permanent benefits from eating the fruit regularly.

Varieties.

A number of growers and shippers from different sections of the southern part of the State collected samples of pomelos from the numerous shipping points and on March 1 (1897) met in Los Angeles and tested them. In the opinion of those assembled the best shape was the flat round; and best color and texture were a lemon color and a peel similar to the St. Michael orange. The most desirable sizes wanted by the trade are those that pack 42, 56, 64, and 80 to the box.

Duarte Seedling.—A Florida seedling, grown at Duarte, met with much favor. The fruit was a flat round, growing from 42 to 80 (per box) in size, with a skin the color of a lemon, and no thicker than that of a Navel orange. The fruit is heavy and a delightful "bitter sweet," so much enjoyed in the East. It had quite a few seeds, but very little rag or waste. The peel and section linings are very bitter.

Colton Terrace Seedling.*—Grown at Colton; was the next best variety tested. The fruit had a thicker rind and a more orange color and much more rag and waste; the flavor, however, was nearly the same.

Prof. H. B. Heiges, late U. S. Pomologist, says of this seedling, in a letter to the Chamber of Commerce of Los Angeles: "The California seedling pomelo was much finer and thinner

*Sample was given the committee thinking the same was for immediate use and not for comparison.

COLTON TERRACE SEEDLING POMELO.

TRIUMPH POMELO.

WALTER'S POMELO.

VARIETIES OF THE POMELO.

in the skin than the Triumph, and was of superior quality; in fact, no pomelo that has been received by this Division surpassed in quality the California seedling."

Fruit medium to large, heavy, subacid and delicate bitter, full of seeds; skin smooth, light lemon color, very small oil cells, turning slightly orange when mature.

From an analysis made by Chemist George E. Colby, of the Agricultural Experiment Station of the University of California, I am able to compare the relative merits of this seedling as against the analysis of the Triumph, a variety which is now very popular, as follows:

Physical Analysis—	Triumph.	Colton Terrace Seedling.
Average weight, in grams	440.	430.
Rind	23.1 %	30.7 %
Pulp, pressed	25.4 %	29.5 %
Seeds	3.40%	3.40
Juice	1.75%	1.38%
Analysis of Juice—		
Solid contents, by spindle	11.20%	10.00%
Total sugars	8.00%	6.80%
Acid, citric	2.31%	2.00%

Triumph.—This variety, in the opinion of those assembled, ranked next. This was considered a fine-looking fruit, full of juice, but lacking in the real pomelo taste of the first two named. The texture of both peel and fruit was pronounced very desirable.

Commercial.—This variety attracted much attention for its large, desirable size, its fine color and shape, and also that it had a good lot of juice, but did not compare in flavor with the first three varieties named.

Aurantium.—A medium to small variety, with a sweet rind; imported from Florida. It is said to be a cross between an orange and a pomelo, partakes greatly of the orange, and does not possess the eccentric bitter principle so much sought in this fruit.

Thesca Blood.—From Florida; a large pear-shaped variety, with pink-colored pulp, described as being "a good grower and heavy cropper. Fruit medium size, pale yellow in color, with slightly bitter pulp."

Blood (syn., Pink).—This variety is apparently very prolific, slight bitter principle of the species, agreeable acid; tree very vigorous, with striking foliage; an ornamental tree, as well as interesting fruit with its tinted texture; skin thicker than some.

AURANTIUM, OR ORANGE, POMELO—Slightly reduced.

PERNAMBUCO POMELO—Reduced one half.

VARIETIES OF THE POMELO.

DUNCAN.—A new variety recently introduced into the State. Much larger than an orange and smaller than a shaddock; a delicious fruit, by many preferred to an orange, Skin smooth, pale yellow, subacid. The membrane dividing the pulp is bitter and must be removed before eating the pulp.

THURSBY.

MARCH SEEDLESS.

LEONDARDY.

THE OTAHEITE ORANGE.

Citrus aurantium, var. *Pumilum*, Gallesio.

This dwarf species of the citrus is largely grown in Florida as a stock for budding purposes. It is used to dwarf varieties of

Branch and fruit of Otaheite orange—reduced one half.

the sweet orange. The tree is a shrub, never attaining a greater height than six to eight feet. The fruit is very small; the flowers are of a reddish color—a pretty ornamental shrub.

DECIDUOUS ORANGE.

Citrus aurantium, var. *Trifoliata*, Linn.

Branch and fruit of *C. trifoliata*—reduced one half.

A hardy deciduous species from Japan. Early in the fall it sheds its leaves and becomes entirely dormant, in which condition it passes the winter. The tree is very dwarf, of a shrubby habit, and suitable for hedges and dwarfing varieties of oranges and lemons. Fruit orange yellow, spherical, about one and one half inches in diameter. Leaves trifoliate, leaflets sessile, elliptical, obtuse, on a winged petiole. Branches robust, often more or less flattened; very thorny.

MISCELLANEOUS SPECIES AND VARIETIES.

The following varieties of the various species have been imported from different parts of the globe, many of which have proved to be duplications of varieties under different names. Owing to change of location, climatic conditions, etc., they have not come up to expectations. Those marked with an asterisk (*) possess merit; all others proved failures, although it is doubtful if any are now grown in this State:

Selecta*	Catania	China	Oval
Candian*	Lorretto	Chio	Early Spanish
Paros	Sabina	Archipelago	Parramatta
Mitylene*	Poor Man	Tenedos	Royal*
Samos	Chinese Oval	Scio	Belearic, or Malorea*
Parakila	Imperial*	Kau	

Accaway*
Shamanty
Tarsus (sweet)
Red Juiced
Round
Havana
Silver Leaf (ornamental)
Violet Flower (ornamental)
Portugal
Belady*
Bisry
Vanigila
Double Flowered
Sicilian
Orange of Nice
Jamaican
Compaida (ornamental)
Lisbon

Many varieties have been introduced into Florida and many have also originated there. In late years many varieties have been introduced into California from that State. After fruiting, the majority of these also proved a further duplication of varieties under different names. Some of them are still grown, but only to a limited extent. The Botelka is extensively grown by A. Scott Chapman at San Gabriel. He considers it profitable to grow, owing to its good shipping qualities. It is also grown in different portions of the northern part of the State. The following is a partial list; those marked with two asterisks (**) being of Florida origin:

Early Oblong**
Egg**
Botelka**
Dulcissima
Prata
Exquisite
Old Vina**
Arcadia
Prolific
Star Calyx
Acis
Centennial**
Dr. May's Best
Nonpareil**
Pernambuco
Mediterranean (Sanford's)
Parson's Navel**
Italian Navel
Double Imperial Navel
Bostrom's Prize Navel**
Richardson's Navel**
China (Tangierine, willow leaf)
Golden Variegated (Mandarin)
Markham's Best**
Higley's Late**
Wilder**
Dixon**
Krause**
Pride of Malta
Everbearing**
Peerless
Madame Vinous**
Cunningham**
Tony**
Pineapple**
Spratt's Harmon
Bell**
Pierce's Blood**
Round Sweet Blood**
Armory's Blood**
Sall's Blood**
Mediterranean Blood
Thornless**
Foundling**
De Barry's Seedling**
Dr. Stark's Best**
Mellwood Seedling**
Dann's Best**
Osceola**
Oce**
Prater, or Silver**
Beach's No. 5**
Foster**
Indian River
Milikensis
Marquis
Sanford's Navel
Orange Lake**
Queen
Queen of Halifax
Sustain Navel
Velvet Peel (ornamental)
Whitaker**
Indian River Sweet**

PROPAGATION OF THE ORANGE.

Planting the Seed.—The best time to plant orange seed is in the months of March and April, and even in May and June. Early planting is not recommended, because it does not give good results. When planted too early many seeds decay, waiting for spring, their time of germination. The seed-bed should be kept moist, but not too wet.

Collecting the Seed.—There are various ways in vogue, but in the one most commonly used the fruit is piled in heaps or put into barrels to rot. When it has decayed sufficiently to break easily when handled, it is crushed in a tub or barrel and the seeds are washed out. A coarse sieve is used; the soft substance of the fruit passes through, leaving the seeds in the sieve. This operation is carried on in a place where water can be used freely, as considerable is required to do the work properly.

Keeping the Seed.—To insure best results, the seed of the orange should not be allowed to dry after being taken from the fruit. If not ready to plant then, they should be put in moist sand. In this way they can be kept until everything is prepared.

How to Put the Seed in Sand.—Take a shallow box, say five inches deep and twenty or thirty inches square; fill it half full of moist sand; then put the seed on top, about two inches deep. On top of the seed place considerable sand and mix the sand and the seed together with the hands. This is done so that the sand will stick to the seeds and prevent them from adhering to each other. Then fill up the box with sand and let the seeds remain until they are to be planted. The boxes can be stacked one upon another.

Taking the Seed Out of the Sand.—The seed-bed having been prepared, take the top box and dump its contents into a coarse sieve. This must be done with care, so as not to bruise the seed. Then shake the sieve; the sand will pass through, leaving the seed in the sieve.

The Seed-Bed.—The seed-bed should be inclosed with boards, eighteen or twenty inches wide, set on edge, about four or six feet apart. The bottom should be floored, so as to prevent the ingress of gophers and other rodents. Laths are nailed on top, leaving a space of one half inch between them, to protect the seed from being scratched up by birds. A covering of thin muslin is put on top of the laths to prevent the young plants from being scorched by the sun. If the weather be cloudy, it is well that the covering be removed to allow the seed-bed to get warm. It is better to plant the seed broadcast, but not too thickly, as the plants will grow slender and not so

strong and thrifty as when sown sparingly. The seed should be covered with fine, rich soil, from one to two inches in depth. Boxes filled with rich soil are also used in which to grow seedlings. They are set close to each other on the ground, watered and covered the same as the seed-bed.

Transplanting.—In one year the plants will be large enough to be transplanted in nursery form. They are sorted, the very small and delicate ones planted by themselves, or transplanted in boxes and kept another year; being so small and delicate, they are generally scorched by the sun when planted in the open ground, and remain small in the nursery.

Distance of Nursery Rows.—The rows should be far enough apart to admit a cultivator between them. Grave mistakes are often made in setting the plants less than four feet apart, as in cultivating after being budded many buds are knocked off by the horse or the traces rubbing against them. Preference is given to rows when set five or six feet apart. This will give ample room for cultivation; and also, in digging up trees, a small, narrow sled can be run in to haul them to the head of the rows without rubbing against the nursery stock.

Planting close together in the rows tends to make feeble and slender trees. If it is not intended to "sack" or "ball" the trees when they are to be transplanted, then the plants can be set from eight to twelve inches apart, and they will make strong and thrifty stocks; but if it is intended to "sack" them, this is too close. They should be at least eighteen inches apart; this will give the digger enough space to take up trees between others. It also has the advantage of not cutting the roots too short, which is apt to be the case when the plants are close together.

Trimming the Stock.—The plants should be trimmed but sparingly until at least one year after planting. They should be left to grow almost at will the first year, as they will withstand the cold of winter better. When plants are trimmed too young they generally make slender and feeble stock. In the following spring, as early as possible, say in February, the plants are trimmed, leaving a clear stock. All cuts should be made close, so that they may soon heal over. The brush is then gathered and burned. As the ground becomes packed by

the trimmers it should be loosened by running a cultivator between the rows.

Topping the Trees.—When a tree is taken from the nursery the foliage should be cut back; the branches should be so cut that in starting they will form a fine-shaped head. This is done because evaporation from the leaves is rapid. In many cases where the top shoots are left on, the circulation of the trees becomes dry and the bark will shrivel before the roots have assumed their natural functions.

Balling System.—A narrow trench is made along the row and within six inches of the tree; the taproot is cut about eighteen inches deep; then with a spade an oblong ball is cut, leaving in it the tree. The spade should be very sharp, or in cutting the roots the jar will break the ball. Pruning shears are used in cutting large roots. When trees are taken up with a solid ball of earth the leaves will scarcely wilt.

Puddling System.—Puddling is practiced where the soil is so loose that sacking is rendered impossible. Many prefer this system to any other, as it gives the trees larger and more roots; and where all due precautions are taken, puddling is the best system, besides saving considerable expense.

A hole is made in the ground and filled half full of water, then soil is thrown in and worked with a hoe, which forms a puddle. The puddle should be thin enough so that when the roots of the trees are put into it, the mud will stick to them, at the same time wetting every part thoroughly. The trees are carefully taken up, the soil shaken from the roots, and they are immediately dipped into the mud or puddle. They are then placed on wet straw in a wagon. A covering is placed over the wagon to prevent the sun from drying the roots, as the roots should not be exposed to the sun, even if only for a few minutes. The wagon is then driven to the field where the holes have been dug. The driver hands the trees, one at a time, to the planter, who holds them in position while his men fill the hole with dirt, first throwing in the moistest. The planter presses the soil very lightly, and goes to the next one. The tree having been set, a basin is made around it and a couple of buckets of water poured into the basin; this will settle the soil and keep the tree fresh until water can be run down the rows in furrows.

Transplanting the Trees from the Nursery to the Orchard.—This important work often determines the future growth and fruitage of the orchard. Its performance in all its details should be conducted in a manner to give as little shock to the growth of the tree as possible. Mr. L. C. Waite, of Riverside, has had great success in transplanting trees in their natural state; that is, removing the tree without balling, leaving the roots free from soil. He attaches great importance to two conditions: first, selecting the proper time for removal; and second, the manner of handling. The time for removing the tree is when it has made a previous growth and has hardened that growth and balanced it by a later root growth. In this condition it is ready to put out a new branch growth. Before this appears the fine roots are cut on one side of the tree by the use of a sharp spade. At the same time the taproot is cut at the proper depth below the surface. The excavation is then filled with earth, and the tree allowed to remain for several days until the rootlets and the taproot have formed a crown of growth. By leaving the rootlets of a considerable portion of the tree undisturbed by the first handling this growth is rapid. When the growth is sufficiently developed the tree can then be removed from the nursery to the orchard by the second handling. This is to cut the remaining roots, being careful to leave unbroken the roots cut at the previous handling. When this tree is placed in orchard form the earlier cut roots are ready to start new growth immediately. The shock to the tree by its last necessary mutilation is hardly felt. Every care must be taken in carrying the tree from the nursery to the orchard to keep the tender and sensitive rootlets from drying.

*"If orange trees are properly handled from the time they are dug in the nursery until they are planted in orchard form, there should be no loss. We have found in our experience in planting, that if this plan is properly followed we do not lose any trees, but if orange tree roots are exposed to sunshine or wind, for a short time only, the planter will lose a large percentage of his trees; besides, those which grow will have such a sickly growth that he would be better off if they had died with the others. We know that it is possible to pack trees so that

*B. F. Dixon, in essay before Escondido Farmers' Institute, November, 1896.

they may be shipped long distances and, when planted, nearly all live, but from observations of the experiences of various planters we have concluded that the only safe plan is to buy your trees from the nearest nursery and superintend the digging of them yourself. After your trees are planted in orchard form they should be watered and thoroughly cultivated every thirty days during the dry season. In the rainy season cultivate enough to keep down the weeds."

*"J. H. Reed, whose systematic methods and habit of careful observation peculiarly fit him for successful experimental work, has demonstrated to the members of this club, and to the satisfaction of various other careful observers, the value of the following methods in transplanting orange and lemon trees:

"*First*—In taking up the trees the roots should be protected by a ball of earth;

"*Second*—That, to the satisfaction of various careful observers the most essential factor in tree growth, should be preserved as far as possible;

"*Third*—Where it is practicable, the tree should be transferred to its new home immediately after the taproot is cut, and loose earth carefully filled in around it;

"*Fourth*—Let water in furrows follow the planters and fill the holes, thoroughly settling fine earth around the balls or roots.

"By carefully observing these points, if the nursery is near by, every leaf may be saved, and the tree will resume the work of growth almost immediately. Examination in a day or two after planting will show a large number of fibrous roots reaching out from the ball into the new soil around it. A small amount of well-rotted manure placed near the roots, but not immediately touching the ball, will assist in giving a vigorous growth.

"The evidence from actual observation and experience is conclusive that trees thus treated will make a growth the first year which can not be approximated if the trees are taken up with bare roots. Indeed, if the leaves wilt and mostly drop, the tree will seldom do more the first year than reclothe itself, and will be a year later in coming into bearing.

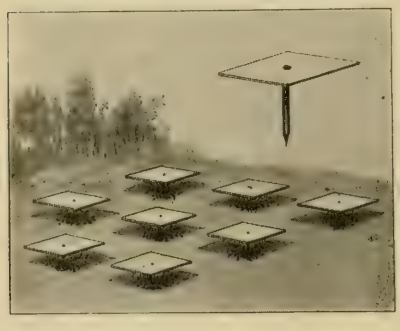
* From report of committee, by J. M. Edmison, to Riverside Horticultural Club, February, 1899.

"It is very important the first season after transplanting trees to run water frequently, at least so as to insure soft and moist earth about the roots at all times. And it is better to run water in furrows through the entire open space between the rows. Experiments have shown that the roots reach out enormously, even the first year, if favorable conditions are provided."

Extending the Roots.—A common practice in planting trees with loose roots, of placing the tree in the hole, filling the hole with soil and water, and then tramping, should be avoided. As the roots are covered with thick mud they will stick together, and if the tree grows it will not do as well as when the *roots are extended with care.* This is very simple. The hole is half filled with earth, which being loose admits the taproot of the tree by slight pressure of the hand; then the lateral roots are spread and the soil is lightly pressed. Heavy tramping is not necessary, as the water settles the dirt and keeps the roots in place. As soon as the water in the basin has disappeared, the basin is covered with loose soil; this will prevent evaporation, and keep the tree from leaning over. Trees planted with these precautions make the best growth and become the most thrifty.

The roots extended in planting.

Shading Newly Set Plants.—Plants set out during summer or during a period of sunny weather often wilt and many perish, unless duly protected. The accompanying illustration shows a simple method of protecting freshly set plants. These shades are made of any size desired, from old pasteboard boxes, which are easily obtained at drygoods stores, etc. Squares are cut from the top, bottom, and sides. They are nailed to a peg made of any kind of material, in the manner shown. These shades can be put down close to the plant, and when taken up after a few days can be kept for future use.



Plants protected by shades.

BUDDING.

There are various systems of budding citrus trees. In Florida and Louisiana the most popular method is the reverse of the one universally practiced in this State.

Time to Bud.—The best time to bud citrus trees is in March and April, as soon as the trees begin to put forth leaves and the sap flows freely. Everything should be prepared; no time should be lost, as buds inserted early in the season start with vigor and by fall have a large and thrifty top. The buds should be looked over at least ten days after they are inserted, and all those which show signs of not having "taken" should be rebudded in order to give them an early start, and that they may grow more evenly with those first budded.

Budding done in June and July is styled "summer budding." It is not considered as good as early spring budding, because the buds do not start evenly; and as the greater portion of them start late their growth is so tender by the time winter sets in that, if they pass through it, they become prematurely hardened by the cold weather, which sometimes causes the trees to become stunted.

Fall budding is generally performed during September and October, and sometimes in favored localities as late as November. After the strings have been removed the buds are left to lie dormant through the winter, to be started in the spring.

Methods Illustrated.—The selection of scions is very important. Only plump and healthy buds should be chosen; dor-

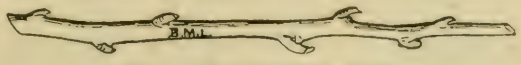


FIG. 1. Thornless orange buds.

mant or *blind* and immature buds should be avoided. Fig. 1 shows an orange stick prepared for budding. In this the leaves have been cut off the leaf stem at the proper distance from the

FIG. 2. Thorny lemon buds.

bud. Fig. 2 shows a thorny lemon bud, also with the leaves removed, and ready for use. The stocks are previously pre-

pared for budding by the removal of all growth to about eight or ten inches from the ground, or at the height they are to be budded, so as not to interfere with the men. The lemon should be budded at such a height that its union with the stock will be above the line of irrigation and moisture arising therefrom. This guards the lemon against disease.

The first operation consists in making a vertical incision in the bark, as shown in Fig. 3. Note the position in which the knife is held. It is not necessary to press too hard, but simply cut through the bark. The transverse incision is then made at the top of the vertical incision, as

Fig. 3.

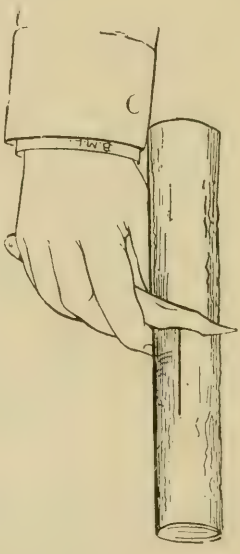


Fig. 4.

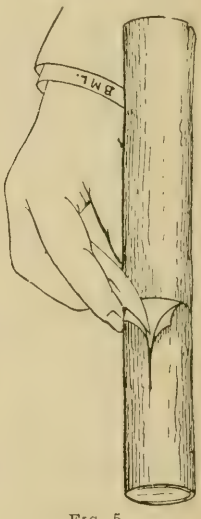


Fig. 5.

shown in Fig. 4, and by a slight twist of the hand from left to right the bark becomes opened sufficiently to admit the point of the bud to enter into the incision (see Fig. 5). Now comes the cutting of the bud, which is shown in Fig. 6. Note the position of the hands and the manner of holding the knife. The point of the bud is held downward and the buds are cut from the back. In this way the buds are cut smooth and do not crack in cutting, as is the case when cut from above. The bud is then inserted by holding it between the fingers and pressing it downward into position, as shown in Fig. 7. It is then

tied with soft budding twine (although other materials, such as cloth, etc., are greatly preferred by some), as shown in Fig. 8, which shows the operation complete. Figs. 7 and 8 show the treatment of the stock after the bud has "taken," and not at the time of budding. In order to start the buds it is best to cut back the stocks as shown in the figures, leaving a portion of the foliage until the buds have made a good start. This prevents a check of the flow of sap, which generally is the case

FIG. 6.

FIG. 7.

FIG. 8.

when all the leaves are removed with the top, causing the

incision to open and the bud to dry. This brush is removed later at the point shown in Fig. 7, at *a*. When the buds start they are very delicate and require to be protected by being tied to the stock, either with soft twine or cloth, as shown in Fig. 9. When the buds have become strong the remaining portion of the stock is sawed off at the point shown in Fig. 9 at *o*. The cut is then waxed over, or given one or more coats of rubber paint, to protect it from atmospheric action, that the cut may heal over without defects.

FIG. 9.

Starting and Training the Buds.—Nursery trees swell very fast in the spring, and three weeks is long enough for the strings to remain on them; but the tops should not be cut off then. The strings should be removed, and the nursery irrigated and cultivated. This will force new growth, and the tops should then be cut back from four to eight inches above the bud. After the bud has grown about six inches or more it is tied to the stock. When the bud has become stocky and able to support itself, what remains of the top is then cut away. The cut should be made smooth and waxed over or painted with rubber paint. This helps the wound in healing over and protects the stock from the action of the atmosphere. Buds left to lie dormant through the winter are "started" in the spring, just as soon as the trees begin to show signs of growth. Great care should be used in the cutting of the top, that it be done at the proper time, and that the top be not cut so near the bud as to endanger it. It is advisable always to leave a little foliage on the stock, to avoid too great a shock by the removal of the entire top and its functions, which in many cases causes the death of the bud and the dwarfing of the stock.

When the stocks put forth in the spring the buds generally start also. The suckers, being very tender, are removed by hand (thumb-pruning), breaking at the touch. Cutting them with a sharp knife has the advantage that no others will grow where so cut, and the cut being made clean will give the tree a smooth body, and as the tree grows very little suckering will be required. When the suckers become strong and are removed by rubbing with the hand, the trunks generally become rough and suckering becomes much greater.

As the buds continue to grow, they are loosely tied with

soft twine or rope either to the remaining portion of the stock or to laths driven alongside. By this practice the trees will grow straight and symmetrical.

Growing Budded Trees in the Nursery Without Staking.—The buds are allowed to grow until they show signs of drooping. They are then pinched at the top. The growth is arrested; the stock becomes firm and erect. The bud starts several new growths. One of these growths, generally the center, is allowed to make an upward growth and the rival growths removed. As this growth advances and, like the first, begins to droop, it is again pinched, when it again assumes an upright position and starts its multiple growths. From these, as before, is selected a growth to further advance the height of the tree. When the tree has arrived at its proper height for the crown, allow all the growths from the last pinching to remain and the tree to form its desired head. Trees grown in this manner are stronger than those that have had the support of stakes.

WORKING-OVER LARGE ORANGE TREES.

Large orange trees are somewhat difficult to bud, owing to the extreme thickness of the bark and the inactivity of flow of sap at the space where the buds are generally inserted. Neither does the bark "slip" as easily as on younger stocks. Three methods of working-over large trees are practiced in the southern citrus counties. One is to bud into the large limbs near the crotch; the second is

Orange tree budded over, showing the buds starting, and trunk whitewashed for protection.

to cut the tree back in the spring and to bud into the young shoots; and the third is to bud high into the limbs, either into the old wood or on the new shoots as they put forth after the trees are topped.

Unless the buds are inserted reasonably early the entire tops are not cut back until the spring following. It is best to cut back a portion of the foliage of the limbs to induce the buds to start without giving the trees too severe a shock, and to allow the buds to grow at will with the rest of the foliage through the winter. From two to five of the large side limbs are left to grow, as a protection to the buds from frost, and to induce the flow of sap to the buds.

Orange tree cut back to force it to throw out shoots from the main branches, which are budded; the body of tree being protected with burlap.

*"I believe the lack of success in budding old trees arose frequently from the fact that it was deferred until too late in the spring, when the sap was in the top of the trees, passing by the bud in its haste to get higher up, and the best success has come from buds inserted as the sap got to be active at the point of insertion."

Budding Large Trees in the Fall.—At a meeting of the Riverside Horticultural Club, Mr. Bryan, a noted horticulturist, recommended inserting the bud from below, and pushing it up instead of the usual way of pushing it down, thereby insuring better protection from damage by rain. Waxed cloth, he said, was the best for tying. In regard to the treatment of the tree when the buds are fully set, he favored leaving a portion of the old wood and foliage to bear fruit for a time as a protection from the fierce rays of the sun in July and August. The heroic treatment of cutting the tree right back, which

*J. E. Cutter, before Riverside Horticultural Club, June, 1896.

might rightly be called "beheading system," he could not indorse. It was found that a much better way was to *girdle* the limbs just above the new buds, to be done with a knife, slanting away from the bud. In old trees several buds can be inserted on large limbs, thus giving greater assurance of success.

Many budders remove from the limb, above the bud, a ring of bark, about an inch wide, which induces the bud to start. The bud is left to grow at will until the following spring, when the branches are finally removed, and the buds which have had a season's start are made to assume the functions of the top.

Large seedling orange trees changed over by budding in the branches.

Protecting the Trunks of Large Trees.—As soon as possible after the removal of the tops the ends of all limbs cut are waxed over. The trunks are then treated with a heavy coat of whitewash, or wrapped with sacks to prevent them from being scorched by the hot sun. Water is applied, and everything possible done to cause the tree and buds to start without being injured. But these precautions are not as necessary where the gradual process is practiced.

Budding Large Trees in the Branches.—The rules laid down for budding large trees in the main branches close to the trunk apply with equal force to budding large trees in the branches higher up, and as shown in the accompanying illus-

tration. The main limbs are cleared of all brush long before the time of budding. They are budded in the spring or in the fall. If budded in the fall the buds are allowed to lie dormant through the winter and started in the spring. The buds are inserted in the limbs, and when they have "taken" the tops are gradually removed, leaving the side limbs to grow for awhile to prevent the flowing sap from relaxing, which keeps the buds growing until they assume the functions of the top. These side limbs are then removed, and the trunks and limbs are given a thick coating of whitewash to prevent sunburn, etc.

Beheading System.—This system is successfully practiced by several experienced budders of Riverside. O. D. Wilhite, a gentleman of long experience, treats his trees before budding by removing all limbs (below the line of buds) that are not needed in the process of budding. He further treats the remaining limbs by removing the small branches near the line of buds, to induce a flow of sap at points where the buds are to be inserted. By this double removal he concentrates the flow of sap over a limited part of the tree and also at the special line of bud insertion. This service is done in the early spring. When the tree responds by increased growth, as it soon will, the sap is circulating in vigor and the buds are inserted. The treatment of the buds is the same as for nursery budding. Immediately after insertion they are tightly covered with waxed cloth. The coverings are allowed to remain about three weeks, or until such time as the buds are well established. They are then removed, and where the buds have not taken, new buds are inserted. Wherever a sufficient number of buds have taken, the top is entirely removed and the wounds covered with heated wax. In processing the tree for protection from injury by the sun a heavy coat of whitewash is applied before the removal of the limbs. This coating is carried above the point of cutting and over the waxed cloth. This insures the whole surface to be covered with the lime except a band where the cloth rests. When the cloth is removed the clear strip beneath can easily be seen in future observations of the buds. The first treatment of the tree is to let all new sprouts grow. These will appear over the entire tree surface, and will keep the sap in motion and the roots in action. The first handling is to pinch the fast growing buds to strengthen their trunks, and to remove a few of the sprouts which have grown

THE WORKING OVER OF LARGE SEEDLING ORANGE TREES TO THE WASHINGTON NAVEL.

VIEW OF A RIVERSIDE ORCHARD, SHOWING BUDS OF A SEASON'S GROWTH; STOCKS HEALTHY AND VIGOROUS—A SUCCESSFUL OPERATION.

near them and threaten to smother them. As the buds grow the remaining sprouts are from time to time removed, being careful, early in their growth, to keep a sufficient sprout growth to maintain a rapid flow of sap. The top of the tree should now be free from sprouts and occupied only by the buds. The bud growth must be often pinched, to prevent a long, straggling, weak growth. As the crown of bud growth increases, all sprouts are removed from the trunk. Large trees treated in this manner should appear with a solid bud growth, as in the illustration (Plate IX, page 99).

Fuller's Rose Beetle — natural size and enlarged.

In some portions of the State the buds are troubled by the leaf-eating beetle *Aramigus fulleri*, which climbs the trees and feeds on the tender leaves and tip ends of the buds. To keep the beetles from ascending the trees, bands of cotton-batting are placed on the trunks of the trees below the buds. These bands are removed from time to time.

PLANTING.

Preparation of the Soil.—The land should be thoroughly worked through the winter and prepared to be planted in the spring, when it becomes warmer. All weeds and stubble should be plowed-under; these will decompose and serve as a fertilizer to the orchard. The thorough working of the soil liberates crude gases and changes the nutritive principles to a form more readily assimilated by the tree.

*"The question is often propounded to us how to prepare the land before planting the orange tree. Our advice to all contemplating planting is to first have a thorough survey of the land to be planted; then thoroughly grade same, so that water can be successfully carried to every tree. Here is where many make a fatal mistake; they undertake to grade the land by the 'eye,' and find after they have planted their grove that it is impossible to properly water all trees in the grove; then their lifelong trouble begins. So we would say most emphatically, always have your land well graded. When this is properly

*B. F. Dixon, in essay before Escondido Farmers' Institute, Nov., 1896.

done, plow the land at least twelve inches deep. Let the land lie until it has been thoroughly settled by rains or by irrigation, then plow again, if possible some deeper than the first plowing. Thoroughly pulverize the soil by harrowing. Go to the nursery and see that your trees are dug with good roots, and tops well cut back and all leaves removed from the trees before they are lifted from nursery rows; have roots immediately puddled, then packed so as to retain all moisture and exclude sunshine and wind. As fast as the trees are planted in orchard form, each tree should receive at least twenty-five gallons of water to thoroughly settle the soil. As soon as the soil is in good condition cultivate thoroughly."

A great mistake is often made by careless planters in digging small holes, just large enough to crowd the roots into. Into these the trees are forced, the roots being twisted out of shape, with no regard to their proper position, and as a result the trees make a stunted and unhealthy growth. The holes should be both deep and broad. It is best to dig the hole deeper than needed; then fill up the bottom with a cone of surface soil, and in the apex of this cone a hole is made with a shovel-handle to receive the taproot. The laterals are then carefully spread out as nearly as possible in the position occupied in the nursery, and the hole filled up. The tree should be planted a little deeper than it originally grew, and when it is set should be pulled up with a gentle shaking motion to its proper height. This will settle the soil about the small roots. A bucket of water is now applied, which will still further settle the soil. As soon as the water has disappeared a little fresh soil is put over the basin, to prevent evaporation and to keep the tree from leaning. Trees planted with these precautions make the best growth and become the thriftiest.

Time of Planting.—The orange, being an evergreen, can be planted at any time in the year when the conditions are favorable, and this is determined by the condition of the tree and the season. The orange tree makes several growths during the season, varying in number and season with different varieties and different seasons. But there are periods when all orange trees are dormant, and others when nearly all are active. In transplanting, the trees should be taken at their dormant stage, as the shock of removal will not then be so

severe and the tree will more quickly recover. These dormant periods usually occur about four times in the year: from the middle of March to the middle of April, in June, in September, and from the middle of November to the middle of December. The warmer season is the best for planting. Trees transplanted in the winter when the ground is cold will remain until spring without growing. It is therefore better to transplant when the ground is warm. The nearer an orange tree is to starting new growth the greater its strength and root power. This is the best time for transplanting—after they have made their first growth and before starting the second time in the spring.

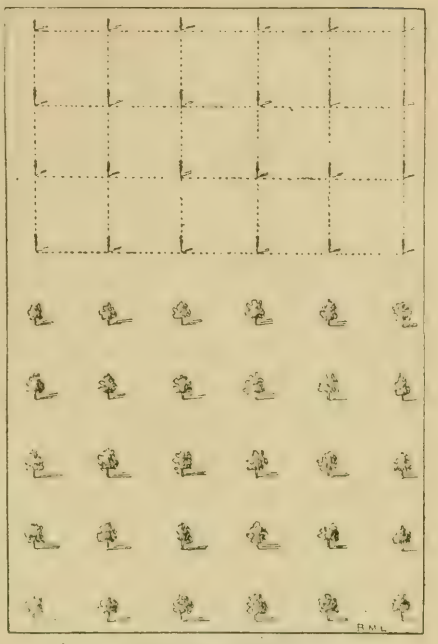
Trees designed for transplanting should be pruned a week or ten days before they are removed from the nursery. This enables them to recover from the shock of pruning before being subjected to the shock of removal.

In the selection of trees it will always be found most profitable to get the best, even though the first cost may be a little more. Scrubby, neglected, ill-grown trees are dear as a gift, and will never repay the care required in their culture. If the trees for the orchard are to be purchased they should be procured from some well-known and reliable nurseryman, who will guarantee them true to name. Only clean, healthy, well-grown trees should be accepted.

Setting Out the Orchard.—In laying off the orchard it is desirable to have it symmetrical and to economize the land. A little thought and care displayed at the commencement will save much annoyance in after years, and it is no greater task to have the orchard neat in appearance and symmetrical in outline than to have it in a haphazard condition. There are three objects to be considered in laying out the orchard: symmetry of appearance, economy of space, and facility for future care. Of course the first thing is to get the trees in straight rows, at equal distances apart, and every one thinks he can accomplish this. But there are various methods of disposing of the straight row, and these methods all have their advocates, and each one its advantages. The principal forms are the square, the quincunx, and the hexagonal or septuple. The methods most common in use are the square and the quincunx systems. The most generally adopted is the square system, as the orchard can be changed to quincunx after being planted, even after a number of years of growth.

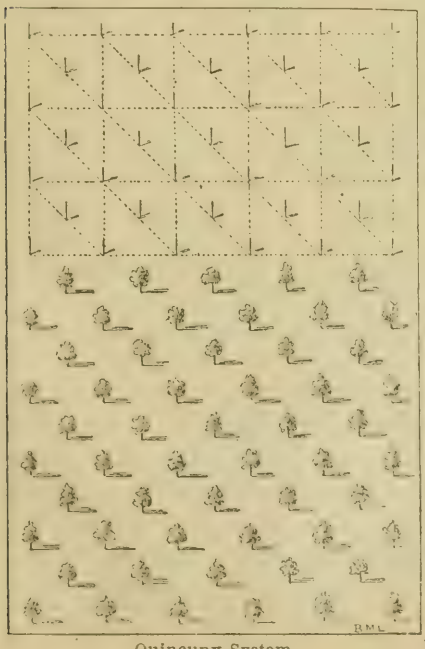
PLANTING SYSTEMS.

In order that the most approved planting systems may be better understood, they are illustrated to show how the orchard is first laid out, and how the trees look after several years of growth.



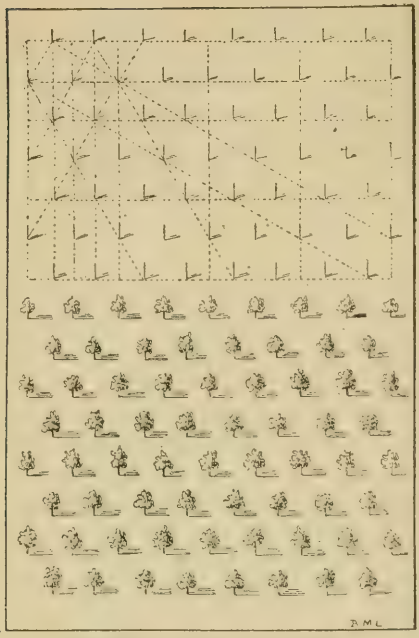
The Square System.

The Square System. This is the most approved method. The orchard is laid off in lines crossing each other, with equal intervals of space, and a tree planted at each crossing of the lines. By the square method, at twenty feet apart, one hundred and eight trees are planted to the acre. The preferable distances for planting are twenty feet for dwarf varieties, twenty-four feet for Navels and Mediterranean Sweets, and thirty feet for all seedling types.



Quincunx System.

Quincunx System.—In this system the orchard is laid off in the same manner as for square planting, except that the number of rows are doubled, and a tree planted in the center of every square. This method is chiefly used in planting with the idea of removing the center trees (which are generally dwarf) when those designed to be permanent shall have at-



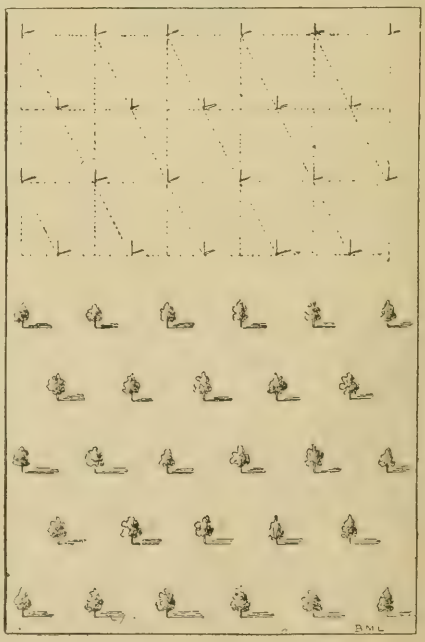
Hexagonal, or Septuple, System.

tained a considerable size; the orchard then assumes the square plan. At twenty feet apart, one hundred and ninety-nine trees are planted to an acre by this method.

Hexagonal, or Septuple, System.—In this system the trees are equilateral (equally distant from each other) and more completely fill the space than any other system can. Six trees form a hexagon and inclose a seventh. The lines in the figure indicate the method of laying out the orchard. By the hexagonal system, at twenty feet apart, one hundred and twenty-six trees are planted to an acre.

Triangular, or Alternate, System.—In laying out an orchard by this system, the lines are run forming a square, as in the square system; a line is then run diagonally across, and a tree planted alternately, forming a triangle. The advantage in this system is that the trees are given more space, and can be planted closer together without crowding.

The following table will show the number of trees to the acre by the square, quincunx, and hexagonal or septuple systems:



Triangular, or Alternate, System.

Distance apart.	Square.	Hexagonal or Septuple.	Quincunx.
10 feet	436	500	831
12 feet	303	347	571
14 feet	222	255	415
16 feet	170	195	313
18 feet	134	154	247
20 feet	108	126	199
22 feet	90	103	173
24 feet	76	86	137
30 feet	48	56	83

NOTE.—In giving the distances of trees of the quincunx, the fifth or central tree is not taken into account.

For any distances not given in the above data, calculate the number of trees to the acre by the square system, and add fifteen per cent. This will give the number if planted septuple.

SOILS.

An old saying among orange-growers, and in which there is much truth, is that "the orange tree must have its feet dry"; in other words, what is true of the requirements of all fruit trees, is especially so of the orange, and the soil upon which it is planted must be well drained. It should never be planted on heavy, low ground, or on low, damp ground, where water can be reached within a few feet of the surface, and never on black adobe soil. A rich, porous soil is absolutely necessary to give the tree a vigorous growth. A deep alluvium intermixed with decomposed granite or limestone, with a porous subsoil, offers the best conditions in soil. A hardpan soil is to be avoided. At Redlands, in San Bernardino County, the soil is, as its name indicates, a deep red, composed largely of disintegrated granite, with a large percentage of oxide of iron. The oranges grown there are of a deeper color than those produced in most other sections. At Riverside the soil is largely of the same character, and much of it, approaching the hills, a sharp granitic grit. The same general characteristics of soil prevail over the greater part of the orange section of Southern California, the land varying as to the admixture of sand, some being more and some less of a sandy nature.

*"The orange is not overchoice as to whether or not the soil is granite, sandy loam, or red soil. Either of these kinds of

*B. F. Dixon, in essay before Farmers' Institute, Escondido, 1896.

soil stands watering thoroughly and can be kept in good condition without an extra amount of culture. The 'adobe' land has probably more strength of richness than either of the other soils named, but we should prefer it to be some other fellow who would successfully grow orange groves on 'adobe.'"

The best citrus fruits are those produced on the higher lands, which are naturally warm and well drained, and the best orange lands in our State are those having the higher altitude.

A southern exposure is usually the best for an orange orchard, and it is better if sheltered from strong prevailing winds. Where the winds are very strong, it is customary to plant windbreaks on the windward side of each five or ten acres, for protection. These windbreaks usually consist of alternate eucalyptus and pepper trees, planted close together, usually ten or twelve feet apart. The pepper is a dense, low-growing tree, while the eucalyptus runs up, and the combination makes a tall, solid wall capable of offering great resistance to the wind. Both are very rapid growing trees, and in a short time give complete protection to the orchard. The Monterey cypress is also commonly used for windbreaks, for which purpose the trees are planted from six to eight feet apart.

IRRIGATION.

Irrigation and cultivation are closely associated. It has come to be accepted as a truism that citrus fruits must be grown on irrigated land. The method and frequency of irrigation and the quantity of water to be applied were subjects of discussion for a long time, and the orange-growers formed opposing schools of irrigators and cultivators—the former advocating a plentiful and frequent application of water, and the latter little if any irrigation but frequent cultivation. As is usual in such cases the mean was reached, and the practice to-day is thorough cultivation with enough irrigation. When the young trees are first set out they must have enough water to insure their growth, for the tender and lacerated roots, without a firm foothold in the soil, can not withstand a long dry season; but after the first year the trees will grow with little if any irrigation, if well cultivated, although in most cases they are watered from two to seven times in the season. When

MODERN IRRIGATION—THE FURROW SYSTEM.

A small stream is allowed to run down the furrow constantly for twenty-four hours, permeating the soil throughout, without washing away the elements of plant-food.

the orchard comes into bearing, however, the trees must be copiously watered, or the fruit will be small.

Of the methods of irrigation, the simplest, best, and most generally used, is the furrow system, in which several furrows

IRRIGATING—THE OLD WAY.
The furrows were made with the plow, and water run through in large streams, thereby cutting up the land and washing away the available plant-food.

are plowed between the rows of trees, the first one about three feet distant from the trunks, and down these the water is allowed to flow gradually until the ground is thoroughly saturated.

THE BASIN SYSTEM OF IRRIGATION.
The orchard is laid out in square basins, ready to run water into them.

Irrigation by the basin method is performed by hollowing out, around each tree, a basin with a diameter equal to the spread of the branches; into this the water is run, and when filled it is conducted to the next, and so on until all the basins have been

filled. These are sometimes filled two or three times, until the soil will absorb no more water. By this method care must be taken to prevent the water coming in contact with the trunks of the trees, or they will become scalded and gum disease will result. A cone of earth is usually banked up around each tree to prevent this, but it must be broken and leveled off after each application of water; if not, bad results follow, such as the breaking out of gum, etc.

CULTIVATION.

Much of the success of the orange orchard depends upon cultivation. If this be carelessly done or entirely neglected the best results from the trees are not to be expected. Cultivation is imperatively needed by the orange grove, from the fact that the orange does best upon irrigated lands, and irrigation and cultivation must go hand in hand. If water is applied to the orchard and it is left without cultivation the soil bakes hard, cracks, the moisture escapes, and the trees suffer. It is the rule, and one established by experience, to cultivate after each irrigation, just as soon as the ground is sufficiently dry to permit a horse to travel over it, usually in two or three days after the application of water. The soil must be kept mellow and free from weeds at all times. Many of the leading orange-growers plow in the fall before the winter rains, turning the furrows toward the trees, and harrowing the land after. This leaves the trees on a ridge with the dead furrow in the middle of the rows and serves to drain the surplus water from the trees. During the winter season the ground is naturally cold, and allowing the tree to stand in water is very detrimental to it. In the spring a second plowing from the trees to the middle fills up the dead furrow and leaves the ground smooth for the summer.

The ground should be cultivated close to the trees, which can easily be effected by the use of a short whiffletree. Care must be taken, however, not to damage or wound the trees, and it is a wise precaution to wrap the ends of the singletree with cloth—a barley sack or something similar—to keep it from barking the trees in case of contact. A careful driver and a steady horse should do the work, and the danger of damage to the trees will be reduced to a minimum.

In regard to the implements to be used, the orchardist must exercise his best judgment and consider the nature of the soil to be worked. There are a large number of good cultivators on the market, some adapted to heavy, others to light, and others to gravelly soil. The orchardist should ascertain those best suited to the requirements of his particular work, and secure them.

CULTIVATION AND IRRIGATION.*

The orange tree is a native of tropical forests, where it obtains warm soil and abundant moisture within easy reach. Its successful culture in the countries like California, which lack summer rains and moisture-laden atmosphere, is necessarily to some degree artificial and a notable triumph of modern horticulture. In order to achieve the highest results, it becomes more and more essential that the grower shall keep the soil in the most perfect condition, shall apply all needed water and plant-food in sufficient but not in excessive amounts, and shall pay especial attention to keeping the feeding roots as low as practicable and to preventing the formation of what is called "hardpan," but is only the well-known "plow-sole," aggravated by shallow irrigation.

"Hardpan," some growers say, appears now where it was never before known. The fibrous roots of orange trees run along its surface, and thus are subject to every vicissitude. It often happens that what orchardists call "hardpan" is only the firm layer of soil caused by uniform cultivation, or plowing, whether deep or shallow. The depth to which soil is stirred should vary from year to year; eight inches, twelve inches, ten inches, fourteen inches, and then eight inches again, would put an end to much of the present outcry against "hardpan." Cultivator teeth should also be kept sharp, and should be "set down" to various depths so as to prevent the formation of "plow-sole" of any description, and to assist in breaking up that which former neglect has caused.

Very few orange groves have been planted upon true "hardpan," and if so planted have seldom succeeded. Only a few trees, such as our native oaks, are capable of thrusting roots through the iron-like layer of natural subsoil that is properly termed "hardpan." When found to exist, it should be deemed sufficient to debar citrus culture, unless so thin that, by boring

*J. W. Mills, in University of California Bulletin No. 138.

or blasting, the root-system can be established in good soil below the "hardpan," or when it is so constituted that when kept irrigated the roots will penetrate it.

An instance of the latter occurred at Riverside, where Mr. Reed planted a few trees on a terrace bordering on an arroyo, and found what was reported as true "hardpan" near the surface. The trees received "an abundance of water over the whole area for a year," and it was then found that the roots had penetrated it to a considerable distance.

The term "irrigation hardpan" is quite generally used in the orange-growing district to describe the condition of some small areas in orchards where irrigation and subsequent culture have been careless, or where sufficient attention has not been paid to the difference of treatment required by lighter and heavier soils.

Of course very sandy soils can be handled sooner after irrigation than can heavier soils, and when a sandy piece of land containing areas of heavy soil is cultivated as soon after irrigation as the sandiest part will permit, trouble may be expected with the so-called "irrigation hardpan," by the puddling of the subsoil, partly directly by the plow, partly by the soaking-in of clay-water.

It is usual for orchardists to put in a subsoil plow to help in breaking up the heavy spots of what is called "irrigation hardpan." But this difficulty can easily be overcome without using a subsoil plow, as was shown by the experience of Mr. W. J. Cox, of Glendora, Los Angeles County, who found that "irrigation hardpan" was forming in a part of his orange grove. He irrigated a few trees that were within reach of the domestic water-supply, and followed this up at the proper time with thorough cultivation. After each irrigation he cultivated a little deeper. As a result of deep irrigation and cultivation, the soil took in water as readily as ever and the trees regained their vigorous appearance. He simply used a chisel-tooth cultivator and plenty of water.

A somewhat different case was that of Mrs. McKenzie, of Riverside, whose orange grove failed to be profitable, though apparently well irrigated. This orchard had been cultivated to the same depth until a hard, clay "plow-sole" had been formed. The stratum of hard subsoil was several inches thick and contained a number of large surface roots. She wrote to the California Experiment Station, sending samples of soil for

examination. It was found that the plow-sole prevented the irrigation water from reaching the deeper roots, and she was advised to plow the entire orchard, roots and all, as deep as the plow would go. This was done, much to the alarm of many growers, and great numbers of orange roots of all sizes were turned to the surface. Following further advice, she irrigated and cultivated the ground deeply, and the following season she harvested the largest crop ever taken from this grove.

The Glendora grove, to which allusion has been made, had had deep cultivation from the beginning, and the roots were mainly below the so-called hardpan. The McKenzie grove had many roots in the hard "plow-sole," so that the only remedy was to destroy these useless roots and force the growth of new and deeper ones, at the same time giving the irrigation water a chance to penetrate. This rather drastic root-pruning was necessary, and if the Glendora grove had been cultivated to a uniform depth a few more seasons, deeper plowing and the destruction of the surface roots would have become inevitable there also. The breaking-up of all hard layers of soil caused by improper cultivation or careless use of water is of the first importance to the health and profit of an orchard.

After Mrs. McKenzie's experiment at Riverside, previously mentioned, subsoilers of different forms were used, and the idea soon became common among growers that the deeper a plow could be run, the better would be the results that would follow. The injurious results of such practice can not be estimated without careful study of the root-systems of orange trees on various stocks and soils. A number of bearing citrus groves were so much injured by the reckless use of subsoil plows that the leaves of the trees actually wilted down immediately after the operation. In these cases, the sharp-cutting plow was run close to and on all sides of the trees. When trees over ten years of age, which have been subjected to uniform shallow plowing and irrigation, are submitted to such treatment, they probably lose at one blow not less than seventy-five per cent of their active roots. The shock is such that it would take several years of careful treatment to restore the trees.

It is almost always more economical to use a subsoiler or plow where "irrigation hardpan" has been formed than it is to use the large amount of water necessary to soften it; but

according to the best practice the deepening of cultivation should be gradual, and the implement should never run deeper than fifteen inches. One must remember that the really serious loss in sudden deep cultivation comes from the destruction of thousands of fibrous roots that grow from the hundreds of laterals branching from the large main roots.

If a plow is run to a depth of one foot, in three furrows, between the rows, and water percolates slowly for a long time through these furrows, no need can arise for a subsoiler. "Irrigation hardpan" within reach of the plow simply shows, as has been said, that too shallow and too uniform cultivation has been practiced. In that case the entire surface should be thoroughly broken up, and irrigation in deep furrows after this will restore the proper conditions.

Experience also shows that when the water is slowly run in deep furrows for a long time and the greater part of the surface is kept dry and is deeply cultivated, better results are obtained than when the basin or block method, or even the shallow-furrow plan, is used, even though they are followed by deep cultivation. When the water is applied below the first foot of soil, and the soil above is kept comparatively dry, there is nothing to attract the roots to the surface; and when the water is thus applied, a team can be driven along the dry strips of land between the furrows, and with a harrow or other appliance the dry soil can be dragged into the wet furrows, to lessen the evaporation, immediately after the irrigation water is turned off. By any other system, it is absolutely necessary to wait at least twelve hours, and sometimes much longer, before a team can be driven over the ground. Then, too, when a soil irrigated by these more wasteful methods has been cultivated, it is still moist near the top, and is soon filled with a mass of new roots so close to the surface that they must be destroyed.

Water applied to the soil sinks and spreads. Some of it is being taken up by the still dry soil underneath and at the sides long after the last drop is visible. Some of it, too, is being drawn back to the surface, and thence evaporated into the warm air. Irrigation after sundown has some distinct advantages, if the water can be handled. Sub-irrigation upon soils adapted to its use is the ideal system of applying water, and greatly lessens waste. Orange roots will not enter a pipe-line unless it is full of water all the time. If the pipe is on a

grade and open at bottom and top so that air passes through it, there will never be trouble from orange roots. Valves, once thought necessary, are not now used. The high cost of the present sub-irrigation systems places them beyond the reach of most orange-growers.

SUBSOIL PLOW.*

Can the necessity for the use of a subsoil plow be avoided by guarding against the formation of hardpan while orchards are young? I am quite of the opinion that it may. But my experience has been with orchards under ten years old, and I have learned that we are frequently obliged to revise opinions very confidently held, as our actual experience extends under new conditions, and this opinion may be quite wrong. If the hard layer is occasioned by repeated drying-out after irrigation, a portion of that stratum should be thoroughly broken up once or twice a year before becoming hard, while the balance of it, I think, can be kept from hardening by careful irrigation. This opinion is based on a good many years' experience in all soils, from sandy loam to stiff adobe, without any of this troublesome layer; yet you will allow me to refer to this experience in illustrating—not in any dogmatic spirit, for every year more and more I find that different men will accomplish the same desired results best, by quite different means. Once a year we thoroughly break up the surface with a walking plow, as deep as we can without permanent injury to the root-system, say from six to nine inches. In our earlier planted orchard, where we did not commence with especially deep plowing, we have trouble with the roots even at six inches. In our later plantings, on deep plowing, repeated each season, we can keep a depth of seven to nine inches easily. With this annual plowing we have no trouble in getting the water into the ground during the irrigating season. We aim to make the irrigation most thorough every time. As aids to this, I want to mention three things that we have found of great importance:

First—We make our irrigating furrows as nearly the depth of the annual plowing as possible, thus putting the water nearest where needed, greatly reducing the surface saturation where so much water is wasted, and facilitating the early covering of the furrows after irrigation.

*Essay by J. H. Reed, of Riverside, read at the Highgrove and Pasadena Farmers' Institute, January, 1900.

Second—Any portion of the orchard where there is any special occasion we cross-furrow before making main furrows. This done, with a little hard work the short pieces of the cross-furrows are easily filled and kept full. (This is of special advantage among large trees where the spaces between the furrows, between the trees, are necessarily wide.)

Third—We run water three days in place of two; total amount of water the same. I think this practice may be adopted to great advantage much more generally than it has been. We find that the third day leaves more water in

The subsoil plow, drawn by eight mules, in the Windermere orchards, La Mirada.

the ground than either of the others. By this method of irrigation I feel quite satisfied that the root strata could have been kept thoroughly wet in spite of the hard layer, in any of the young orchards where I have seen the subsoil plow used. In older orchards where this layer had been hardening for years, the implement may prove of great service. Of course, even in young orchards, the desired results can not be secured by the most careful irrigation, except the water when once in the ground is conserved by proper cultivation.

Again, I would like to refer to our own experiences. Instead of waiting for the irrigating furrows to become dry and then breaking them up thoroughly, bringing much of the saturated earth to the surface, as we used to do, as soon as possible—often within twenty-four hours—we cover the furrows instead

of breaking them up. We do this with a single twelve-inch upright plank, dragged lengthwise with the furrows. We attach the plank to the shanks of an old two-horse walking furrower. This fills the furrows from their shoulders and leaves a light coat of pulverized earth on the rest of the surface. The object is to stop as soon as possible the evaporation of moisture from the saturated bottoms of the furrows. Others doubtless have, or will know, better methods of doing this. For cultivating, for several years we used the Planet Junior, with the widest shovels, for the purpose of moving the hard earth at the bottom, which is more easily done with wide than with narrow shovels. But the objection to bringing so much of the damp earth to the surface had so impressed itself upon me, that this season I determined to try the Killfeler cultivator, with its large number of shovel-pointed teeth, which thoroughly stirs all the ground without exposing the wet earth. There are serious objections to this implement, but I must confess to being greatly interested in the results from it. Using it thoroughly once after each irrigation, when the ground is in best condition, after the furrows are covered, then keeping the surface well loosened with a fine-tooth harrow, I have been able, so far as I can determine, to hold the moisture better than I have ever succeeded in doing before, and I find no signs of any permanent hard layers forming to retard irrigation.

PRUNING.

For years a strong contest was waged between the advocates of high pruning and those who favored low pruning, and many arguments were urged by the champions of each system in behalf of their favorite method. Victory finally perched upon the banner of the low-pruners, and the greater part of the more recent orange orchards have been trained low, experience having demonstrated that in our peculiar climate and in the dry soils in which our citrus fruits attain their best condition, low pruning offers great advantages over the rival system.

In pruning orange trees, especially when allowed to grow for several years without it, considerable work and skill are required in removing the surplus inside growth and limbs without destroying the natural symmetry of the tree. The sun should not be allowed to strike the inside wood and foliage, as it is

PROFITABLE TREES PRUNED LOW—Valencia Late on Left, Washington Navels on Right.

sure to scorch the bark and cause the fine brush to die; a diseased tree is apt to result. The advice, so often given, "that the tree be opened so as to allow plenty of air and sun heat to enter," does not hold good with the orange. Whenever the foliage that protects the trunk and main branches is removed, the inside growth is left exposed to the hot rays of the sun. Trees with one side of the trunk sunburned, and dead bark, resulting from the removal of the brush that protected it, are not uncommon throughout the State.

Low-trained trees protect their trunks and inner growth by the shade of their limbs and foliage, and the ground underneath is prevented from drying out.

Orange orchard pruned high.

*"Experience and careful observation have fully satisfied the members of this club that the formation of low heads is the true method for the Washington Navel and other varieties of budded oranges. The shears should be used sparingly; in fact, scarcely used at all in young orchards, at least for six or eight years. The young growth should be guided with the definite object of developing a close and systematic head. J. H. Reed, to whom I am much indebted, in writing this paper, for definite statements in regard to his experimental work, says: 'As to pruning, I have demonstrated, to my own satisfaction at least, that need of pruning the orange can be

*From report of J. M. Edmison to Riverside Horticultural Club, February, 1899.

almost entirely avoided by suitable clipping during the early and rapid stages of growth, while the lemon needs constant and often heavy cutting from the first.' It is clearly a great mistake to cut out branches and to thin the top, as we sometimes hear, to let the sunlight in. Indeed, to keep the untempered heat of the sun out from the tender young fruit when setting, and to give shelter from the desiccating hot northers which sometimes cause the destruction of almost the entire crop of a young orchard, should be constantly kept in view, and not a leaf should be removed that can help in the work. Take a Washington Navel tree with dense foliage of a rich, dark green, and you will seldom fail to have a bountiful crop of choice fruit."

The illustration on the opposite page shows an orchard where the lower limbs of the tree have been removed, leaving a clear stock, so as to allow, in cultivating, the horse to pass under their branches and the cultivator to work the ground close to the trunks. No under support is left to the branches, and they require to be propped with poles, and have to be tied to the main limbs. The trunks are left exposed to the sun, and the ground under the trees invariably "bakes" before it can be worked.

Citrus-tree pruning can be commenced as early as January and continued through the spring months, but the best time to prune is immediately prior to the season of blooming. Oranges in the southern counties are picked from December to June; pruning follows the removal of the crop, and is regulated according to climatic conditions and the season. In the northern counties the fruit is removed much earlier, and pruning is pursued accordingly.

At all seasons of the year all superfluous sprouts on the trunk, and stray branches that threaten to throw the tree out of balance, should be removed without delay. The use of a sharp knife is very essential, and all cuts should be made as smooth as possible. All cuts made with a saw, especially large limbs, should be pared down smooth with a sharp knife, then waxed over or painted with gum shellac in proper solution to spread easily.

The advantage low-trained trees have over the high-trimmed is easily seen in the accompanying illustrations, made from

photographs taken in two of the largest orchards in the State, at San Gabriel.

The cut on this page illustrates the method of high pruning followed by some growers who until recently were firm believers in the system. The trees require to be propped to support the fruit which is borne at the ends of the branches. As many as ten to fifteen poles are required on some trees to prevent the breaking of limbs that become heavily laden with fruit, besides tying them with ropes to the main branches. The ground underneath always "bakes" and the trees show yellowing of the leaves. Now, pause for a moment, study the picture and see what proportion of foliage is cut away, which, if left, would protect the upper limbs from breaking and allow the fruit to be borne proportionately throughout. It is needless, perhaps, to remark that the crop borne on such trees is considerably less than that borne by trees having a dense foliage and trained low.

High-pruned trees—propped.

The illustration on page 122 is of a low-trained tree, from a photograph taken in an orchard, and a fair specimen of how the entire orchard looks. No props are used; there is little or no dead wood inside, caused by the hot rays of the sun; no limbs are required to be tied; and above all, the crop is always twice the size of that borne by high-trimmed orchards.

In summer the trees must be irrigated, and as the cultivator can not run close to the trunks the surface of most soils will "bake" by the heat before they can be worked by hand. On

SWEET SEEDLING ORANGE ORCHARD—Showing Low-Trained Trees, Their Productiveness, Proper Propping, Etc.

low-trained trees, the shade of the branches keeps the ground moist, and in case of excessive heat or scarcity of water, the trees will not suffer; whereas the heat dries out the soil beneath high-trimmed trees and causes the leaves to curl, and also checks the growth of the fruit unless the trees are again watered. Low-trained trees become well balanced, vigorous, healthy, and more productive, and the fruit is much more easily and cheaply gathered.

A low-trained tree—The favorite method.

Propping.—Proper propping of orange trees becomes one of the essential features in orchard work. The old method of propping with willow poles has been improved upon by the construction of a prop which is both durable and adjustable, of which there are several patents. The prop is so placed that the ends rest under the tree, as shown in the illustration on the next page, from a photograph. When so arranged they do not interfere with the cultivator, as they naturally would if placed surrounding the tree on the outside.

THE ORANGE CROP—GATHERING, ETC.

Picking.—Generally the fruit is not taken from the trees at one picking; the ripe fruit is first picked, thus lightening up the trees. The clean, bright-colored, smooth, fine-shaped, firm oranges always command the best prices. Fruit is handled with care. Growers find it an advantage to stem-cut (clip), rather than to pull the orange, as in pulling there is danger of tearing the skin. The fruit should not be packed fresh from the tree, as when so packed it will heat and sweat in the box at an ordinary temperature, and, as the entire contents of the box become damp, there is great danger of rot and decay. The fruit should be picked into boxes and left in the packing-house three or four days, to allow the rind to shrink and lose its surplus moisture. Unless the weather is very cool oranges go through a natural sweat, in which the surplus moisture escapes and the rind becomes tough and pliable; many unseen imperfections, such as slight bruises, etc., will develop into spots, necessitating a more careful selection of the perfect fruit for market.

Orange tree properly propped.

Packing.—Packing oranges has almost been reduced to a fine art, and the following suggestions offered by experienced growers should be carefully followed:

Use only the standard box, which is $11\frac{1}{2} \times 11\frac{1}{2} \times 26$ inches, with a partition in the middle. It is of great importance in securing a perfect pack that the partition and ends of the box are, in their making, correctly placed. The sizes of oranges vary only one eighth of an inch in diameter, and the least irreg-

ularity in box-making will cause the oranges of one side to be too high and the other side with the same sized fruit to be too low. In topping the packed box of oranges for shipment, the old method of hooping the ends and middle of the box to secure the box during shipment has been discarded. With a proper machine the fruit is pressed at the extreme ends of the box only. The top pieces are held in place, and narrow, thin cleats are nailed across the top ends, which hold the top firmly in place. The center of the top is left free. By this method the fruit is hardly pressed in the box, and two advantages arise from this practice: The fruit arrives in better condition as to shape and soundness, and the buyer by removing the cleats can readily inspect the fruit and not injure the package.

The arrangement which brings one orange directly on top of another, instead of breaking joints, has been discarded by the best packers. Alternated so that each orange comes over the space between two, the whole has more solidity and elasticity, and the fruit, as a result, sustains less injury from rough handling. It is best to pack oranges upon the dovetail plan, which allows the packing of more oranges in the box, and they are so braced against each other as to be immovable.

Regulate the size so as to have the oranges packed in tight and rise a full three quarters of an inch above the top of the box. Packers confine themselves to the 96, 112, 126, 150, 176, 200, 216, and 250 sizes. If the sizer be properly adjusted, this will provide for all sizes and simplify matters very much.

Do not dump the fruit into the boxes carelessly. Pack close and firm, so that the fruit will not have room to tumble about in the boxes and get bruised.

Oranges classed as "fancy" should be extra bright, with very smooth, thin skin. Rough, thick-skinned fruit, be it ever so bright, should never be classed as fancy.

Oranges classed as "choice bright" should be strictly bright and of fairly smooth skin and desirable size.

Oranges classed as "bright" should be bright and free from smut.

Never pack bright and smutty oranges in the same box. Never pack large and small oranges in the same box.

One of the most important features in the packing of oranges is the uniform neatness of the packages. Buyers will pay more

for fruit that is neatly and properly packed than they will for that which is carelessly put up.

All growers should endeavor to avoid, as far as possible, the shipment of *green* and *imperfect* fruit. A few years ago the "windfalls" and "culls" brought paying prices, for the simple reason that there was, comparatively speaking, only a limited quantity of this class of fruit. Remember, however, that of late years the crop has steadily increased, and the supply of *strictly good fruit* is now becoming amply sufficient to fill ordinary demands, hence, the shipment of "drops," "culls," *green and inferior fruit* simply aids in depressing markets, and interferes seriously with the sale of good fruit. The shipment of inferior fruit is neither profitable to the grower nor creditable to the State.

THE STANDARD ORANGE BOX.

Standard Orange Boxes, 11½″ x 11½″ x 26″.

Ends	3 pieces 11/16″ x 11½″ x 11½″
Sides	8 pieces ¼″ x 5¼″ x 26″
Cleats	2 pieces ⅜″ x 11/16″ x 11¼″

Standard Orange Boxes, 11½″ x 11½″ x 26″.

Ends	3 pieces 11/16″ x 11½″ x 11½″
Sides and bottoms	9 pieces ¼″ x 3½″ x 26″
Tops	2 pieces ¼″ x 5¼″ x 26″
Cleats	2 pieces ⅜″ x 11/16″ x 11¼″

Standard Orange Boxes, 11½″ x 11½″ x 26″.

Ends	8 pieces 11/16″ x 11½″ x 11½″
Tops and bottoms, and sides	12 pieces ¼″ x 3½″ x 26″
Cleats	2 pieces ⅜″ x 11/16″ x 11¼″

Half Orange Boxes, 5¾″ x 11½″ x 26″.

Ends	3 pieces 11/16″ x 5¾″ x 11½″
Slats	6 pieces ¼″ x 5¼″ x 26″
Cleats	2 pieces ⅜″ x 11/16″ x 11¼″

Half Orange Boxes, 5¾″ x 11½″ x 26″.

Ends	3 pieces 11/16″ x 5¾″ x 11½″
Tops and bottoms	6 pieces ¼″ x 3½″ x 26″
Sides	2 pieces ¼″ x 5¼″ x 26″
Cleats	2 pieces ⅜″ x 11/16″ x 11¼″

Half Orange Boxes, 11½″ x 11½″ x 13″.

Ends	2 pieces 11/16″ x 11½″ x 11½″
Slats	8 pieces ¼″ x 5¼″ x 13″
Cleats	2 pieces ⅜″ x 11/16″ x 11¼″

SIZES OF ORANGES.

No. in Box.	Inches in Diameter.
112	$3\frac{2}{8}$
126	$3\frac{1}{8}$
150	3
176	$2\frac{7}{8}$
200	$2\frac{6}{8}$
216	$2\frac{5}{8}$
250	$2\frac{4}{8}$
300	$2\frac{3}{8}$

PAPER USED IN PACKING DIFFERENT SIZED ORANGES.

Size of Paper.	Number of Oranges in Box.
8 x 8	288–324–360
9 x 9	216–250
10 x 10	176–200
11 x 11	112–126–150
12 x 12	80– 96

Weight of Oranges.—The weight of a box of oranges varies in each season, in the months of the same season, in different varieties, and in the different sizes of each variety. The difference in weight is caused by many circumstances. In some seasons climatic conditions are such as to build the tissues solid and firm. The plant seems to have an added power to construct the heavy sugar compounds and to build its tissues compact and with more than its usual weight. In arriving at the weight of oranges all of these conditions have to be considered. An average season is when there is a continuous and even distribution of heat units during the summer months, with no frost to break the inner tissues of the orange, causing both evaporation of its juices and re-absorption, preventing the tree giving and the orange appropriating the starch-building compounds from the injured and unelaborated sap. There are also local conditions—as soil, nearness to the ocean, altitude, and the general slope of the orange area, as to the north, east, south, or west—to which may be added those personal conditions of irrigation, fertilization, and cultivation.

Taking the season of 1895 as an average season, and the orange growths of March, April, May, and June, produced on the terrace lands of Colton, the average net weights of packed oranges in the standard orange box were as follows:

	Pounds.
Washington Navel	65.144
Australian Navel	64.282
Florida Navel	67.972

	Pounds.
Seedling	64.095
Homosassa	65.182
Mediterranean Sweet	66.510
St. Michael	69.172
Bloods	66.352
Valencia Late	68.632
Net average weight per box, all varieties and sizes, during the above months	66.37

The three principal varieties grown in California, or that will be grown, are the Washington Navel, Seedling (either natural or budded), and Mediterranean Sweet. The weights of these varieties are:

	Pounds.
Washington Navel	65.144
Seedling	64.095
Mediterranean Sweet	66.510
Net average weight of these varieties	65.247

The sizes of oranges vary from 80 to 360 to the box. The size variation in weight per box of the three varieties of fruit is:

	Pounds.
Washington Navel	6.56
Seedling	7.51
Mediterranean Sweet	5.03

The average difference in weight of the three varieties of the light or heavy sizes is 6.36 pounds.

Taking the same size for the determination of monthly variation in weight, and comparing the lightest and heaviest month's fruit of the three varieties named, the following variations in monthly weights appear for the 176 size:

	Pounds.
Washington Navel—	
February	66 34
March	67.12
Variation	.77
Seedling—	
February	61.24
May	67.51
Variation	6.27
Mediterranean Sweet—	
May	65.96
June	67.10
Variation	1.14

These deductions are of value in determining the proper sizes of each variety to grow and the profitable season to market each variety.

The monthly variation of the Washington Navel shows that it matures early, and that it is practically uniform in weight. With the Seedling it is different; the increase in weight from February to May is over ten per cent—surely a good argument against sending to market the immature fruit of the former date.

Standard Car of Oranges.—The regulations governing the variety of size in the "standard car of oranges" were adopted by the Fruit Growers and Shippers' Association of Southern California, as follows:

Navel Oranges.—A standard car of Navel oranges to consist of sizes 96's to 200's inclusive; not over 15 per cent 96's and 112's. Any excess of 15 per cent 96's and 112's to be considered off-sizes and invoiced at a reduction of 50 cents per box. Sizes 64's, 80's, and 250's, Navel, to be considered off-sizes and invoiced at a reduction of 50 cents per box from the price for regular sizes. Sizes 216's, in Navels, to be considered off-sizes and invoiced at a reduction of 25 cents per box.

Seedlings, Mediterranean Sweets, etc.—The standard car of other varieties (except Valencias and Paper-rind St. Michaels) to consist of sizes 126's to 250's inclusive; not to exceed 15 per cent 126's and not over 15 per cent 250's. Any excess of 15 per cent 126's and 15 per cent 250's to be considered off-sizes and invoiced at a reduction of 25 cents per box. Sizes of Seedling oranges larger and smaller than 126's to 250's, inclusive, to be considered off-sizes and invoiced at a reduction of 25 cents per box.

It is understood that each car of oranges may contain a reasonable quantity of off-sizes, at the reductions named above.

ORANGE DROPPING, DISEASES, ETC.

Generally during the month of June, and as early as May in some years, growers experience a continuous dropping of young fruit, due to various unknown causes.

*"As a rule, growers ascribe it entirely to hot winds, and it is doubtless true that the extremely hot weather finds trees partially dormant and the damage is wrought on the young, tender oranges and lemons before the sap could start to flowing freely. But, on the other hand, we can see orchards that still have a fair crop of fruit. Why is it? is easily asked, but not so easily answered. The most universal remedy that is recommended is water, and in so far as it is used to put the tree in good condition, is doubtless effective. To do that water should be applied two or three weeks prior to the hot or cold weather; or in other words, the tree should at all times be in strong growing condition. To accomplish this, water in abundance down deep in the ground is necessary. Surface irrigation is of little avail. It will be noticed that those irrigators who are applying water in the furrow until it reaches the lower end, are the ones who scarcely ever have a crop, whether we have hot or cold weather, or the best of conditions. And right here I might say that the ideal season never comes, for there is always something with which to contend. I plan to irrigate my trees every six weeks, running the water eight or ten hours in each furrow. On heavy soil this would not be sufficient, but on my sandy loam it is. Following the irrigation I cultivate deeply and thoroughly. I deem the deep cultivation essential so that the surface roots may be destroyed. This is still better accomplished in the wet season by deep plowing. I am thoroughly convinced that deep plowing is beneficial in all seasons, and especially so in dry ones. The roots are forced to go lower to where the supply of moisture is more permanent, consequently such trees are not so quickly affected by any hot wave or sudden change. Therefore, I would say that the first requisite of always securing a good crop of oranges is deeply rooted trees irrigated so thoroughly that at all

*C. B. Messenger, before Farmers' Institute at Pomona, October, 1896.

times there is in store a plentiful supply of moisture. Should I stop here and say that this is the one thing needful, I presume there are some who might declare it a fallacy, and quote their own experience in proof. In fact, in my inquiries I consulted one orchardist who had irrigated thoroughly three different plots, respectively four weeks, two weeks, and one or two days before the first hot wave this spring, and yet a large percentage of his crop went to the ground."

Wm. C. Fuller, of Colton, says: "I find the best crops near the heads of irrigating streams, and use the method described as so fatal by Mr. Messenger. To be sure I do not get as large a crop as some who use this same method. I had twelve carloads from about fifteen acres."

Yellow and Variegated Leaves on Orange and Lemon Trees.—It is doubtful if there is a section in the State where orange and lemon trees can not be seen with yellow and variegated leaves. This has been ascribed to various reasons, such as too much or not enough water, too much or lack of cultivation, excessive cold, excessive heat, etc.

Prof. S. M. Woodbridge, of Los Angeles, says: "Without wishing to offend any one for ill treating so good and paying a friend as the orange or lemon tree, we would suggest the answer in one word: *Starvation.* The remedy then would naturally lie in feeding. In reviewing the analyses of the soils in Southern California, one is naturally struck with the deficiency in sulphuric acid that such soils show. Having been brought up in a section of country where it was definitely settled that the 'only expensive ingredients that any soil was likely to be deficient in were nitrogen, phosphoric acid, and potash,' and considering that there the form of phosphate was invariably a superphosphate, *i. e.*, made soluble by sulphuric acid, and further finding that untreated bone is the usual form in which it is used there, and also being convinced that the soil-analysis *theory* had been exploded years since and discarded by people the world over who are looked upon and considered 'authorities,' and having shown, by actual field tests, that potash was beneficial even on soils that had been reported as very rich in potash, and when the theoretical advice had been given that no potash would be required

for many years; and also having followed out the experiments of A. B. Griffiths, Ph.D., F.R.S., of England, with the use of sulphate of iron, and also similar experiments conducted in France, and not having obtained as satisfactory results from a certain test plot on wornout soil as could have been desired, the writer used sulphate of iron in conjunction with the test plot. The result was so satisfactory that when one of the large growers of lemons and oranges last September asked what remedy could be applied to prevent the leaves of his trees from turning yellow and much of the fruit from ripening prematurely when not half grown, I suggested a liberal dose of complete fertilizer—that is, one containing nitrogen, phosphoric acid, and potash—together with about seventy-five pounds of sulphate of iron per acre. The orchard had previously been liberally treated with stable manure, yet some of the trees were not in a healthy condition. Now the trees have a healthy green appearance, and nearly if not quite all of the new growth is of a bright or deep green color, whereas the trees that were not treated have the new growth showing a variegated, streaked leaf. Since the first experiment was tried several other plots have been treated in the same way, with the most gratifying results. As to the why and wherefore of the encouraging results obtained from the use of sulphate of iron, we confine ourselves to quoting what Dr. Griffiths says upon the subject:

"'Three years' experiments show that a small dressing of a hundredweight of iron sulphate per acre is a most beneficial manure.

"'The author's proposition (Chemical News, Vol. XLVII, p. 27) was that a "fairly large proportion of soluble iron in a soil is favorable to the growth of plants developing a large amount of chlorophyll." And all subsequent investigations on the growth of crops with iron sulphate have entirely confirmed the accuracy of that proposition.

"'All soils contain iron as a constituent, but the iron is not always in a form to be readily taken up by growing crops. This being so, a crop must suffer, iron being one of the ingredients requisite for the formation of green chlorophyll.

"'Chlorophyll is a substance of primary importance in every plant (giving rise in the first instance to starch, woody fibers, fats, and carbohydrates generally); therefore it is necessary to

add soluble iron compounds, where the soil is deficient in these ingredients, or where the iron is not in a form for root-absorption. Some soils are certainly deficient in soluble iron, and no amount of nitrates, ammonia salts, etc., will replace this ingredient. The farmer must add soluble iron salts to his land if he desires to obtain a full yield with the least expense. Dr. E. Wolff, the German authority, found that when soluble iron was omitted in certain culture experiments, the young plants became yellow and sickly, but they quickly became green and assumed a luxuriant growth when a small quantity of iron solution was added.' (Griffith on Manures, p. 268, etc.)"

*"**The 'Die-Back' Trouble.**—This serious trouble is exanthema or 'die-back.' The name is given to a weakness affecting orange, lemon, and other orchard trees. There are several especially bad cases in the San Gabriel Valley, where solid blocks of citrus trees are now utterly worthless. Trees seven years old and in a frostless location have not attained a height of over four feet, in some instances, and bear little or no fruit, while adjoining trees of the same age and seemingly under similar conditions are of large size and bear heavy crops.

"Orange trees affected with 'die-back' make an apparently healthy growth in the spring and early summer, but the young shoots soon turn yellow, the leaves drop off, and the twigs die back to the older wood, from which a brown granular substance exudes. In a season or two, this older wood also dies. Adventitious buds keep developing at the axils of the leaves, until at the end of the season there are small knots, where there should be healthy lateral branches. Experiments with Bordeaux mixture and carbonate of copper have been made in a badly affected grove near Pomona. The work so far has shown no appreciable results, but it has not yet been carried through one season.

"[In almost all cases of 'die-back,' examination has shown some fault in the subsoil, which puts the roots under stress. Such fault may be an underlying hardpan or impervious clay, pure and simple; or it may be excessive wetness or dryness of the substrata surrounding the deeper roots; or the rise of bottom water from below, as in cases of over-irrigation. The

*J. W. Miller, in University of California Bulletin No. 138.

true 'die-back' is not properly a disease, but simply the manifestation of the distress felt by the root-system underground. The first thing needful is to dig down and examine the roots, and then to relieve whatever fault may be found, if possible; which may not always be the case. Sometimes an appearance similar to the 'die-back' is caused by the roots encountering a marly stratum, which is apt to stunt the growth of the tree, causing it to put out a multitude of small, thin branches, and sometimes causing the tips to die off. For this form of the trouble there is no permanent remedy; the trees should never have been planted in such ground, any more than in such as has shallow-lying hardpan or clay. (E. W. H.)]

"['**Mottled Leaf.**'—Closely related in its causes to the 'die-back,' and sometimes accompanying it, is the 'mottled leaf' trouble. It may be properly called 'partial chlorosis' of the leaves, and on the basis of that designation it has been attempted to treat it like the corresponding human ailment, with iron tonics and fertilizers. But in every case that I have closely examined, and in most of those reported to me by others who have made such examinations at my suggestion, the cause was not lack of nourishment that could be remedied by such means, but simply an improper condition of the root-system, especially of the deeper roots. When a thriftily growing tree suddenly stops and begins to show mottled leaves, it is clearly not because of lack of nourishment in the soil, but because some of the physical requirements of the tree's well-being have ceased to be satisfied. In such case fertilization can afford but temporary relief, if any.

"The commonest cause of mottled leaf is a layer of dry gravel or sand reached by the taproots, throwing them out of healthy action. Of course the same effect may be expected from the exhaustion of the usual supply of moisture in the substrata, which has not been made up for by the comparatively scanty irrigation permitted by the diminished water-supply during the past three yerrs. The cause of the present great prevalence of mottled or yellow-leaf in the citrus orchards is probably a parallel to the wholesale dying out of vineyards in the Santa Clara Valley, regarding which a special bulletin (No. 134) was issued by this Station some months ago.

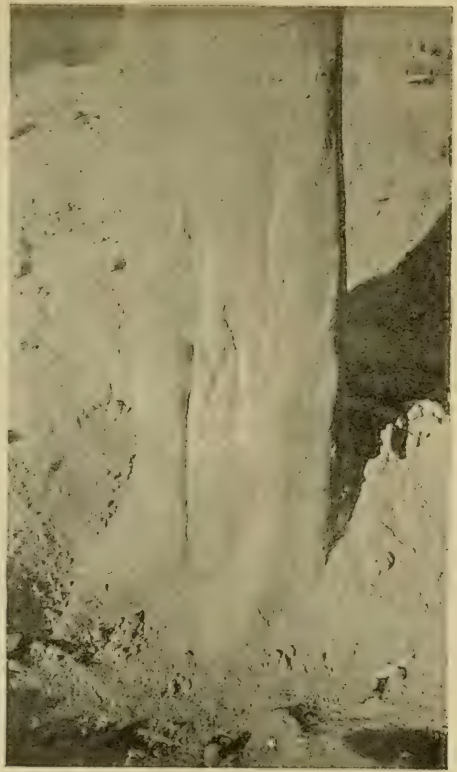
"Quite probably, however, other unfavorable conditions affecting the roots, such as alkali, marl, or a hardpan layer, may in many cases produce this effect. In any case, the cause should be sought for at the roots before deciding upon possible remedies. (E. W. H.)]"

Gum Disease.—There are various forms of so-called "gum diseases." One attacks both young and old trees at the crown and roots of the tree, while another appears on the large limbs in the form of a "scab," and another on the trunks and main branches.

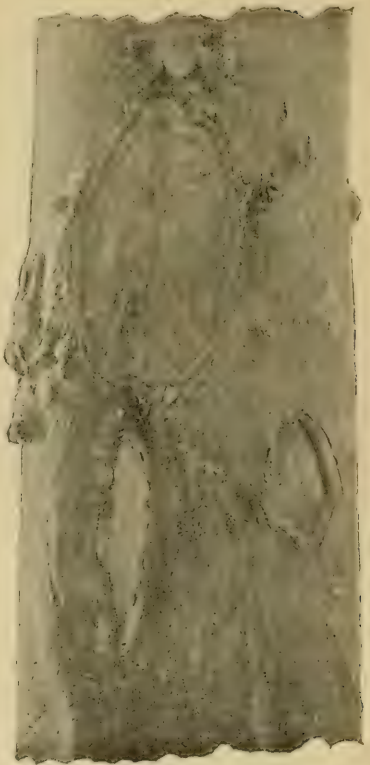
The most deadly of these is the "root form," which is prevalent almost everywhere. This form of the disease is first detected on the trunks of trees close to the ground, and is an exudation of the sap, which breaks through the bark and congeals in the form of a gum. No citrus tree is free from the disease, and one of the newest facts regarding its appearance is that frequently the finest trees are attacked. It often happens that in making a search for the early development of the disease, no trace of it is observed until exudation has freely commenced. It often happens, too, that in digging away the surface soil around the stem, little more than a black scratch about one to two inches long has been discovered, which when cut open shows the gummy fluid more or less encircling the wood under the bark.

Remedy for the Gum Disease.—The best method of controlling this disease is to cut away the bark surrounding the place from whence the gum is oozing, in order to detect the main parts affected. The wood where the gum is oozing is cut out with a chisel and left for a day or so, to determine if all the disease has been removed. If it is not altogether removed, the affected parts soon commence to ooze out gum, when more of the wood is cut until it ceases. Yellow streaks of sour sap are generally seen in the grain of the wood, which are traces of the disease. If the affected parts show no further exudation it is proof that the disease has been removed, and the affected parts so treated are either waxed over or covered with a good coat of rubber paint. Where the disease has reached around the tree there is no possible cure for it, and in such cases it is

Tree affected by gum disease, showing removal of bark over affected part, ready to cut out.



An affected tree cured by the removal of the diseased portion.



Trunk of tree cured of citrus scab disease by the removal of same.

THE GUM AND SCAB DISEASES PREVALENT ON CITRUS TREES.

better to remove the tree and put a healthy one in its place. The spot where the tree stood should be disinfected by a slacking of fresh lime, and the ground permitted to remain exposed for a reasonable time.

This disease being of a bacterial form, all chips and scrapings should be carefully collected and burned, to prevent the spread of the disease through the orchard. The tools should also be dipped in some disinfectant before being used on other trees.

Some growers are led to believe that badly diseased trees can be restored to perfect health by cutting back the tops and removing all large limbs to force a new growth. In all badly infected trees there are always a few healthy roots that furnish enough vitality to the tree to keep it alive. The cutting away of all the foliage forces new growth, and while the trees sometimes produce large, coarse, puffy, and sour oranges for a few years, they finally succumb to the effects of the disease, and it is only a waste of time and energy to try to restore them.

*"Crude commercial carbolic acid was found to be the best remedy, and was used in varying strengths. When mixed with its own weight of water it was found to answer the purpose admirably, the gum having been previously cut away, so that the application could be made directly on the parts most affected. The result in almost every case was that new bark began to grow over the diseased parts, at the lines where the old bark was healthy. In cases where the roots had become affected, the ground was carefully pulled away from the roots of the tree to the depth of from six to ten inches, and, after a day or two exposure, the diluted carbolic acid was applied, and in the course of three or four weeks a second application was made, when the soil was put back to its original position, and subsequent applications of diluted carbolic acid were made, from time to time, above the surface of the ground. Coal tar has been found to be very efficacious also. It is applied by taking the soil away from the roots of the tree and putting from one half pint to a quart (according to the size of the tree) in the soil about the roots of the tree, and covering the tar with the soil so removed. Among those so treated are some

*Prof. S. M. Woodbridge, in essay before Farmers' Institute, Santa Barbara, 1894.

trees in the famous orange avenue of Sunny Slope. Too much care can not be exercised in the use of carbolic acid. The strength of the commercial acid varies, and it must be diluted to such an extent that the vegetable tissues will not be destroyed by it."

FERTILIZATION.

*"The question of fertilizers for the orange orchard has in some form been almost continuously before the club. What kind of fertilizers are the best, and how and when they should be put on, are questions often asked, but never as yet answered to the satisfaction of all. Careful experiments are being made by members of the club, but as yet we have nothing definite to report. However, it is known that the different commercial fertilizers on the market are good, and that freely applied they generally give satisfactory results. But the growers believe that they are too expensive, and that by buying the chemicals and doing their own mixing, or by applying the chemicals in suitable quantity to the soil without mixing, they may reduce the expense almost one half. This method is likely to be adopted by many growers, and that will tend to lower the price of the fertilizers now on the market.

"There is a growing conviction among our orchardists that stable manure is one of our most valuable fertilizers, when it can be secured at reasonable figures. A member of our club has a small Navel orchard, fifteen years old, a part of which has been fertilized exclusively with stable manure. It has borne regularly, and the fruit has been fully up to the average standard in quality. But it is probably better as a rule to vary the kind of fertilizer applied."

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*From report of J. M. Edmison to Riverside Horticultural Club, February, 1899.

THE USE OF FERTILIZERS.*

In the use of any kind of fertilizer there are so many unknown conditions prevailing, so great difference in soils and in their general treatment, and the ignorance of the construction of the fertilizer, that with me it is difficult to attend to this important work with any scientific exactitude. I presume those who will make the question a study may eventually gain such knowledge as will enable them to discern the wants of their soil, and become sufficiently posted in agricultural chemistry that they will know how to provide these requirements at the least expense and with the greatest degree of accuracy. But what is the ordinary rancher going to do about it?

Uncertain Results.—The growers of my section have experimented with almost every kind of fertilizer, but the results, in the way of better crops, have not been so marked and so plainly attributed to the applied articles, that many of us dare speak with any degree of certainty. We wish we could. One grower, and the only one I have talked with who has continued to use the same compounded article for so long as four years, has gathered each year a profitable crop. A neighbor adjoining, who has used nothing, has also harvested good crops. Another, who has used different kinds of fertilizers, and with no attempt at regularity, has usually gathered abundance. This, of course, is not conclusive evidence that fertilizers are not helpful, but when similar experiences are general it leaves one in great doubt as to what should be done. We have no money to spend upon that which does not at least bring an equivalent in larger or better crops, yet we are quite anxious to do that which will enhance the quality of the fruit and maintain the groves in vigor for the longest possible time.

The soil in the Fullerton and Placentia districts in general abounds in the essential elements—potash, nitrogen, and phosphoric acid—and is capable of sustaining an enormous draft upon it for a considerable time, if properly manipulated. Winter plowing, a couple of good irrigations, and proper cultivation, I believe, have never failed to produce a good crop, providing always that the trees are free from scale and intelligently pruned. We do not consider it prudent, however, to make too

*By C. C. Chapman, Pomological Meeting, Covina, 1898.

great demands upon the soil without giving back some equivalent in the way of plant-food. I think many of our people have tried to discover just what is most needed in the way of substantial diet, but, as previously stated, only a few have found that which is satisfactory. As our groves advance in age, however, more marked results may be noticed in the application of fertilizers.

Pretty much every brand of commercial fertilizer finds users among our growers; but so far as my information goes, with one exception, of those who are not interested in some way in the sale of these goods, the users have no very decided views as to results. They are unable to say positively that one kind has given better results than another, and in many cases are not convinced that any favorable returns were obtained from their use.

There may be reasons for these discouraging experiences which can be explained by those informed. If we only knew just what to employ with that degree of certainty that we use hydrocyanic acid gas to kill scale, we should feel that the production of citrus fruits could be regulated with almost scientific accuracy.

Great Anticipations.—I recognize one difficulty in the employment of commercial fertilizers that not infrequently prevails, and that is, the too great expectation of immediate good results to be derived from their use. The fertilizer is scattered about and then a magical change is looked for, and a consequent inactivity in cultivation results, and in the end perhaps disappointment. We should follow the example of the good Baptist deacon who prayed most fervently for a good crop, and then turned all hands out early to help the Lord answer his prayer. We should not depend upon the fertilizer, however high priced, to take the place of the whole process of crop production.

An Experiment.—I have been frequently questioned as to what fertilizer we use on the San Isabel ranch; the parties inquiring wishing to know so that they might employ that which had produced such excellent results. I regret very much that I have been unable to reply to these inquiries in a manner that makes the answer of any practical value. Two years ago I made what I intended to be a fairly practical test of different

fertilizers. I can not say that the experiment was satisfactory in giving the information that would guide me in the future as to what to do to insure a good crop. Upon a plot of one thousand trees I put a light dressing of sheep manure. Upon the next one thousand I used commercial fertilizer. The adjoining one hundred I passed without giving anything. Upon the next plot I used lime cake. Next to this I used bone meal. Then, upon another plot, I used the sheep manure, commercial fertilizer, bone meal and lime cake, and some wood ashes—a little of each. The crop came, and it was in great abundance in all parts of the orchard. I am frank to say that I could not distinguish any material difference in the size, quality, or texture of the fruit grown upon the various plots. This was not a little disappointing, for I had looked forward to this plan of testing soil requirements and the relative value of various fertilizers to decide this most perplexing question. I supposed I would be able to tell thereafter just what the soil demanded in order to produce desired results. But I was still left in the dark. I will add that while I may have been unable to distinguish any material difference in results after employment of fertilizers, I have noticed unmistakable evidences of the value of proper irrigation and cultivation.

The year following, last year, being able to secure sheep manure at what I considered a reasonable price, I used it in giving the orchard a light dressing, with the exception of two plots. The harvest was the heaviest ever secured, and the fruits of the highest grade, and I still could distinguish no material difference in the yield in any part of the orchard.

I am quite aware that there was a combination of favorable influences generally prevailing last year, which gave the greatest abundance of fruit to non-users of fertilizers as well as to their most enthusiastic advocates, or to those who used a common article, as to those who applied the most expensive commercial production. So I am still in doubt.

The portion of the orchard which is the heaviest set this year is the plot that had the entire combination of fertilizers two years ago. Other favorable conditions, I think, are at least in a measure responsible for this.

Aëration of the Soil.—I am convinced that we have much plant-food in some of our soils that is not utilized on account

of our failure to sufficiently aërate the soil by proper and frequent cultivation. The air, I believe, is an essential factor in carrying on the process of nitrification. A circulation of air through the soil will unquestionably increase the available supply of nitrogenous food.

I know little of chemistry, but I observe that soils kept open and thoroughly aërated produce great growth, even without the application of fertilizers of any kind; whereas, soils compacted, however rich in plant-food, will not compare in results. I thus philosophize because I believe much plant-food will never be utilized until the soil is properly aërated. Cultivation is therefore an important factor in proper fertilization of soil.

How to Apply.—Fertilizers are variously applied by orchardists. One grower, and he has a fine, well-kept orchard I notice, scatters barnyard or sheep manure immediately around the trunks of the trees, and extending out five or six feet. Generally, however, fertilizers are scattered broadcast between trees and plowed under; some, however, drill them in. The latter, for commercial goods or ground sheep manure, is the best method, in my opinion. I observe that the grove first referred to is vigorous in growing, but this year has a light crop.

However, the advocates of these different methods generally point to good crops as the result of their plans. One thing is certain, it either makes little or no difference with us what is used, or how applied, or else the fertilizers are so all-powerful that it is only necessary to have them come in contact with the soil to have it respond.

Some of our people have experimented with green crops for fertilizing, but have nothing satisfactory to report. Perhaps if they had used some of the leguminous plants recently secured from Europe, and so highly recommended by Professor Hilgard and others, results might have been quite different.

More Investigation Desirable.—I want to commend this subject to the careful investigation of the more observing and scientific of our growers, so that the work of fertilizing our citrus orchards may be reduced to a science so plain, simple, and practical that any of us may comprehend it, and that the results will be such that an all-assuring faith in its principles may prevail. I am pleased to note that the Agricultural Department of our State University, as well as those interested

in the manufacture of fertilizers, have made and are making a careful study of the subject, and have done much in disseminating general knowledge of the question and in educating the public. Those who give the matter candid and honest thought should be commended, and while they may be primarily promoted by selfish motives in the way of financial gain, yet if they devote any special ability they may possess to a more perfect comprehension of the question they should be regarded as public benefactors.

FERTILIZING CITRUS TREES.*

Some four or five years ago I commenced hauling stable manure on the orchard, and on the information of good authority, that the trees would not need fertilizing probably for some years, and that when they did it would be nitrogen, I bought and applied in the fall Chili saltpeter, a small amount per tree, with the evident result that I had more puffy fruit than I ever had before up to that date. I say evident result, as the orange-growers who used it in Los Angeles County had the same experience.

Four years ago I commenced to apply Woodbridge's Orange Fertilizer. Following this use my oranges improved in color—at least had a higher color—the increased yield making the oranges smaller and more desirable. Last December I sowed twelve pounds of Woodbridge's Orange Fertilizer No. 1 per tree, and cultivated it in. Then in January and February last I put in addition upon one section of the orchard fifteen pounds per tree of the West Coast Fertilizer; and on another portion of the orchard fifteen pounds of Bradley's Nursery Stock Fertilizer; and on another portion of the orchard fifteen pounds of pure guano, to test their relative values. From the portion of the orchard where I used West Coast Fertilizer the fruit was the tenderest I ever had; perhaps the word *softest* would explain the character—and it needed shipment first. My opinion was that it should go under ice; but Chicago said not to ice. When the fruit arrived in the East, then the advice came to ice the cars. After shipping this fruit I commenced on the section where I had used the Bradley Nursery Stock Fertilizer, and this fruit,

*Extracts from essay by N. W. Blanchard, President of the Lemonia Company of Santa Paula, before Farmers' Institute, 1897.

while not soft like the first, did not stand up well, and a large amount of it became puffy and could only be classed as culls. The last shipments of oranges came from the portion of the orchard where guano was used. The fruit was not puffy, although it was late in June. The oranges, however, had commenced to drop a good deal and did not keep much better than the rest. It should be added here that the promise for the next year's crop of oranges is best where I used the Bradley fertilizer; then next the West Coast, and last where the pure guano was used. It should be said that there was a general complaint last year that all the oranges did not keep well. I was told in both San Francisco and Sacramento that never before did oranges keep so poorly. Now, the interesting question is, Why did the oranges not keep as well as formerly, and what was the cause of the difference in the quality and keeping of the oranges? It will be remembered that the rains of last winter came slowly and timely for the agriculturists, and a larger portion of the rain was taken up by the soil than in any winter of my remembrance since I have been in the valley, a period of twenty-five years. The orchards were soaked with water for several months. This probably explains the reason for the general non-keeping quality of the last orange crop; and the only reason I can assign for the difference in the keeping quality of the oranges from the different sections of my orchard was the difference in the amount of nitrogen in the different fertilizers—the poor crop being accentuated, perhaps, by the stable manure put on the orchard. One point was called to my attention, to wit: that the trees bordering a deep ditch through the orchard had better fruit than the trees more distant from the ditch, indicating that the ground needed draining.

In regard to the use of nitrogen or ammonia, I had supposed that the same result would be attained in whatever form it was used, and have only recently learned that this is not the case. For instance, ammonia in Chili saltpeter is very quickly taken up by the tree roots, or washed out of the soil by rains or irrigation, while it may be so combined in other materials as to give up its ammonia slowly, and this would make a difference in the value of fertilizers of the same analysis.

A few years ago I found some of the limbs of the orange trees dying and some dead. This I have arrested, I believe,

by fertilization. I am this year using the Bradley Orange Tree Fertilizer at the rate of thirty pounds per tree, or twenty-four hundred pounds per acre, making two applications in the year, say one in January and one in July.

ECONOMY IN FERTILIZATION.*

Numerous inquiries regarding the necessity or expediency of potash fertilization in this State, and the fact that active misrepresentation of my views and teaching in the premises has been made by interested parties, render it expedient that these views should be briefly formulated in print for the benefit of persons interested.

What the Plant Needs.—It is an elementary fact, pretty generally understood, that, strictly speaking, *all* substances used by plants for building up their tissues are of equal importance; in so far as in the entire absence of any one of them, plant development can not occur at all. But it is universally known and admitted that all but three or four of these are present in ordinary soils in sufficient amounts and in an available condition for the purposes of plant growth. The only ingredients usually required to be replaced by the use of fertilizers are potash, phosphoric acid, nitrogen, and lime. Any fertilizer containing all of these may be considered "complete," and when supplied after each crop in the same amount and in the same proportion as has been finally withdrawn by the sale of the crop, soil exhaustion can be indefinitely prevented and fertility perpetuated. The only question, then, about which there can be any discussion is: *whether in every case the use of all the four substances is really necessary*, or whether one or more can, for the time at least, be omitted. This question arises most obviously with reference to the great differences existing in the kind and amount of draft made by different crops on the soil. Thus, root crops withdraw very large amounts of potash from the soil, while drawing but lightly upon phosphoric acid and nitrogen; on the other hand, cereal crops are known to draw very heavily on phosphoric acid and nitrogen, while taking up a comparatively small amount of potash only. These facts form the main basis of the utility of rotation of

*By Prof. E. W. Hilgard, Director of Agricultural Experiment Station, University of California. In "Pacific Rural Press," November 4, 1896.

crops; and the same principle is recognized in the practical fertilization of the root crops with fertilizers that include chiefly potash, while for grain a combination of nitrogen and phosphoric acid is usually given and found most profitable.

Supplying Deficiencies.—The reason why in many cases the return of one or two of these fertilizing ingredients can be omitted from the replacement is that the soil itself frequently contains a larger proportion of one or several of these same ingredients in a form available to plants; that, moreover, these ingredients, usually occurring in the soil chiefly in a difficult soluble condition, are gradually set free, by the "fallowing" action of the atmosphere, from their insoluble combinations, so as to become available to plants; and that if the soil is naturally rich in one or more of these ingredients, the return of such ingredient may be omitted, either after a fallow or after a crop that has drawn but lightly upon it. Thus, after a root crop phosphoric acid may usually be omitted from fertilization, if the soil is known to be (naturally or artificially) rich in phosphoric acid; and the same, of course, is true of potash and nitrogen in other cases. In so doing, the husbandman draws upon the natural resources of the land, availing himself of the advantages of a rich soil; but those who cultivate soils naturally poor may be compelled to return in every case each one of the three or four ingredients needed for and commonly used in fertilization.

Wasteful Practice.—Were the immediate return of *everything* that the crop takes away necessary on *every* soil, the possessor of rich land would have no advantage over the owner of poor land, for as soon as the first flush of fertility is exhausted in the virgin soil, both would be equally obliged to supply the full amount of ingredients withdrawn from the soil by each crop. But the experience of centuries has shown that such integral replacement is altogether unnecessary on very many lands, and, as a result, the use of a "complete" fertilizer is in Europe a rare exception, save as regards stable manure. Farmers buy the individual ingredients as furnished in commerce, according to the supposed requirements of the land, as deduced either from its previous history or from the known richness of the soil in either one or the other ingredient in question.

Complete Fertilizers.—In the United States the habit of purchasing everything "ready made" prevails to an unusual extent, and fertilizer manufacturers mostly cater to this demand by supplying "complete fertilizers," compounded in accordance with the known requirements for certain crops, therefore *on the supposition that the soil supplies nothing of itself.* In purchasing these complete fertilizers the farmer is, therefore, likely to pay for one or perhaps two ingredients which the soil may not require at all to produce the most profitable crops, when his money would be probably much better spent in procuring a larger amount of one substance specially needed. The enormous waste of money thus incurred is now so well recognized in Europe that the manufacture and sale of mixed fertilizers has been almost completely superseded by that of the simples themselves. A farmer buys superphosphate, potash salts, or nitrogenous fertilizers separately, in accordance with a rational understanding of the requirements of his land, more particularly with reference to the nature of the preceding crop, the amount and the kind of draft made on the land, and the character of the latter.

That this is the only rational and economical mode of using commercial fertilizers is indisputable; it is only in the case of stable manure itself that the farmer is compelled to use all the ingredients indiscriminately. The farmer who, either from lack of knowledge or from inertness, spends his money for "complete" fertilizers, a part of which he may not need at all, need not be surprised if the increase of crop resulting from their application does not yield adequate returns for the outlay incurred. The fertilizer manufacturer naturally desires to sell his wares and is not specially interested in reducing the farmer's expenditures therefor.

California Soils.—As regards the soils of this State, experience has shown that an unusually large proportion of them remain profitably productive without fertilization for a considerable length of time, and that when virgin soils, or such as have been under cultivation for a short series of years only, fail to produce satisfactory crops, it is usually due to other defects than lack of fertility, requiring to be supplemented by fertilization. Even in the East it takes from seven to thirty years to reduce the production of "fresh" soils below profitableness, and the nature of the crops grown being known, it is not difficult to

determine what ingredient or ingredients are most urgently required to restore production.

A simple leaching with water shows many of our valley soils to contain, *in water-soluble condition*, a large proportion of *potash* salts, so as to render the idea of supplying more of the same substance simply absurd. Thus, the ten-acre experimental tract near Chino contains per acre an average of over 1,200 pounds of water-soluble potash in the first three feet, equivalent to the amount required for eight twenty-ton crops of sugar beets, without drawing on the less soluble but much more copious soil store. Similar cases are common in other valley regions of the State. These facts speak for themselves.

Equally simple tests show that in the great majority, probably at least three fourths, of the soils of the State, *lime* is so abundant that it need not be supplied for centuries to come at least. These facts are easily ascertainable by any one having even a superficial knowledge of chemistry.

But more elaborate investigation and analysis show that while both lime and potash are present in unusually large proportion, as compared with soils east of the Mississippi and in Europe, phosphoric acid and nitrogen are, on the contrary, as a rule, present in small amounts, and likely to become deficient in a short time under exhaustive cultivation.

What to Use First.—Upon these plain and simple facts is based my recommendation to California farmers that, whenever production of their land becomes unsatisfactory, they should try any large-scale fertilizer first with phosphates and nitrogen, and, should this not prove fully satisfactory, then with potash also; this being the order in which these substances are likely to become deficient in most of our soils under cultivation.

In the course of time potash fertilization will become widely necessary in this State, also; but it is certainly not among the first things generally required, as is actually the case in the East and in Europe. Under continuous heavy cropping with root crops, such as beets, potatoes, or artichokes, or with small fruits, such as strawberries, potash fertilization has already, as a matter of fact, become necessary at some points and will gradually become more so. On the gray soils of the foothills of Amador and Placer counties we have found it necessary from the very

outset, these soils being as poor in potash as Eastern lands. The same is true of some of the sandy lands of the interior.

My advice to the farmers of California is and has been simply that, in order not to waste their money for the purchase of ingredients probably not necessary, they should begin by supplying those most likely to be required at the time, and to turn to the use of potash fertilizers only after they have found the effect of phosphatic and nitrogenous ones to be unsatisfactory.

The efforts of those interested in selling as much as possible of their manufactured products are, quite naturally, in opposition to this policy, but the advice of the interested party is not usually the one most likely to benefit the taker.

How to Make Experiments.—Plot experiments made with different fertilizers must, in order to be of definite value, be made on a sufficiently large scale to eliminate the source of error arising from local differences in soil and subsoil, and must be checked by several check plots so interposed between the others as to not only check them by direct comparison, and to prevent the washing of fertilizers from one fertilized plot to another, but must also be compared, first of all, among themselves, so as to determine what is the normal product of the unfertilized land. It will frequently be found that these unfertilized check plots differ more widely between themselves than do the fertilized ones from them or from each other. It usually takes several seasons to come to definite results.

A question wholly aside from those discussed above is that of the special modification of crops by the use of a surplus of certain substances known to produce a specific effect. Thus, common salt is known to make asparagus and some other vegetables more succulent and tender; nitrogenous matter increases the size and succulence of fruits, and some experiments made with potash fertilizers on oranges point to an increase of sweetness thereby. It is then simply a question whether or not purchasers appreciate such modifications sufficiently to render their attainment a profitable undertaking, apart from any increase of the crop or the maintenance of soil fertility.

ADVANTAGE OF FERTILIZING SMALL TREES.*

Careful experiments have established another important point in bringing a young orchard into speedy and profitable bearing. That is, that by giving it a moderate dressing of stable manure, or some other good fertilizer, it may be brought into bearing one or two years earlier than if no fertilizer had been used. Experiments have been made by fertilizing some parts of a young orchard and leaving another part without, demonstrating that the part fertilized would bear enough more than the other, the first crop, to far more than pay for the fertilizer used, while, owing to the increased growth of the trees, a still greater difference in productiveness would be realized in the second crop. The fact is well established that a young orchard judiciously fertilized and well cared for, at five or six years from planting may be brought into profitable bearing, while one of the same age which has not been fertilized will give small and unsatisfactory returns. The two orchards cost the same for water and care, and yet the one fertilized yields a handsome profit, while the other little more than pays expenses.

FERTILIZING THE SOIL AS AFFECTING THE ORANGE IN HEALTH AND DISEASE.†

Fertilizing for Growth and Fruit.—Primarily the orange-grower desires to know how to fertilize so as to stimulate either growth or fruit production. With oranges, as with many other agricultural plants, one may fertilize in such a manner that excessive growth is stimulated at the expense of fruit production. A strong nitrogenous fertilizer results usually in much growth and little fruit. This seems to be particularly true if the ammonia is added in an organic form. While trees are young it is probably well to favor the growth of wood principally; but at the age of seven or eight years from the bud, the tree, if it has grown properly, will have attained sufficient size to begin to produce a fair quantity of fruit. It should then be given a slightly modified fertilizer, containing more potash and

* From report of J. M. Edmison, to Riverside Horticultural Club, February, 1899.

† Extracts from an article by Herbert J. Webber, Assistant in Division of Vegetable Pathology, Washington, D. C. A deduction from Florida experience, which naturally will interest California citrus-growers.

phosphoric acid and less nitrogen, to stimulate fruit production as much as possible. The so-called chemical manures appear to be much more active in stimulating fruit production than organic manures.

Effect on Quality of Fruit.—The experience of many orange-growers indicates that the quality of the fruit may be largely controlled by fertilization. As oranges are purchased very largely on their appearance and quality, this becomes an important consideration in manuring. Many intelligent growers are coming to believe that the best results can be obtained by giving the trees an application of that element only which seems to be lacking, and not using, as a majority do, a complete fertilizer, in definite proportions, regardless of whether all the elements are needed by the plant or not. If it can be determined by the appearance of the tree and fruit what element is lacking, this would seem to be the most rational way to fertilize.

It seems reasonable to suppose that by careful study pathological characters induced by starvation might be found, which would serve to indicate clearly the lack of any particular element. Some growers claim to be able to recognize these characters now, and are fertilizing largely on this modified plan, taking advantage of what we might call the sign language of the tree. Some of these characters will be mentioned below under the consideration of the different elements used.

Effect on Soil Moisture.—In fertilization at least two factors must usually be considered: the element of plant-food supplied, and the effect of this upon the soil as aiding it in supplying the plant with moisture. The heavy application, in late fall or early spring, of an organic manure, like blood and bone, which is extensively used in Florida, is liable to lead to injurious effects during the spring drought, if the trees are on high and dry land. On the other hand, such soils might be ameliorated by using substances which attract water and increase the surface tension of soil moisture. Nitrogen, for instance, used in the form of nitrate of soda, and potash, in the form of kainit, would tend to draw up the subsoil moisture and probably aid largely in supplying the necessary moisture during this trying season. The use of organic manures, on the contrary, would only exaggerate the damage produced by drought.

If groves are on very moist land, as is frequently the case in Florida, where the necessity is to lessen the moisture rather than to increase it, some form of organic manure, as muck or blood and bone, might be found of benefit.

Effect of Fertilizers on the Orange in Health.—The elements which need to be supplied in fertilization to most Florida orange groves are nitrogen, potassium, and phosphorus; or, using the terms in which they are expressed in most analyses of fertilizers, ammonia, potash, and phosphoric acid. The application of lime would also prove of benefit to many groves. Probably no element of plant-food used in the fertilization of orange groves should be more carefully considered, with respect to both form and quantity, than nitrogen. It is the most costly and at the same time the most dangerous element to use, as excessive applications are liable to result in extensive dropping and splitting of the fruit or in the production of the serious disease known as die-back.

Effect of Nitrogen.—A grower may with considerable certainty determine by the appearance of his trees the condition of his grove in respect to the supply of nitrogen available in the soil. An abundance of nitrogen is indicated by a dark green color of the foliage and rank growth. The fruit shows the effect of an abundance of nitrogen by being, in general, large, with a comparatively thick and rough rind. If the trees have a yellowish foliage, with comparatively small leaves, and show little or no growth, there is probably a lack of nitrogen. In this case there is but little fruit formed, and that formed is small and usually colors early. If the tree is starving from a lack of nitrogen, the foliage will become very light yellow and sparse, and the small limbs will die, as will also the large limbs in extreme cases. If the starvation is continued, no fertilizer being added, the tree will finally die back nearly to the ground and probably die out entirely. The extreme symptoms of general starvation from lack of all elements are probably nearly the same. The nitrogen used in fertilization is commonly derived from mineral or organic sources. Of the former, sulphate of ammonia and nitrate of soda are the forms most used; of the latter, muck, dried blood, blood and bone, cottonseed meal, tankage, fish scrap, stable manure, etc., are the forms most commonly employed.

Stable Manure of Doubtful Utility.—Barn manure is largely used by many growers, who still hold to the tradition that chemical manures are injurious to the plants. The benefits of barn manure in an orange-grove are in serious question. The fruits produced by nitrogen from this source are usually large, coarse, thick-skinned, with abundant rag, and of inferior flavor. If barn manure is used—and most growers have a limited quantity and desire to use what they have—it should be spread over the grove lightly, so that each tree receives only a small amount. Where such manure is depended upon as the main element of fertilization, liberal dressings of potash should be occasionally applied; this will tend to correct the evils of an overbalanced nitrogeneous fertilizer. What has been said as to the effect of barn manure on the quality of fruit applies equally to the effects produced by muck, cottonseed meal, blood and bone, tankage, etc.

In general, organic fertilizers do not stimulate fruiting to the same extent as the mineral fertilizers. It is probably better economy to apply such fertilizers to annual crops, cereals, garden truck, etc.

Mineral Nitrogen.—The mineral nitrogen manures, nitrate of soda and sulphate of ammonia, apparently stimulate production of fruit more than organic manures, and yet promote a fair general growth. The fruit produced by fertilization with these salts, used in correct proportions with the other elements which it is necessary to apply, is usually of good quality, being solid, juicy, and rich, with thin skin and little rag. Sulphate of ammonia has the effect, growers testify, of sweetening the fruit to a considerable extent. There seems to be little doubt as to the correctness of this view, but why it is so remains in question. The sweetening is probably more marked if there is a slight deficiency in potash. The use of very large quantities of either sulphate of ammonia or nitrate of soda may result disastrously, acting as "chemical poison," killing the trees outright and causing them to throw off their leaves.

Sulphate of ammonia has been very widely used among orange-growers. Nitrate of soda has been but little used thus far, but is apparently growing in favor. Its insecticide and water-attracting properties are probably much greater than those of sulphate of ammonia.

Potash Fertilizers.—In fertilizing the orange, potash is most frequently used, either in the form of the sulphate or of wood ashes. While sulphate of potash has been most widely used, there is apparently little evidence that it is superior to other forms. Muriate of potash, containing the equivalent of about fifty per cent of actual potash, the form probably most used in the apple and peach orchards of the North, has been little used in orange groves. Apparently those who have used this form have obtained uniformly good results. Kainit, or German potash salt, which is a crude double salt of magnesium sulphate with calcium chloride, containing the equivalent of from twelve to fourteen per cent of actual potash, is a form much used in Northern orchards and is promising for use in orange groves. Its very active effect in increasing the surface tension of the soil moisture, and thus attracting water to the trees, might make it an excellent form to add in early spring to aid the plant in withstanding the spring drought, which is so frequently injurious to the orange tree and sometimes fatal to the fruit crop. Growers not supplied with facilities for irrigation would, undoubtedly, find it profitable to consider carefully points of this nature in fertilization. The noticeable effect of potash on the orange tree appears to be its aid in completing and maturing the wood. Apparently an insufficient amount of potash is shown by an excessive growth of weak, immature wood, which does not harden up as winter approaches and is liable to be injured by frost.

An abundance of potash, in the form of sulphate of potash or tobacco stems, is said by many growers to produce excessively sour fruit. That potash is very necessary in fruit production is shown by the fact that the fruit contains a large percentage of this element. An average of fifteen analyses of different varieties of Florida oranges shows 52.05 per cent to be about the usual amount of potash in the ash of the orange fruit. The ash in these fifteen analyses averaged 0.916 per cent, or less than one per cent of the total weight of the fruit.

Phosphoric Acid.—Phosphoric acid, which is a very necessary element of fertilization on Florida orange lands, is mostly used in the form of dissolved bone black, acidulated bone or phosphate rock, soft phosphate, raw bone, guano, etc. The immediate effect of phosphoric acid on the orange tree and fruit is little understood. Several intelligent growers claim to be able

to recognize the effect of phosphorus starvation by the appearance of the new growth of leaves. If these, when they first push out or while they are still young and tender, present a slightly variegated appearance, mottled with light and dark green, it is claimed they are suffering from lack of phosphorus, and that if a liberal application of some soluble phosphate is applied this appearance may be checked. If this can be shown to be true it will prove a valuable index to the available quantity of phosphoric acid in the soil. A similar appearance may, however, appear in light cases of the so-called "frenching," a disease, or probably more properly a symptom of disease, which is not uncommon. Phosphorus starvation, it is true, may have some effect in inducing this disease.

Lime.—Lime, it is usually supposed, is present in sufficient quantities in most of our soils. It may be questioned, however, whether the common high pine land and scrub land, and indeed much of the flat woods and hammock of the interior of Florida, might not be benefited by dressings of lime. From the superiority of oranges grown on soils which are known to be rich in lime it would seem that this is probably a very desirable and necessary element for the production of superior fruit. The fine, smooth-skinned, and deliciously flavored Indian and Halifax River oranges, with their characteristic aroma, are grown largely on soils rich in lime from shell mounds and coralline and coquina rock. The oranges produced in the noted Orange Bend hammock, which are of distinctive quality, with delicate, rich aroma, and thin, smooth rind, are produced on a soil underlaid by a marl rich in lime. Lime soils are in many orange countries considered superior for orange-growing.

Dr. A. Stutzer, in his work on the Fertilization of Tropical Cultivated Plants, writes: "The orange and citron fruits desire a deep, porous, dry soil, rich in lime. If sufficient lime is not present the fruit will be thick-skinned and not have a fine aroma." It appears also that the effect of abundant lime is to hasten to some extent the time of ripening. Fruits grown on soils rich in lime appear to color and become suitable for shipping somewhat earlier than those grown on soils containing but little lime. To secure a good quality of fruit the regular application of lime may be found very desirable in many groves.

Fertilization as Affecting Disease.—Probably the most common cause of injury to orange trees is a lack of fertilization, yet it is not infrequent for disease to be induced or aggravated by excessive or improper fertilization. This may, indeed, be of much more importance than we are at present inclined to believe. One of the forms of die-back, a common and destructive disease of the orange, is quite evidently due to errors in fertilization. In other cases the disease appears to be caused by planting in improper soil.

FROST PROTECTION.

The Riverside Horticultural Club appointed a committee consisting of J. H. Reed, E. W. Holmes, E. L. Koethen, E. A. Zumbro, and J. H. Martin—all practical orange-growers—to investigate the question of orchard protection against frost. The committee, after a careful investigation of all the methods in use and experimented with, made its report, which was adopted, as follows:*

With the assistance of some fifteen or twenty citizens interested in the study of the points involved, a most complete test has been made of the many different methods employed to prevent frost damage. With such a force of competent and impartial observers, it was possible to secure data of much value in forming an estimate of the efficiency of the various plans made use of. Careful comparison was made between those orchards where no work was done, and where no direct effect of the fire was probable, and those where the different methods were being tried. As indicated by our partial report at the last meeting of the club, these tests were in some particulars eminently satisfactory, as showing the way to definite conclusions.

The exceptionally long period of cold following gave additional opportunity to verify the first conclusions reached, and subsequent investigations made by ourselves, as well as by other citizens who have awakened to the possibility of protecting their property, strengthened and confirmed the opinion formed as the result of the tests already partially reported upon.

*Riverside Press, February 19, 1898.

Some theories are proven to have little practical value, and members of your committee have modified their views somewhat in consequence. No preconceived notions have been allowed to stand in the way of a thoroughly practical study of the facts as they exist, to the end that the growers may not, for the lack of definite knowledge as to the direction their efforts should take, neglect reasonable precautions hereafter to insure the safety of their crops. These, therefore, are our conclusions:

First—There is no doubt whatever that the temperature of our orchards may be materially raised by the use of dry heat.

Second—The radiation of the earth's heat can be very considerably lessened by moist smudges, when these are started early enough and are properly managed.

Third—The possibility of raising the dew-point on one of the dry cold nights peculiar to our climate, sufficiently to prevent damage, by means of steam-producing apparatus, seems impracticable.

Fourth—Fruit and trees can undoubtedly be saved, even in the coldest sections, by covering them with cloth or matting; but the expense involved makes this method impossible on the part of the ordinary grower.

Fifth—It is found that the temperature in an old seedling grove, or where tall windbreaks afford to smaller fruit trees a like protection, is almost invariably one or two degrees higher than in exposed orchards in the immediate neighborhood. This fact seems to thoroughly upset the theory strongly held by many intelligent growers that the tall, well-located windbreak is a disadvantage; the contrary seeming to be the truth.

Sixth—It is found that the temperature twenty feet above the ground is from one to two degrees higher than at the surface, and that, as a rule, when the cold is severe enough to injure the ripest fruit, fifty feet from the ground there is almost invariably a temperature above the freezing point of water.

Prof. Zumbro, who has given special attention to this matter, finds that at the height of fifty feet the temperature is from five to ten degrees higher than at the surface, when the air is not in motion. When there is any considerable breeze it varies but little.

Seventh—Our conclusion is that, all things considered, the coal baskets, sufficiently numerous, will prove the most satis-

factory and effective means of warming the orchards yet made use of. It is true the oil pots make a far hotter fire, and are neither expensive nor difficult to manage, but the deposit of lampblack upon tree and fruit resulting from their use condemns this system for general use.

As to the value of smudging, the members of your committee are not so well agreed. Because of less sharply defined results, we find it more difficult to come to definite—at least uniform—conclusions. But, under certain conditions, we are convinced that, properly used, it may be made a valuable means of protection. We think this especially true in localities where the temperature never falls but little below the danger point, and where there are considerable solid areas of young orchards exposed. Here it will work well if the protection is made general. But where the danger is considerable, we think it wise to be prepared to use dry heat, even in connection with the smudge. The benefit from smudging is probably as much from its protecting fruit and trees from the sudden rays of the morning sun after a freezing night as from modifying the temperature during the time of danger.

Experience demonstrates that flooding or running water in connection with dry heat or smudging is a valuable adjunct. One of the committee which has been testing this matter carefully for three years is disposed to think that the direct benefit from running water is overestimated by the majority of growers. Its value in putting orchards in condition to withstand safely quite severe weather is unquestioned, but the committee is inclined to think that entire dependence upon this method will occasionally result in serious loss to those who trust to this means alone, especially when used in young orchards.

As to the number of baskets needed when coal is used, we find the most decided and satisfactory results have been gained where from twenty to fifty coal fires have been used to each acre. If intelligently and energetically used, this plan will never fail, except when the mercury drops below 24° for a long while, and even then it is believed the larger portion of a crop may be saved if anything like a general use of such fires be secured. The smaller number of fires named has in numerous cases, and even when a man was working alone, secured a rise of from three to five degrees and saved a crop. Can it be doubted that fifty fires per acre used in every orchard would

save both trees and crop on the coldest night ever known in California's history?

To equip an orchard with fifty baskets to the acre means an outlay of only a little over $5. The fuel to run them one night costs from $2.50 to $3. If a crop of Navels upon the trees is worth $400, it will pay well to spend in fuel and labor $4 per night, or one per cent of the value of the crop, to insure its safety. In the orange region of Southern California it is not usual to have more than two or three nights in a season when the fruit is in danger. But even if, as in the present season, the period of cold is more extended, will it not pay to expend at least as much as one pays for his irrigating water to secure the safe maturing of a crop it has cost him a year's labor and heavy expense to produce?

The conclusion is obvious that we have only to provide for the insurance of this sort of property exactly as we would in the case of that liable to destruction by fire, to be enabled to follow the business of orange and lemon growing with the certainty of having perfect fruit to market at the season's end.

While the practicability of protecting our orchards from frosts seems established, the problem of the most economical and scientific means of accomplishing this is probably yet to be solved. However well the wire baskets may serve us now, there doubtless will be improved methods for burning coal, and even other material may be found that will serve the purpose better; and while wet straw seems at present to be the most available for smudges, doubtless when the need is made known, chemists will find some vapor-producing material more compact, efficient, and economical. Hence we recommend that the club appoint a permanent committee to continue these investigations.

ROOFING PROTECTION AGAINST FROSTS, AND HEAT IN SUMMER.

After having tried several other methods of protecting trees from frost, none of which proved absolutely safe, the Everest Rancho incorporation at Arlington Place, Riverside County, decided to roof over a portion of their orange grove. Such were the results of the first trial on three acres that the company extended it over seventeen acres, shown in the accompanying illustrations, made from photographs taken on

the spot. The proposition embraced in the covering is to prevent the warm air from leaving the immediate vicinity of the trees at night. During the day the earth and trees become warm, but as the night cools the atmosphere the process of

Roofing over an orange grove at the Everest Rancho, Arlington Place, Riverside County.

radiation sets in and the heat from the earth and the trees is carried off, the cold frosty atmosphere taking its place. The idea was conceived of covering the orchard with canvas, which could be rolled up in the morning and let out at night. One

Covering shown from beneath.

acre was covered in this way, but it was found to be too expensive and unstable, as the canvas would get wet and decay. The present method costs about $450 an acre. The fruit borne by the trees under this covering has matured perfectly and the

covering serves two purposes, *i. e.*, protecting the trees from the effects of frost, and from excessive heat in the summer.

The posts are 3 x 4 redwood, 18 feet long. The trees are so planted that the posts are placed 21 feet 3 inches apart each way, setting them 3 feet in the ground, thus allowing about 15 feet in the clear for height of the trees, which is sufficient for most Navel trees. These posts are connected by pieces of 1 x 4 pine suitably braced, on top of which another strip of 1 x 4 has been securely nailed to prevent the whole from swaying sideways with the weight of the cover. This, when placed in position, is braced horizontally with braces of 1 x 3 pine, 7 feet long. Thus is secured a framework that is quite rigid and on which a man may walk freely, provided he has a head clear enough to walk on a four-inch strip.

Over this were stretched galvanized iron wires, diagonally, of No. 11 wire, which are securely stapled on top of each post and to the horizontal braces. These diagonal wires are stretched very tight with iron stretchers, and throw a portion of the weight of the cover on to posts directly that would otherwise be borne by the pieces of 1 x 4 pine, 21 feet 3 inches long. These diagonal wires are supplemented by wires running across the framework at right angles to the direction in which the cover is laid. These four wires—two diagonal and two cross wires—steady the whole construction and distribute the weight more evenly.

Thus is the framework completed. For the cover Arizona laths were used, being the lightest and best for the purpose, and were wove on a lath machine into common chicken fencing, placing the lath one inch apart and weaving with six wires—three double strands. This is made in sections 21 feet 3 inches long and rolled up preparatory to being taken to cover. In covering the framework four rolls made of four-foot lath and one roll of five-foot lath are used, thus filling out the space over each tree of 21 feet 3 inches as nearly as is necessary. It takes 100 lath to each roll, or 500 to each tree; and as the trees are planted 100 to the acre, 50,000 laths are required to the acre. This Arizona lath is cheaper than ordinary pine in that part of the State.

The crop of fruit under this covering was of good size, color, and quality, and while the construction of the cover could be, and no doubt will be, improved upon, it has proved of great benefit as built.

LEAF SHELTER AN ADVANTAGE.*

Old "Sunny Side" has again covered herself with glory. Eight consecutive big crops is her record. I had sold five carloads before the chilly night of December 29th, and have just finished delivering the second lot of five cars on a satisfactory cash sale. Since the "chill" I have delivered in bulk at the packing-house, and the fruit has packed nearly four fifths "fancy," and this fruit, too, was, by special contract with the buyer, picked from the outside of the trees where most exposed.

The fact is that my twenty-acre orchard of 1,500 orange trees is well prepared to resist chilly weather. The trees are so large, so thrifty, and so densely covered outside, that they are like so many houses shingled with broad orange leaves clear to the ground. The interior spaces under each tree, filled with the sun-baked air of the day, bid defiance to "Jack" on a cool night, and prevent him getting in his diabolical work before another day's sunshine comes along to oust him entirely. I have never lost a crop, though of course some of the fruit on the outside will sometimes "take cold"; but there is great protection in a shelter of thick, broad, healthy, glossy leaves.

QUESTIONS AFFECTING ORANGE CULTURE.

During the year 1898 the Horticultural Society of Highlands invited its members and citrus-growers having any questions regarding any phase of orange culture to send them to the Society, for submission to the orange-growers of the State. The following were received and answered:†

QUESTION: *Should hardpan within two feet of the surface be considered a barrier to the planting of orange trees?*

PROF. E. W. HILGARD, of Berkeley: Yes, if impenetrable by roots.

J. H. REED, of Riverside: Yes.

* B. B. Barney, in California Fruit Grower, February 1, 1896.

† Reported by W. M. Bristol, chairman of committee.

H. D. MOORE, of Redlands: Hardpan within two feet of the surface will eventually ruin any orchard. Its effects will probably be noticed by the third or fourth year.

DIGEST OF DISCUSSION BY THE CLUB: The question doubtless refers to the natural hardpan underlying the red mesa soil common in California, and not to the artificial hardpan (so called) which is formed in orchards by the tramping of horses used in cultivating. The latter occurs immediately below the cultivated stratum, and is caused by driving over the ground too soon after rain or irrigation. The natural hardpan may be divided into three classes, namely: gravelly, sandy, and clayey hardpan. It is found at varying depths, and runs from a few inches to several feet in thickness. Analysis shows it to be deficient in nitrogen, but rich in potash and phosphoric acid, the same being true of the looser soil found underlying it. In many cases it is impervious to either water or roots, and consequently marks the downward limit of the soil capable of holding moisture or of yielding plant-food to the tree.

QUESTION: *Is it advisable to break up this hardpan, and will it stay broken up?*

PROF. HILGARD: Yes, to both.

MR. REED: Other conditions being markedly favorable, yes. If well done it will stay broken up.

MR. MOORE: If an orchard is already planted in such soil, it would be advisable to put in three or four cartridges at equal distances around the trees. The soil has been found to pack down hard again in three years after blasting.

C. E. MOSHER, of Pasadena: Yes. Hardpan once broken up will not form again.

THE CLUB: Yes, if the stratum is not too thick. The gravelly hardpan, which is probably the hardest for roots or water to penetrate, is the most easily and permanently broken up.

QUESTION: *What is the best method of blasting in such cases, and what is the expense?*

PROF. HILGARD: Bore into the hardpan and use one-half pound of No. 2 giant powder in each hole.

MR. REED: Giant powder. Expense depends on condition of hardpan.

MR. MOSHER: I took the contract for blasting the hardpan

on seven acres of land near Raymond Hill, South Pasadena, at 15 cents per hole, and cleared $5 a day at it. The top soil was 2½ feet thick, the hardpan 3 feet. I dug the holes to hardpan, then with a 1¼-inch wood bit welded onto a 5-foot shank I bored down 20 inches into it, put in one stick of No. 2 giant powder, tamping it with fine earth. It blew a hole clear through the hardpan, the hole afterward being cleaned out and filled with top soil.

THE CLUB: The foregoing replies were indorsed. No. 2 giant powder is preferable to No. 1, because its slower action cracks and shakes the hardpan more thoroughly. Good results have been obtained in orchards already set, by putting one stick of powder directly under the tree. It is important that the charge be in the hardpan—not under it. If exploded below the hardpan its force is expended in making a cavity there without breaking up the overlying stratum. It is well to clean out the hole and fill with sand, thus insuring the free penetration of water to the substratum. Of course in putting the blast directly under the tree, the hole must be made slanting. Some roots are necessarily broken, but the benefits are largely in the majority.

FRUIT AND BRANCH—PRIMAL TYPE.
(*Citrus limonum vulgaris.*)

THE LEMON.

Citrus medica limonum, Risso.

SEEDLINGS.—*Hypocotyl* becoming woody, erect, terete, finely pubescent, wiry, pale green, 2.3–2.9 cm. long.

Cotyledons two, rarely three, mostly alternate, fleshy, oblong, obtuse, pale green, finely pubescent, sessile or subsessile, somewhat notched at the base.

Stem woody, erect, terete, finely pubescent, wiry; first internode variable, 1.6–2.3 cm. long; second, 2 mm.; third, 3 mm.; fourth, 7.5 mm.

Leaves compound, cauline, alternate, exstipulate, petiolate, glabrous, deep green, shining, pubescent on the nerves beneath when young, permeated with translucent glands, doubly crenulate, emarginate; petioles subpubescent, winged, [sometimes wingless,] with a prominent midrib, and tapering toward the base.

Nos. 1 and 2 unifoliate, frequently also Nos. 3 and 4. All alternate at greater or less distances from each other, or in pairs, or all four verticillate, ovate, obtuse, emarginate, articulated at the top of their petioles, or the lowest pair articulate at the base only.

Nos. 3 and 4 frequently digitately trifoliate, the terminal leaflet being lanceolate-elliptic, attenuate at the base; the lateral leaflets arise by segmentation from the terminal one.

No. 4. In some instances five-foliolate; the rachis between the basal and next pair of leaflets winged and tapering toward the base in the same way as the primary petiole; leaflets sessile, lanceolate-elliptic, emarginate, minutely and doubly crenulate, smaller than the leaflets of unfoliate leaves.—Sir John Lubbock, "Contributions to our Knowledge of Seedlings," Vol. I, 1892.

The flower of the lemon is of medium size, with a reddish tint outside, but white within. Fruit pale yellow, generally oval, ending in a nipple-like point, seldom round or pyriform. The skin is smooth, about the thickness of that of the orange, becoming greatly reduced, thin, pliable, and leathery to the touch after being stored away, styled "curing."

The lemon is not so hardy a tree as the orange and is more susceptible to frost. While this is true, it is also true that it does not require so high a temperature to bring out its best qualities, which it will attain on the coast, where the orange is inferior. The lemon is a prolific tree, bearing more fruit than the orange and requiring more water; but the treatment of the tree in the matter of planting, cultivating, etc., except pruning, is the same as that required by the orange, and the rules laid down for the latter apply equally to the former.

The lemon has received less attention in California than the orange, owing partly to the extra care required in its preparation for market, and partly to the impression that it was not so profitable a fruit to grow. Of late years, however, much more attention has been given to lemon culture, and the area adapted to lemon growth has been widened. It was thought that this fruit would flourish only in a few favored nooks in the citrus section, but experience has proved that there are numerous places in the higher lands—the *foothills* and *mesas*—of the southern and central counties where the lemon will flourish. The result of this has been a great impetus in lemon planting in San Diego, Orange, Riverside, San Bernardino, Los Angeles, Ventura, Santa Barbara, and Tulare counties. This has been aided, too, by the fear that the very extensive planting of oranges would result in the reducing of profits in orange-growing. Improved methods of handling and curing the lemon—the outcome of years of experiments—have resulted in securing a fruit which commands a good price and competes with the imported article, making lemon-growing profitable. These facts have turned the attention of planters toward the lemon, and it is probable that this fruit will steadily advance in popularity until it reaches a place in our fruit exportations beside that of the orange.

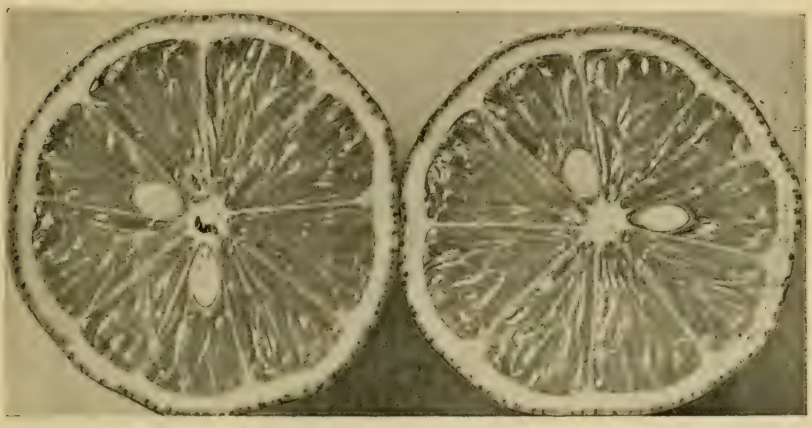
VARIETIES.

The varieties of the lemon are not as numerous as those of the orange. While many varieties have been introduced, some of our choicest have originated here. The common seedling, of poor shipping and keeping qualities, that used to be met with in almost every orchard in the State, has been discarded, and in its place stand varieties which possess exceedingly high merit. The fruit of the varieties now grown is not over-large, but of a uniform medium size, good keepers, with a sweet rind and a delicious, strong acid.

Lisbon.—Fruit of medium size, fine grain, sweet rind, acid strong, few seeds, an excellent keeper. Grows very uniformly on the tree, and ripens evenly. The tree is a strong grower, very prolific, thorny, but thorns decrease as the trees grow older. Imported from Portugal.

Dr. J. H. Needham, in an essay before Pomological Society, at Covina, in 1898, says: "The advantages claimed for the Lisbon are that it bears its fruit uniformly all through the tree. But the disadvantage is that the tree is thickly studded with long, sharp thorns, which, when the branches are waved by the winds, puncture much of the fruit, spoiling it for the market, especially the Eastern market. Another objection is that it does not come into bearing until it is from seven to ten years in orchard, and bears only one crop a year."

VILLA FRANCA.—Fruit oblong, slightly pointed at the blossom end, rind thin, without any trace of bitterness, acid strong,



Cross-sections of Villa Franca Lemon (cured specimens)—natural size.

juicy, nearly seedless. Tree almost thornless, branches spreading and somewhat drooping, foliage very abundant, which protects the fruit from scorching. The tree is a strong grower and less susceptible to cold than most varieties. Imported from Europe.

Dr. J. H. Needham, in an essay before Pomological Society, at Covina, in 1898, says: "The advantages claimed for the Villa Franca are that it makes a more compact tree and bears its fruit more uniformly over the entire tree; but, from my experience, it requires at least one year longer to come into bearing, and the fruits on young trees are shorter when they have the requisite diameter for picking than either the Eureka or the Lisbon."

Acme (syn., "Sweet Rind," "Hale's Seedling").—This is an old established variety; originated at Los Angeles. Resembles the Lisbon in many of its characteristics, so much so that it has been confounded with it. The fruit is similar to the Lisbon, grows uniformly, of medium size, strong acid, with a sweet rind; a good keeper. The tree is a more upright grower than the Lisbon, has fewer thorns, and is of a much less spreading habit.

Eureka.—Fruit medium size, sweet, smooth, glossy rind, and an excellent keeper. Acid strong and most pleasant, with very few seeds. Tree semi-dwarf, sparse foliage, inclined to bear at the extremities of the branches, and endangering the fruit to sunburn. A remarkable lemon. Originated at Los Angeles.

Dr. J. H. Needham, in an essay before Pomological Society, at Covina, in 1898, says: "The advantages of the Eureka are its comparative freedom from thorns, its tendency to early bearing, and, when properly trained, to enormous crops when it comes into full bearing, by its continuous blooming and setting of lemons all the year, especially in sections that are comparatively free from frost. The objections are its tendency to set its fruit on the tips of the branches, and the inclination to grow long canes with but few laterals, and to drop its leaves on the long canes or branches, thus leaving the limbs and fruit too much exposed to the hot rays of the sun in the heated term of summer. But this can be remedied by proper pruning from the time the tree is one or not more than two years in the orchard, being careful to keep off all sucker growth, and cutting back the long branches to not more than twelve to eighteen inches, in the spring and fall; June and October being a fair division of the growth of the year. Always cut away the larger of the two or three branches that have started near where the branch was pruned the previous time, as the bold, rapid growers will only make a wood growth, while the smaller twigs or branches will form the fruit spurs, which bud, bloom, and bear the fruit."

Genoa.—Fruit medium size, oval, sweet rind, and nearly seedless; a good keeper. Tree of a dwarf habit and thornless. This is one of the best lemons grown in the State.

Asiatic.—Fruit medium size, oval, thin rind, with an agreeable strong acid. Tree semi-dwarf, thornless.

Bonnie Brae.—A vigorous growing tree, quite thorny, and with distinct foliage. The fruit, which resembles a lime in appearance, is of a medium size, ribbed, and with exceedingly thin rind.

Sicily.—Fruit large and coarse; keeps only with extreme care; inferior.

Agnes.—Fruit medium size, sweet rind, pulp very fine, with strong acid, and few seeds. Thorns few, short and blunt. Tree a rapid grower, medium dwarf, and drooping in character.

Olivia.—Fruit medium size, of good quality, acid strong. Tree a thrifty grower and a good bearer; thorny.

"Royal Messina."—Introduced from Florida, under the name of Sicily, but there being numerous varieties under this name, "Royal Messina" was applied to it, identifying the same with one grown in Florida by that name. It is a choice lemon of medium size, seedless, strong acid, skin thin, pliable, and an excellent keeper. Tree nearly free from thorns, strong in growth, and of dark, elegant foliage.

Garcelon's Knobby.—Fruit medium size; when cured, very thin rind, juicy. Tree a good grower and prolific.

Bouton.—Fruit medium size, sweet rind when cured, very seedy. Tree very thorny; inferior.

Sweet Rind.—Fruit very large; tree very thorny; inferior.

Milan.*—Fruit medium size; an exceptionally fine lemon.

California Sicily.—Name applied to common seedling lemons.

Chinese.—Fruit large, the size of a citron, which it resembles. Fruit of little commercial value, except the peel, which is used for preserving purposes. Tree is of a dwarf habit—a bush. In former years it was extensively used as a stock, but being subject to the gum disease and unable to support the growth of the orange and lemon, it has been discarded.

Ever-Bearing.*—Fruit large and coarse. Decreases in size as the tree grows older.

Sicilian.*—A lemon of superior quality.

Lamb.*—Fruit medium; strong acid.

Bijou.*—Fruit medium and a good keeper.

Variegated.—The leaves are mottled with white; ornamental.

Napoleon.—Fruit medium size, thin rind, oblong. A prolific bearer.

*Florida varieties; some have been introduced into California.

August.*—Fruit medium size, elongated, a good shipper. Tree a rapid grower.

Belair Premium.*—Fruit medium size, without bitterness. Tree a strong grower and thrifty. Considered the best variety grown in Florida.

French Seedling.*—Fruit quite small, sweet rind, and a strong acid. Tree a strong grower, almost thornless.

French, or Florida.*—Rough; used as a stock.

French Seedling.*—Said to be very good.

Other Varieties—

Valentina*	Genoese	Castilian	Bracy*
Leghorn*	Garden Lemon	Royal	Imperial*
Neapolitan*	(inferior)	Candian	Long*
Makay*	Mela Rosa	Chio	Naples*
Meranda*	Paradise	Praos	Sweet Brazilian*
Malta*	Communis	Messina*	Tuberculata*
Waring's Seedling*	Suacco	Roman	Waring's Seedless*
	Melaroce	St. Jerome	

The Sweet, or Bergamot, Lemon.

Citrus limonum, var. *Dulcis*, Risso.

This species of the citrus family has been grown in a small way in dooryards and gardens by early settlers, and must have had its origin, or was introduced, at a very early period. It has never assumed much importance in the markets, and for this reason has only been grown to a very limited extent. The flowers are pure white, slightly tinged with purple on the outside and white within. The leaves are large, ovate roundish, serrated; petioles subulate, very smooth and aromatic. The fruit resembles the lemon in appearance, but is globose, with a blunt, nipple-like protuberance at the blossom end, a firm rind, sweet pulp, and a non-aromatic juice.

The tree is a prolific bearer, is easily grown from cuttings, and is also worked on orange stocks or vice versa. The tree requires the same treatment and conditions for its growth as the lemon, and on its own root is very much subject to the attacks of gum disease. There are various types grown, and while some possess marked qualities, perhaps owing to the climatic conditions, soil, etc., none have been so far classed as distinctive varieties.

*Florida varieties; some have been introduced into California.

LISBON—Natural size.

LISBON—Cross-sections—Natural size.

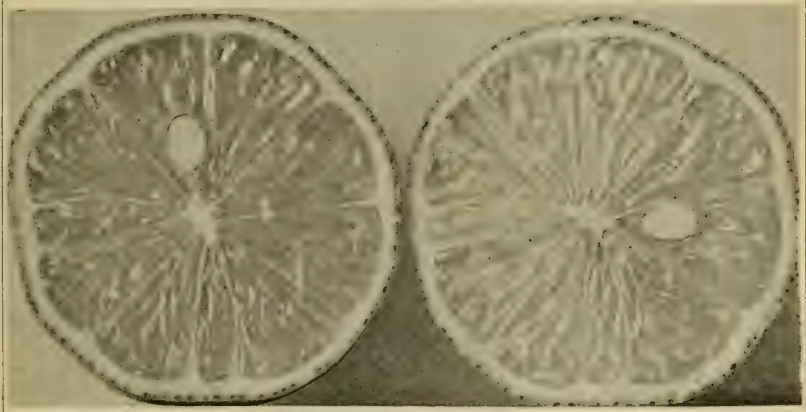
VILLA FRANCA—Slightly reduced.

BONNIE BRAE—Natural size.

BONNIE BRAE—Cross-section—Natural size. (Cured specimen.)

BONNIE BRAE—Cross-section, showing seed variation and thickness of rind. (Uncured.)

EUREKA—Natural size.

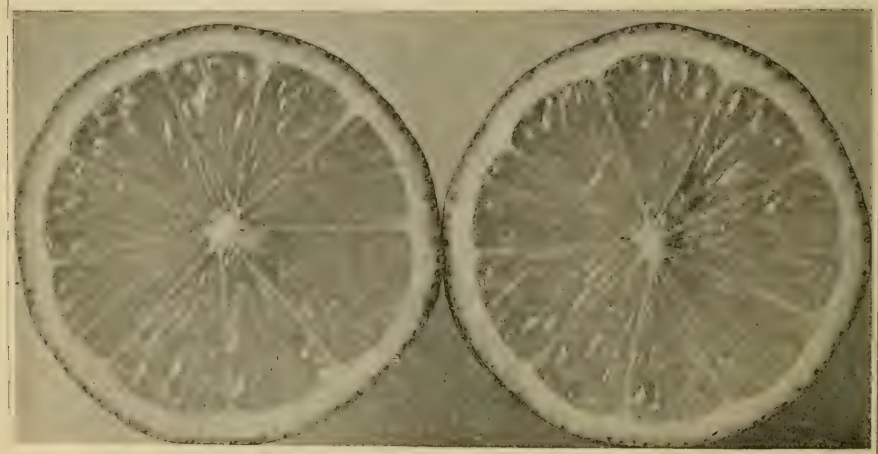


EUREKA—Cross-sections—Natural size.

GENOA—Natural size.

GENOA—Cross-sections—Natural size.

"ROYAL MESSINA"—Natural size.



"ROYAL MESSINA"—Cross-sections—Natural size.

MILAN—Natural size.

MILAN—Cross-sections—Natural size.

SICILY—Cured specimen—Natural size.

PRUNING THE LEMON.

"How shall we prune, and when shall we do it?" I. C. Wood, of Ontario, Cal., an experienced lemon-grower, answered the question before the Southern California Pomological Society, as follows:

"If the tree is one year old, I would cut it to about three and one half feet high; if older, possibly higher, according to strength of plant. Then let it branch from near the ground, say one to one and a half feet. As soon as the young shoots are strong enough, select from four to six or more of the best of them; see that they are evenly distributed on every side of

Lemon orchard pruned high, without cutting back the upper shoots, which continually break by the weight of the fruit.

the stem and at different heights from the ground; allow the uppermost to form the leader, which should be encouraged from year to year to continue as a leader, so as to avoid as far as possible decided forks.

"At the end of first year prune-in all side shoots and top according to the amount of wood made—usually one half will be about right for the lower branches, and more severe for the upper ones. The object is to shape the tree and keep it in the form of a letter "A," limbed right from the ground or nearly so. In pruning, do not cut at random, especially at this stage, but see which way you want the upper buds to grow, as the upper bud usually makes the leader which we want to

encourage to go upward and not outward, as we are laying a foundation for a heavy crop of fruit and we want to keep that crop protected as much as possible by a mass of foliage, and equally distributed through the tree and close to the stronger or main branches. The object is to make the tree carry a full crop, and that, too, without props or ropes, which are expensive, take time and labor to put in place, besides being unsightly and in the way. Moreover, the tree will be so compact in its make-up that should we be located where subject to winds, the resisting power of the tree will be much greater and losses of fruit and breakage of branches very much lessened. The crop of fruit will be found very largely on the inside of the tree, insuring less sunburn or that unpleasant deep yellow color on the side exposed, as is so general when the crop is allowed to bear on the outside and at the extremities of the branches.

"In this section (Ontario) there is a half-dormant season during the months of February, March, and a part of April, which I would consider the proper time for making our heavy cutting. If it becomes necessary at any time, which may be the case with young and thrifty trees not yet in bearing, I have before recommended pruning the lighter wood at the time of picking the fruit, and experience has taught me that there is no time when we can do pruning so effectually. When this method is followed we invariably find a large amount of the fruit on the inside of the tree, and on small, willow-like branches. When the stronger growth has been kept in check, these smaller branches are encouraged and live on, because they receive a fair proportion of the tree sap, which would otherwise go to the stronger parts, and if allowed, the smaller shoots, especially on the inside, would die, and the inside of the tree would become a scraggy mass of small, dry branches."

*"The idea of growing as large a tree as possible in three or four years, or until bearing age, must be reversed; must be done by cutting back the tree when one year old and keeping it cut back and thinned out until the growth is controlled. The wood must never be cut on its first growth; let it become hard, not less than two growths old. The older the wood the more inclined to small fruit growth when cut back. The length to leave depends altogether on size of wood and location of

* J. W. Scott, in Covina Argus, October, 1895.

branches; but seldom leave more than eight inches, and often only one or two buds. The one great mistake made by some in cutting back heavily is to shear off the crown of the tree year after year, causing it to grow thicker and thicker each year, sacrificing all of the lateral fruit growth and the fruit growth inside the tree.

"In cutting trees three years old and upward, one must understand the nature of the tree especially, or he will leave too much foundation for new growth. After the new wood is dormant it should be thinned out, leaving plenty of lateral and inside growth, but taking out everything from the top that has a tendency to shoot upward, especially large wood. The idea is to keep the top down and work for a lateral growth, always keeping out suckers and large young wood. Above all do not try to form any more branches by utilizing a sucker to fill in a vacancy; better let time fill it up with the old wood, or grub out the tree and put in a new one.

"During pruning, use very little water, if any, until the first growth is dormant. I believe there is a great mistake made in watering lemon trees at just the wrong time. Until they are in full bearing they do not require much water. I think the majority of growers will agree with me that the time to water the lemon tree is when dormant; then a good, healthy stock of wood is secured; but it requires more labor keeping out suckers. I think the time will come when lemon-growers in irrigation districts will build their own private reservoirs that they may be able to use the water when needed. I have made the assertion that a lemon tree needs more water than the orange, and it is very evident, for the reason that when a lemon tree comes into bearing it is capable of producing, at the same age and with the same care, two or three times as much fruit as the orange, and is setting fruit all through the year."

G. W. Garcelon, a pioneer lemon-grower of Riverside, says: "After the tree is set, let it grow. As soon as suckers appear, remove them, although some growers leave them for a time to protect the trunk of the tree from the sun. Rather burlap the trunks and let the growth come from the top, which will constitute two thirds of the tree. Allow all top growth to remain, except shortening-in any too luxuriant branches, or winds will prune for you, and more than is desirable. Now this is all

that is necessary, except annually to clean out any wood in the tree which has got through being useful to the tree, always remembering that the best fruit of the lemon comes from the inside of the tree and nearest the ground."

The lemon tree being a strong and vigorous plant, requires liberal irrigation and, above all, judicious pruning, for almost before a person is aware of it, long straggling branches will hinder cultivation, and must be cut back, thereby entailing an absolute waste and greatly lessening the vitality of the tree. To prevent this waste and loss, the ends of the branches should be pinched off at the proper time, and with such discretion as will result in forming a symmetrical and well-balanced top. Great care should also be taken in thinning out the small and weak branches, so as to afford circulation and to allow sunshine to penetrate. Pinching off the ends of the limbs will cause them to throw out spurs, thereby bringing the fruit nearer the body of the tree.

*"We have learned from observation that the lemon tree produces its best fruit on twigs or small branches in the interior of the tree. To get any considerable quantity of such twigs we must cut back the branches, for the habit of the tree is to send out long shoots that fruit on the end, often leaving two or three feet without a break. The fruit that grows on these branches is largely culls. If the branches are properly cut back, the body of the tree will probably fill up with fine wood, which will furnish bearing surface for all the fruit that the tree can properly mature.

"Two difficulties have confronted us as growers: one, that much of our fruit does not attain the proper size before we are obliged to pick it in order to prevent its deteriorating in quality; and the other, that our crop is ready to gather too late for one market and too early for another, or during the early winter months. The former of these difficulties can probably be largely overcome, and the latter by somewhat reducing the bearing surface of the tree and bringing the fruit nearer to the source of supply. All experiments along this line go to show that both the grade and size of the lemon are improved by the process. Many lemons, from being too small or too highly colored before picking, go into the second grade or culls that otherwise should

*J. W. Freeman, in "Pacific Rural Press," April 25, 1897.

go into the first or second grade. One can easily see that it pays better to grow twelve boxes of lemons at $1.25 per box than to grow fifteen boxes of second grade at $1, or any number of culls for nothing, as the cost per box is the same in each case.

"It is thought by some that by certain methods of pruning the habits of the lemon tree can be so changed that from bearing the bulk of its fruit in the fall and early winter it may be made to bear in the summer. It would seem that in certain localities that is the habit of the tree, but we speak of this as we know it; that to our minds is unquestionable. The possibility of it lies, of course, in the fact that the tree is a continuous bearer; but supposing that it could be done, the thing of itself is of doubtful benefit, especially in localities subject to injury by frost. The so-called summer crop is on the trees during the winter months, and if it passes through safely, is just the thing to be desired. Until we can devise some method of protection (from the elements, we mean), it would seem that the wisest course will be to do what we can to hasten the time of maturity of our fall crop to catch as much of the early market as possible, and to hold the balance of our crop over until spring, if necessary. This fruit is of much better keeping quality than the summer crop.

"If this method is adopted it will be much better to begin with the trees when they are young; but with old trees, the sooner the better. Some have the practice of rounding up their trees like a billiard ball, irrespective of what may be the length of the limbs in the body of the tree. This seems to us to be a mistake, as it will leave the trees with too dense a growth of foliage. Others cut them off like a billiard table. This is open to the same objection, besides taking from the tree much wood that is already in the place desired. Each limb should be treated by itself and cut back to within six or eight inches of the fork; when limbs spring from this, instead of cutting each one off at the same distance, they should be thinned out to two or three, cutting the surplus shoots right back to the branch. It may be necessary to reduce the surface still further each year by cutting out a portion of the bearing wood, so that each limb shall not carry more fruit than it can mature. We can show trees treated in this way that are now one mass of bloom right through the whole body of the tree, so that one could scarcely put his hand in without touching a blossom.

This may in time need thinning out, but that is an easy matter.

"This may seem like heroic work, and many dislike to undertake it, though they may be convinced that it will pay in the end. It does not mean the total loss of a year's crop by any means. The yield will not be so large, it is true, but the actual returns may not be far behind. Let me call your attention to the saving that will be effected in the cost of picking. To go into the top of a large tree five or six times a year for a half box of lemons is an expensive business and increases the cost of picking to almost more than the actual value of the fruit. By this method of pruning, the fruit will be kept within easy reach.

A low-pruned tree headed back, and supporting a large quantity of lemons.

"To get the best results from this system of pruning the work must be followed up and all useless growth removed while the process will shock neither the feelings of the grower nor the sensibilities of the tree.

"Let me say here that the grove that yielded the largest returns in this section seems to me to have been pruned nearly in line with these suggestions. By a common-sense method of pruning, lemon trees are gotten into such shape that the wind causes less damage to fruit and tree, and the branches are not broken if overburdened with fruit. Props and twenty-foot ladders are rendered unnecessary, the cost of picking is reduced from one third to one half, the quality of the fruit is materially improved, the returns are largely augmented, and the grower made correspondingly happy."

*"Head the tree about two and a half feet from the ground; keep it shortened-in for three or four years, forcing a thick, stocky basis for after-growth. The tree by this time is bearing freely, and the fruit will pull or bend down the long shoots, which will then put up or throw out small fruit-bearing timber all along the upper side of the drooping limb. I think this preferable to a continuous shortening of all long growth. A dense, shady tree is what is wanted, since the denser the shade the more symmetrical and smoother the fruit will be. Limbs that reach to and lie upon the ground may from time to time, as needed, be tipped off."

THE BARONIO METHOD OF PRUNING THE LEMON.

The so-called "Baronio Method" of pruning the lemon takes its name from A. C. Baronio, an Italian gentleman who recently introduced it into some orchards at La Mesa, San Diego County, and who is now a resident of that locality. While this method of pruning is not new, it is practically new as applied to the lemon in this State. Gallesio, in his treatise on the citrus family, written nearly a century ago, mentions "the lemon of Genoa as a vigorous tree which will also extend itself *en espalier* (on a trellis) and bear an abundance of fruit." He also mentions other varieties "that will not submit to be trained *en espalier*." This system partakes of the principles laid down by Du Breuil, Barry, and Downing in the *Espalier* and *Cordon* systems of pruning long in vogue, but applied to deciduous trees. Mr. Baronio claims that the present method as practiced by him on the lemon is the outcome of a series of years of personal tests and practical experience as a matter of study, which led him to the conclusion that it is preëminently suited to the lemon, especially in various sections in the southern part of the State. Whether this method, and others that have come into general use of late, will ever be pronounced eminently successful, time can only determine. Suffice it to say, however, that they are much believed in and are applied in many orchards. The method is described as follows by A. C. Baronio:

The method of pruning the lemon as practiced by me, although having been mistaken for the old *vase*, or the "*tronco*

*Dr. W. B. Wall, an extensive lemon-grower of Tustin, before Southern California Pomological Society, June, 1896.

rovesciato" form of the Italians, is entirely different, because it brings the tree under such control as is not to be obtained by any other method. It really aims at producing a very low, wide-open, standard tree, possessing all the merits of an *espalier* with none of its drawbacks.

When once the tree has been brought under subjection, every part of it is kept within easy reach of an ordinary man standing on the ground, the structure strong enough to carry a great weight of fruit and capable of standing undisturbed by wind and weather. The fruit is of superior quality, free from culls, the succession of crops regulated, and the fruit-bearing surface

Lemon orchard of T. F. Jones, at La Mesa, cut back by Mr. Baronio in July, 1898. Photo taken October 30, 1899.

can be enlarged and directed at will as the tree acquires age and strength, so that it is a question of laying the foundation for a permanent structure, which may be enlarged for an indefinite time. Of course it necessitates an entire reconstruction (unless so raised from the beginning) in order to lay the foundation for such a lasting and progressively profitable tree, which can not be done by a single operation. I have emphatically warned those who may be enticed by some of the half-and-half attempts which have sprung up since as new systems and which find favor in some quarters as a happy compromise on what would seem to be too radical a reform. But these are merely makeshifts or bad imitations likely to lead to temporary encouragement and ultimate disappointment, through lack of knowledge and experience in the proper application of vital

principles. Instead of the pruner being able to control the tree, it will be found that the tree is master of the situation, growing its own way without proper foundation. The lemon tree is either the most tractable or the most obstinate of servants, but the choice rests with the intelligence of its master. The great object in view is to grow lemons for "profit," which must be progressive as the age and strength of the tree advance, always with due regard to its future life and well-being. The method is based on well-formulated physiological principles, of which the following are the most important:

(*a*) A tree is most profitable when the flow of sap is evenly distributed over all its surface, each branch maintained properly covered with elaborated growth all along from its base extending outward in methodical form; and when it is held under absolute control so that the root shall always be capable of feeding the whole top, which is kept within easy reach from the ground.

(*b*) The sap circulates faster through a shoot running straight up in the air than through a branch going out in a lateral direction.

(*c*) There is little or no elaboration along the length of a straight shoot until the top is reached.

(*d*) There is a larger amount of elaboration along a branch in proportion as it goes out in a lateral direction.

(*e*) There can be no fruitfulness without elaboration; therefore,

(*f*) A lateral branch is more fruitful than an upright one.

(*g*) If a young, vigorous shoot (commonly called a sucker) running straight up is allowed to persist on a branch, it will draw most of the sap and tend to starve the other growth below.

(*h*) A branch may be built slightly crooked and strong in short sections made up of wood of different ages, and so pruned that, a rush of sap never being permitted, it is forced to elaborate a lot of small fruiting growth all along its length.

(*i*) Fruitfulness and excellence are the results of a slow but steady circulation.

(*j*) An over-accelerated circulation tends to foster unnecessarily vigorous or rank wood formation.

(*k*) A tree must never be permitted at the top to outgrow its root-system, but allowed only sufficient wood formation to keep

it growing, and all the fruit compatible with its age and strength.

(*l*) Branches should never be so crowded as to preclude the free admission of light and air between them.

(*m*) In order that a tree might have the sap evenly distributed, its main branches must be of equal size and run out at similar angles.

(*n*) A limb which branches off at an acute angle is liable to split at the fork.

FIG. 1—Baronio method of pruning the lemon. (From a sketch by G. P. Hall, of San Diego.)

(*o*) A limb which branches off at a blunt angle is not liable to split.

(*p*) A limb (like a chain) is no stronger than its weakest point, and therefore there must be no weak points about it.

(*q*) The strongest points of a limb must commence at its base.

(*r*) Foundation branches can never be built too strong.

(*s*) Limbs seldom break down by mere weight, but mostly by vibration, which brings all the strain on the weakest point at the fork.

(*t*) Main branches should be perfectly stiff, not affected by any vibration whatever.

It is impossible, in a short article like this, to do full justice to the system, or even attempt to partly explain it in detail. A few hours with me in the field will do more than can be attempted here on paper, especially since I am willing and capable of explaining everything about it. The method is

FIG. 2—Baronio method of pruning the lemon. (From a sketch by G. P. Hall, of San Diego.)

shown in the accompanying illustrations, made from sketches and photographs taken on the spot.

Figs. 1, 2, and 3 represent three rather extreme cases of straggling Eurekas taken immediately after the first operation. With the center leader, which probably carried a top to the height of about ten feet, cut out so that little if anything is left, any one with a timid heart who did not know any better would certainly think it impossible to get anything like a tree back again, but it is astonishing how quickly an entirely new and

better structure is brought into existence. First of all, by the removal of the great leverage which the high top exercised on the root, this at once gets a chance to obtain a firmer hold of the ground; the tree puts forth a new effort, and by a much more vigorous growth and healthier foliage, which act as new lungs to it, a correspondingly increased activity goes on under ground, forcing the formation of fresh rootlets, the trunk begins to thicken in proportion, and so an altogether more satisfactory condition of things is established. The great necessity for a good and strong constitution is a proportionately large stem from the base up, since a tree, like a man, of a strong constitution can stand more than a cripple. Now, fixing our attention

FIG. 3—Baronio method of pruning the lemon. (From a sketch by G. P Hall, of San Diego.)

on Fig. 1, according to my plan the tree is branched too high, for I consider sixteen inches the best height, and if more it should not exceed two feet; it will therefore be noticed that on the stem about a foot below the first branch two suckers are already started, the intention being to let them run straight up, like the one shown in Fig. 2, then arch them over as seen in Fig. 3. Observe how the two suckers have been intentionally selected not to be exactly opposite, one about four inches below the other, this being essential to form strong, independent branches. It would require a great number of diagrams and a too lengthy description to attempt an explanation of the process whereby the perfect conditions of principle are secured. How weak

LEMON TREE PRUNED BY THE BARONIO METHOD.

In orchard of T. F. Jones, La Mesa. Cut back by Mr. Baronio, in July, 1898. Photo taken October 30, 1899.

LEMON TREE PRUNED BY THE BARONIO METHOD.

In orchard of J. A. E. Thoustrup, La Mesa. Cut back by Mr. Baronio, in July, 1897, and cared for by him up to summer of 1899. Photo taken October 30, 1899.

limbs are made strong enough to overtake those which are strong already, and how new ones are raised at any desired position, may be seen in the various orchards of Mr. G. O. Hilton, and on the "Anna Belle" ranch of Mr. T. F. Jones, all of which are situated in the "Lemon Villa" tract of the San Diego mesa, where new limbs from one and a half to two inches thick have been raised in less than two years, notwithstanding the exceptionally dry seasons.

When the necessary well-placed limbs have been obtained, the most eligible ones are selected for structural purposes and future fruit, whereas the others are reserved for present fruit only.

The same remarks apply to Fig. 2; and as to Fig. 3, although at present it looks to be the most unlikely thing out of which to evolve a good tree, it will nevertheless make the best structure and get into shape quicker than either of the other two. All that is wanted to make it perfect would be to have the two branches right and left in the picture not located so nearly opposite to each other.

On each of these three arched branches two suckers are allowed to run, say one about one foot and the other sixteen inches from the trunk (all other growth being suppressed), and when properly matured these suckers are similarly arched, one to the right and one to the left of the respective original three branches, which by this time will be set into position and may therefore be shortened in, leaving to each a sufficiently long projecting stub to which the corresponding newly arched suckers may be fastened, and thus no longer obstruct the ground below. There will then be three main branches, each subdivided into two secondary branches, giving six structural points around a circle; and by a succession of similar operations these are in due time doubled to make twelve, and so on, always remembering to leave sufficient space between each of these fan-like main branches so as to allow a man to crawl through them and get into the middle of the tree to command the inside surface as far as he can reach.

Everything, in fact, is reduced to a perfect system, rendering the work a pleasure rather than a toil.

Plates XX and XXI commend themselves, but here the structural frame is not visible at all, or the effect would probably be as startling as in the three cases discussed above. Of

course, each tree being a separate proposition in itself, it is needless to say that where there is found already a tolerably good supply of well-placed branches, an opportunity is offered for an almost immediate symmetrical appearance. But this ambition must not be too greatly encouraged to the detriment of solidity, for it is easier and quicker to build a proper branch anew than to patch up an old one. To know what to remove and what to leave is an art to be acquired only by practice.

OPEN-CENTER PRUNING OF THE LEMON.*

(Modified from the Baronio Method.)

In the early days of citrus culture in California many lemon-growers did not believe in pruning. At the present time there may be a few who still cling to the idea that nature should be let alone; but nearly all observant growers have been forced, by the logic of facts, to the conclusion that the lemon tree, in all its varieties, needs pruning, more or less severe, to bring about the best results.

While the untrained tree grows rapidly and produces heavy crops, the fruit runs largely to culls, and often fails to come to a profitable size. The tree, with its great load of fruit growing at the ends of long limbs, is at the mercy of the winds, and is often split and ruined by the mere weight of its burden. Therefore, it may be true that the lemon tree left to itself will produce heavily, but it is generally recognized that to produce the largest per cent of good-sized and fancy lemons the tree must be intelligently pruned.

In the method of pruning given in the sketch the main object has been to shorten back and strengthen the scaffold or main limbs, so that they will carry their load nearer the center of the tree and be stocky and stiff enough to withstand strong winds without swaying and bruising the fruit. This method, properly carried out, has produced good results. It has, however, caused a tendency in the tree to form too thick and dense a head; a tendency very hard to combat. Even when carefully thinned out, trees shortened back in this way grow faster in their tops than in their lateral branches; on the principle that the sap flows most freely in vertical lines. The result is apt to be a tree high and all top; and this top, while beautiful to

*By C. W. Leffingwell, Jr., Manager of the "Leffingwell Orchards," Fullerton, Cal.

behold (to a "tenderfoot") is not fruitful, but consists chiefly of rank-growing, vertical leaders, commonly called suckers. These suckers are not supplied with fruit spurs, and are as worthless as so much bamboo. Even did they bear fruit, it would be almost inaccessible, and expensive to pick. The lower limbs, naturally the most fruitful, are robbed of sap by the superior drawing powers of the top, and fail to do their duty.

To overcome these difficulties the "open center" style of pruning has been tried, and has given good results. By

Skeleton sketch of a cross-section of an open-center tree. Hair lines indicate where to cut limbs.

eliminating the top entirely, the sap is thrown into the lower branches. These limbs being horizontal rather than vertical, and more or less bent, elaborate or digest the sap and produce heavy crops of good-sized fruit. This fruit, moreover, is within reach from the ground and can be economically picked. When the tree is once adapted to this form, the regular pruning is more easily and quickly performed, the number of limbs to be cut being greatly reduced, and all being within reach from the ground.

An explanation of the details of this system should properly come under two heads: "Pruning of young trees," and

"Altering old trees." As most of the lemon trees in California are three years old or over, this paper will be confined to a discussion of the method of altering old trees to conform to the "open-center" style.

It is assumed that the trees to be altered are branched fairly near the ground. If they have been up high no system of pruning will bring the fruit within reach from the ground, but to cut out the tops will save sap and make the lower limbs, such as they are, more fruitful.

Lemon tree pruned by the open-center method.

Assuming, then, that the grower has trained his trees near the ground, and has not caused the branches to grow up for elephants to walk under, the method of procedure is as follows: Draw an imaginary line around the outside of the tree, as high up as a man can reach standing on a picking-box. All the limbs that terminate above this line should be cut out. Cut them off at their juncture with the limbs that terminate below the imaginary line. The sketch on page 192 shows roughly

the places where to cut to eliminate the top. When this is done the top of the tree, looking down into it, will look like the inside of an inverted cone, and the tree may be called open-centered.

If the trees are small, cut out all limbs that extend up from the center of the tree at an angle greater than forty-five degrees from the horizontal. The tree in appearance will then be proportionately the same as the older tree above described, and can be trained gradually to the same limit of height.

The after-treatment of an open-centered tree, whatever its size, resolves itself into two distinct operations: the treatment of the hollow top, and the training of the main branches.

The hollow, cone-shaped opening in the top of the tree will soon be filled with shoots springing from buds on the main limbs, these buds being now exposed to the sun and excited into growth. Some of these shoots will stop growing when from six to twelve inches long, and will harden up and form fruit spurs. Others of these shoots will continue to grow at their terminal bud, retaining the color and appearance of tender sucker growth. When all have grown long enough to show their character, cut out the suckers and leave the fruit spurs. As a result, the saucer-like top of the tree will in time be clothed with short spurs, shading the main limbs, and bearing fruit of finest quality. The top, before a dense thicket, is now made fruitful, without in any way interfering with the remaining (most fruitful) branches. With each growth the suckers will for some years persist in coming, but are easy to take out as soon as they show their identity.

The treatment of the lower branches which remain is the same as if the top had not been removed. If the tree has been well trained from the start its skeleton will consist of three or four strong main branches leaving the trunk near the ground, and running out more or less horizontally; and one or two more sets or decks of the same number of branches, leaving the trunk above these and extending out at an angle of from thirty to forty-five degrees. These limbs will have been pruned back at intervals, and, forming forks at each pruning, will be found to support an increasing number of branches as the outside of the tree is approached.

The problem is how to handle the new growth on the tips of these branches. In solving this problem we should keep in

mind the objects in view, which are: to make the tree stocky, and at the same time to keep it from getting too dense. The pruning should be confined entirely to an effort to control the growth of the skeleton of the tree, letting nature take care of the fruit spurs with which this skeleton is clothed.

The terminal shoots or leaders of the tree should be left alone until they have grown to be several feet in length and from one quarter to one half inch in diameter. They should then be cut back, leaving from six to ten inches from the last pruning. In cutting back a vertical leader, cut to a bud that points out, away from the tree; horizontal leaders should be cut to a bud that points up. By persevering in this practice the limbs can be trained out, then up, then out again; they will be angular and crooked, which is conducive to fruitfulness. Their angling direction will help to brace them against the evergrowing leverage of their fruit and foliage, so that, while they may in time be bent down to the horizontal, they will never droop and rest upon the ground.

After each cutting back these leaders should be left alone and nature given full sway; and this is what will happen: Five or six buds nearest the cut will be excited into growth. Then will ensue a struggle to see which of these buds will get the most sap. The terminal bud is sure to get its share, and become a strong, sucker-like shoot. Probably one or two others will secure enough nutriment to become suckers likewise. The rest of the buds will have to give up their ambition to shine, and will settle down to the domestic rôle of bearing lemons, and thus perpetuating their species. These are the shoots that we are after. Were it not for the cutting back these buds would become dormant and lost to use; the leader on which they are situated would grow five or six feet perhaps, before nature would make another branching, and give more buds a chance to go to housekeeping.

How to handle the shoots which get the sap and become leaders is an important question. It is right here that judicious thinning should be done, to keep the tree from becoming too dense. All the shoots should be left until long enough to show which will be fruit spurs and which leaders. All but one of the leaders, the one which points in the desired direction, should be cut off clean. This leader will thus become the foundation of all future growth on this branch. At the next

pruning it would be well to leave two leaders, laying the foundation for a new branch. By alternating in this way we can increase the number of ramifications of the tree, without getting it too dense—the trouble with most lemon trees.

These new leaders, when grown big enough, should in turn be cut back, and treated in the same manner. Beyond this, and keeping water-sprouts out of the center, little need be done to the tree. Nature will take care of the rest.

It may seem impracticable to apply one set of rules to all varieties of the lemon tree, but in the experience of the writer, all have responded to this method of treatment. The Lisbon, being first and last a lusty grower, is bound, whatever the style of pruning, to make a rank mass of new wood. Let it grow, and cut off what is not wanted; let it grow again, and cut it back again. It can be made to bear plenty of fruit within easy reach; if left to itself it will produce little but stovewood.

The Eureka and Villa Franca, being of more tractable habits, form less and less new wood as they grow older and their crops increase; so that in time little or no pruning is necessary.

The question has been asked, whether the fruit spurs of the lemon go on bearing, or die after bearing a few crops; making necessary a constant growth of new wood, as with the orange and peach. From observation the writer believes that the lemon spur, with the apple and pear, is long lived and goes on bearing for years. If, on the other hand, the spurs are really short lived, severe pruning alone will insure new wood.

No radical system should be generally adopted without careful trial. The "open-center" system has been applied to a large acreage of lemon trees, with unmistakable benefits, and the number of acres so treated is increasing. In the orchards in charge of the writer sixteen thousand trees, mostly three years old, have been changed to conform to this style. Hardly a tree has been lost in the transformation, and prominent horticulturists pronounce the trees unsurpassed for their age, in size, condition, or fruitfulness. Where before was despair as to what to do with the troublesome tops, now all is simple and easily done. It would pay every lemon-grower to try these suggestions on a few trees, and let the results speak for themselves.

OPEN HORIZONTAL TRIMMING.*

It is so called because the tree is trimmed to present this form. It is a compromise between the one-deck form of the perfect Baronio, and the method of allowing trees to run to suckers.

The principles of Barry, Downing, and Baronio are well established, and their utility is understood by observing students of horticulture.

Trees can be trained to grow in the square, espalier, globe, vase, or neglected form. The requisite is to have a definite idea of the form desired and of the office the tree is to perform. We get peculiar ideas of form rather from sentiment than from thought of utility or profit. We think the form we have been used to seeing is the only proper one to produce, hence can not think of an apple tree trimmed on the cordon plan (raising fruit on parallel limbs not two feet from the ground). There was a man who thought lemon trees should be trimmed up high, like he had seen apple trees in New York—so that horses could pass under the lowest limbs. He is now clerking in a livery stable. We do not fail to trim the grape until a vineyard looks like a conception of a portion of Inferno by Dante and Doré. But it is the profitable way to do. We sucker corn because we want ears instead of bare stalks. Why not treat the lemon as commercially? It is simply a business proposition to remove all the superfluous timber, and to retain the bearing surfaces. It means dollars to have the tree low and open, rather than so lofty that the price of the fruit is consumed in traveling up and down the stepladder to get it.

Trees arrange their forms by reason of the different methods of the distribution of sap. The oak differs from the cypress by reason of this unerring law. Shrubs, conifers, palms, and all forms of vegetation assume their respective shapes because the sap is differently disposed. Some trees, if left to themselves, run all the sap to the extremities, as is the case with the peach, apricot, and others, hence in their case the extremities must be severely cut back, or there is a crop of dead wood in the center of the tree.

We deduce from this principle, which we have not time to

* By George P. Hall, of San Diego.

enlarge upon here, the conclusion that the vigor of the tree depends upon an equal distribution of the flow of sap. Dead wood is the result of loss of sap in either root or limb. Trees left to themselves assume an individuality that is seldom profitable. The wild apple, orange, and lemon are of little value commercially. We must therefore train them along lines of production. To obtain certain results we must direct the flow of sap in the channels in which we wish it to flow, having a definite purpose in view, otherwise all so-called trimming is simply butchery. The tree must be balanced, therefore arrest growth where there is a superfluity and encourage growth where it is lacking. Trim short when wood growth is desired. Use the biblical injunction, "To him that hath shall be given, and to him that hath not shall be taken away even that which he hath." Cut feeble limbs short and encourage upright growth, because upright growth produces wood. The feeble parts deprived of fruit will produce wood; the strong parts loaded with fruit will produce less wood. Bend the strong parts down, keep the weak erect. The more erect the branches, the greater the flow of sap to the growing parts; hence the feeble parts left erect attract more sap than the strong parts bent down or inclined. Sap acts with more force on a limb pruned short than on a long one. Two buds with the same flow of sap as in twenty buds will be stronger than any of the twenty. Prune short for wood branches, because vigorous shoots produce few fruit buds. Prune long for fruit, as it is the most tender and feeble buds that produce the fruit; bend the limbs at an angle or to a horizontal position to produce fruit buds. Prune short the parts that have overborne; to secure a prolongation, prune to a vigorous wood bud and let nothing interfere. The more the sap is obstructed in its circulation, the more the tree is disposed to produce fruit. The sap traveling slowly is subjected to slower assimilation and is better adapted to the production of fruit.

To change a fruit branch to a wood branch, give it an upright position; to make a wood branch bear fruit, bend it to nearly a horizontal position.

Light and air are essential. The rapid growth is toward the source of light. Upward growth gives strength of wood, but less fruit.

I do not say the horizontal method is the only one, for fruit

can be produced on a tree of different form; but I do say that the principles which I have stated must be followed in order to obtain the best results financially, and also to promote the longevity of the tree.

My reasons for advocating the horizontal form are that fruit raised on short spurs is less expensive to pick, is of better quality, and the tree relieved of its superfluous wood may develop into a fruit producer instead of being a specimen of growth under the timber culture act. The tree can not produce an immense amount of wood and bear a large quantity of good fruit at one and the same time. Educate the tree to cease raising suckers, and the height and size of your trees are controlled.

In cutting back large trees and in retaining all the horizontal limbs, the tree immediately turns its attention toward fruitfulness, because the sap is directed along fruitful channels instead of being sent toward the sky. By preserving all well-placed limbs a foundation to build on is secured, with some expectation of reaping a reward for labor expended.

The cost of picking fruit from trees trimmed on the horizontal plan, and not more than eight or ten feet in height, is greatly reduced.

We can but barely hint at the wideness of the application of the principles of the horizontal method, so we simply recapitulate:

Trees receive their individual form by the natural direction of the sap; therefore, direct the sap and you control the tree.

Most trees send the sap to the top, being drawn thereto by the sun. Change the habit.

Vigor of the tree depends on equal distribution of the sap; therefore, distribute it by judicious trimming.

Trees left entirely to themselves are seldom profitable. The wild tree must be civilized by grafting or budding, and pruning.

Trees can be trained to assume at the same time profitable and symmetrical forms. Results come from systematically directing the growing life of the tree.

The tree must be balanced top and root. Pruning gives activity to root growth. Loss of limbs incites healthy action of the roots.

Deprive the feeble parts of fruit, and make the vigorous parts bear all they will.

Bend the strong parts down, put the weak erect. Tie and arrange limbs as you want them. Make the tree your servant.

The greater the number of erect limbs in a tree, the sooner will its vitality be exhausted; it lives too fast.

Fruit grown on short spurs is less liable to injury.

The horizontal type of pruning gives a definite plan for the life and habit of your tree, which is immensely superior to all others.

Lay a horizontal superstructure, and you build your tree strongly.

It is important that the man who plans the form of the tree should follow its training thereafter. Do not deliver it over to the accidental haggler who does not understand your plan, and has none of his own. Snipping is not trimming.

There is but little loss of fruit, or time, in changing the form of the tree by the horizontal method of pruning; the tree immediately begins a fruitful career.

Tree pruned by the so-called "Semi-Baronio System."

SEMI-BARONIO SYSTEM.

As is often the case, there are always many who believe they can improve upon whatever method may be used, as in this instance. Several orchards have been treated by what is called

the "Semi-Baronio System." This consists mainly of taking out the center of large trees, allowing the ingress of air and light, but otherwise without any scientific principle. The growth at the top and on the outside is cut back, as in the rounding system of old. The branches put forth numerous shoots, which are again shortened the season following, and so the work goes on.

TREATMENT OF THE LEMON.

The systems of processing the lemon for market are numerous, but in all the main objects are to reduce the thickness of the rind, to close up the pores of the skin in a natural way, so as to render the texture smooth and velvety to the touch, while the lemon remains firm and solid, to increase its juiciness, and to hold the fruit in that condition to supply the market when it is at its best.

J. W. Freeman, of Ontario, gives the following suggestions in handling and processing lemons, derived from the experience of years of processing and marketing lemons by the Ontario Exchange:

"The question that is now to the front in the lemon industry is what might properly be termed lemon-holding. Those most familiar with the business have, for some time, been convinced that some way should be devised for taking the surplus fruit off the winter market, and holding it for the summer trade. Indeed, the life of the industry seemed to depend upon the possibility of that being successfully done. With that end in view a few of our growers, beginning with the November pick, held their winter lemons until May, June, and July, of the season of 1896–97, securing satisfactory results as to keeping qualities and prices. Encouraged by the success of these, some eighty of our members pursued the same plan the following season, with like results, excepting that some of the fruit was marketed in August, a month later than the year before. It would be only fair to say that success has not been uniform in each case, but it has been in proportion to the care taken and the facilities for storing the fruit. An expensive house is not necessary, indeed almost any place will do in winter; but appliances for keeping a low, even temperature are necessary in summer, and doubtless are desirable in winter as well. A fairly tight box with

plenty of fresh air circulating about it, at a temperature between 60° and 70°, seems to us to be the essential condition for the best success in holding lemons. Shade will greatly help in keeping down temperature, and is, by some, thought to be equal to a double wall. Means should be provided, by doors, windows, or ventilators, for thoroughly changing the air every night, unless in very damp weather, when it might be advisable to air in daytime. Fruit should not be allowed to wilt before putting away, but the boxes should be left somewhat open for a time, varying according to the conditions of the place in which they are, to allow surplus moisture to pass off. The top boxes should be well covered, so that the fruit will not dry out and thus become worthless. It is desirable to retard what is known as the curing process as long as possible; therefore, each grower should study the conditions of his house, and have as little evaporation as possible, without allowing moisture to collect on the fruit. This will also prevent the fruit from getting soft. Stacking fruit in large piles without spaces between should be avoided, although we have known it to keep well for a time in that way, when it was not in a close room. Medium-sized houses seem to be preferable. To be in ideal condition the fruit should come out firm, with stems fast and green. This will not be the case if fruit heats or sweats. The fruit should be placed so that it can be inspected occasionally, and defects remedied.

"Having said this much, any description of a house will be unnecessary, as such a one as will meet the requirements of each grower will readily suggest itself. I might say, however, that a sloping roof inside with air holes at ridge will give better ventilation than a flat ceiling. We deem it desirable, if not essential, that each grower hold his own fruit.

"A word as to the fruit. All that has ever been said as to the need of carefully handling the fruit should have full weight. The trees should be kept clean. The fruit can not be at its best if the trees are infested with scale and the fruit has to be washed; but should that be the case, the lemons should, by all means, be brushed or washed when taken from the trees. The fruit should be looked over carefully, and the inferior, dark-colored, and small-sized kept by themselves with a view to earlier marketing. Fruit carefully picked and properly stored under right conditions, if uninjured by frost, will need very

little handling, if any, before shipping. The less handling the better. As much fruit as the trade will take at fair prices should be marketed during the winter. The matter of the desirability of winter marketing will have to be governed by the outlook for the coming summer and the supply.

"What effect a heavy rain or an irrigation has on the keeping qualities of fruit picked immediately after, is a disputed question. Ordinarily no harm can come by waiting, and good may.

"The important points regarding the question of storing are, we think, fairly well covered, so far as our experience goes, and they are: Experience in picking the lemons at their proper maturity and size; the greatest care and tenderness in handling them in all the processes of storage and marketing; keeping them in an even temperature of from 60° to 70°, and frequent change of air in the storage house and apartments; and individual holdings."

A. J. Everest, manager of the Everest orchards at Riverside, in the "California Fruit Grower" of November 25, 1895, describes his method of picking, curing, and packing lemons for shipment, as follows:

"We pick our lemons whenever they are large enough, without regard to color, preferably while green or slightly turned, taking care that no fruit smaller than the 300 size to the box is picked, as the fruit shrinks some in curing, and thus increases the number to the box. We have used rings to determine the size, but find it too much trouble to try a ring on each lemon, and now give each packer a lemon of the proper size, and let him continually compare his picking.

"After being picked we haul the lemons to the shed, and pile them up in the picking-boxes for two or three weeks, or until most of the moisture is dried out, before placing them in the curing-house. We then wrap the lemons separately in tissue paper and lay them on trays one layer deep, having previously graded the fruit. We then store them in our curing-house, which is made with double walls, filled in with sawdust to keep the room at an even temperature. We have ventilators in ceiling and floor of room, and regulate amount of fresh air and temperature by them, allowing temperature to stand from 56° to 60° as a rule.

"Storage curing-trays are about three inches deep, with a cleat on each end, thus raising them up to allow the air to

circulate among the fruit, and to keep everything dry as far as advisable. We find that fruit picked early and while quite green, say in November, always cures the best and with the least possible shrinkage or loss by decay.

"When packing the fruit for shipment, the wraps that were used for curing can be used, except where the paper has been moistened by decay in the vicinity or is torn or wet from other causes. It is better to remove all old wraps, regrade the fruit, and then pack the same as oranges, using if possible the Sicily style of box, which is obtainable now on this Coast."

In 1890, N. W. Blanchard, of Santa Paula, an extensive lemon-grower, and President and General Manager of the Lemonia Company, of Santa Paula, read an essay on "The lemon and its treatment," before the State Fruit-Growers' Convention, in which he described his method of curing lemons, essentially the same as now practiced by him. In 1894, in an essay before the Farmers' Institute at Santa Barbara, he said:

"The essentials for keeping lemons several months are to exclude the air, or any circulation of air around the fruit, and at the same time to give ample circulation of air about the trays or boxes that contain the lemons. My experience is, that if there are a good many boxes of lemons closely massed, even with cool weather some of the fruit will decay. When one lemon begins to rot heat is generated, and this acts like yeast, causing fermentation and rottenness to spread rapidly. I do not think expensive buildings are necessary. I have seen no better cured and preserved lemons than some that were wrapped in pieces of newspaper, placed in layers in common boxes with more paper between layers, the boxes covered with light covering so as to shut off all circulation of air, and all piled in the end of an airy barn. These lemons were shown to me in July, and I was informed that they were cut in November previous. The lemons were firm, finely colored, and in excellent condition for shipment.

"I know no reason for changing my method of curing lemons. I continue to use trays two by three feet and three inches deep, each holding only one layer of lemons. They are convienient to work with and to examine the lemons. They should be carefully made, so that when the trays are stacked one on the other there is no chance for the air to reach the fruit.

"The lemons are picked frequently, if there are any suitable to pick, so as to prevent having over-large and over-ripe fruit. I generally use a ring two and one quarter inches in diameter, and take all that will not pass through it.

"The lemons are cut close to the fruit, handled very carefully, hauled from the orchard in a truck on springs, washed immediately if smutty or dusty, then placed on trays, and from one to ten days afterward piled away for keeping, if they are to be kept or need the darkness to color. If already colored and needed for immediate consumption, the trays are cross piled, so as to give them all the air possible. If for remote shipment, the lemons should be shipped quite hard, and even a little green, for they will cure in transit or in the hands of the jobber and retailer."

T. J. Ashby, Secretary of the Pasadena Lemon-Growers' Association, in a report to the association, says:

"The stems must be cut close, but care must be taken not to cut, scratch, or bruise the fruit. It is found that many culls are made by careless clipping and long finger-nails.

"The desirable sizes are the 360's in summer and the 300's in winter. These measure $2\frac{1}{8}$ and $2\frac{1}{4}$ to $2\frac{5}{8}$ inches. Lemons above and below are graded, subject to the discretion of the manager.

"Lemon groves should be picked over once a month. Use padded baskets or pails, into which the fruit should be laid, not dropped or thrown, then carefully transfer to boxes placed in the shade.

"Pick before irrigation or wait several days. Never pick lemons moist from fog or dew, or leave them unprotected after gathering.

"Haul to the warehouse on easy springs; drive carefully and have the lemons covered to protect from dust and sun. We advise delivering or placing in barn or shed as soon as possible after picking.

"Smutty fruit received will be washed or sponged at the expense of the grower. Members have the option of doing this for themselves, but it is well to remember that spraying or fumigating is much less of an expense.

"It will pay the grower to cull his own fruit and not be forced to haul it both ways. Experience will soon show a novice what to reject.

"The sum of these suggestions is that the one who brings the best grade of carefully handled fruit is the one who gets the best returns at the least personal expense."

The Advisory Board of the Lemon-Growers, who are affiliated with the Southern California Fruit Exchange, through Morton Haig, of San Gabriel, formulated and published, in April, 1897, the following hints regarding the gathering, etc., of fruit:

"Have pickers' nails trimmed short; few will believe how much fruit goes as 'culls' from damage by long finger-nails.

"Clip the fruit close to the stem.

"Do not use sacks in which to gather; lemons are thereby bumped and bruised with every movement of the body. Use baskets lined with sacking.

"Do not tumble fruit from the basket into boxes, but handle lemons as you would eggs, from start to finish.

"Never pick when there is moisture from fog, and wait at least four to five days after rain or irrigation.

"Place all filled boxes on the north side of the tree, and shade closely from the sun.

"Go over trees once every four or five weeks, and thus save sun-burned and over-sized fruit, all of which goes as a third-grade fruit, or is, more frequently, thrown out.

"Pick in winter months to a uniform size of $2\frac{1}{4}$ inches in diameter, and in summer months to a uniform size of $2\frac{1}{8}$ inches. Metal rings for this purpose can easily be obtained or made.

"Loaded wagons should never be allowed to trot or bump over plow furrows, ditches, or chuckholes.

"If dirty fruit has to be washed, let this process be gotten over quickly; by employing the greatest number possible to this end, will save the fruit immensely. During all undue exposures the work of deterioration is rapidly progressing. Here again avoid all dumping of the fruit, and look to washers' nails.

"If fruit has to be taken to depot or central packing-house, let it be done, in summer, during the cool of the morning or evening.

"The grower, in following out such suggestions, has then done his level best. A responsible curer, packer, and a good market will do the rest.

"The above applies equally to oranges in their separate treatment. There would be fewer complaints of fruit arriving at its journey's end 'heated,' etc., if growers were more particular with regard to handling.

"It has been specially noted, for instance, by the exchanges, that during the wet months serious damage has ensued from gathering oranges too early after a heavy rain, and in many districts the 'washing and scrubbing' system has been added to the already soft and soddened fruit conditions."

LEMON SIZES—STANDARD BOX.

The sizes of lemons packed for shipment differ from those used in packing the orange for shipment. The sizes are 210, 240, 250, 275, 288, 300, 360, and 420. Occasionally larger and smaller sizes are packed, should the market warrant their shipment. Of the sizes named, the 300 and 360 are recognized by the trade as regular sizes, and all others known as off sizes.

The standard lemon box, and the one now generally used in California is—

Standard Lemon Box, 10½″ x 14″ x 27″.

Ends	3 pieces 11/16″ x 10½″ x 14″
Sides	2 pieces ¼″ x 9⅞″ x 27″
Tops and bottoms	4 pieces ¼″ x 6¾″ x 27″
Cleats	2 pieces ⅜″ x ¾″ x 13½″

COST OF HANDLING LEMONS.

The cost of handling lemons from the tree to the car, without including the expenses mentioned, was given to the Tariff Committee of Southern California as follows by N. W. Blanchard, of Santa Paula:

"Actual cost of picking, brushing, sorting, and packing lemons, per box, including paper wrappers and boxes, for the year 1896, as per account kept of same, was 63 cents. The box used for lemons was the orange box. The standard lemon box is fifteen per cent larger than the orange box, the standard box being 10½″ x 14″ x 12½″, inside measurements for each of the two compartments. Adding fifteen per cent to the above cost of 63 cents would make the cost of the standard lemon box 72 cents.

"For labor I pay the following prices per day:

For girls	$1 00
For ordinary men's labor	1 25
For more experienced men	1 50
For foreman of the pickers in the orchard	1 75
For overseer in packing lemons	2 00

"The cost of handling lemons, as above, does not include anything for general overseer of the orchard, or for clerical help in the office."

B. A. Woodford, Secretary and Manager of the Ontario Lemon Exchange, gave the same committee a statement showing in detail the cost of a box of lemons from the tree to the car, as follows:

Picking (Hauling calculated in orchard expenses)	$0 15 to $0 18
Exchange expense	20
Packing	08
Rent of plant ($5,000 investment)	08
Curing expense (labor)	15
Office and miscellaneous expense	14
Total expense to car, per box	$0 80 to $0 83
Freight	1 00
Cost of selling, winter	12
Total cost per box, winter shipment	$1 92 to $1 95

Summer Shipment.

Winter shipment	$1 92 to $1 95
Increased cost of selling (25c.)	13
Icing	229
Cost per box, summer shipment	$2 279 to $2 309

Lemon Grove, Chula Vista.

SICILIAN LEMON INDUSTRY.

By W. Catton Grasby, F.L.S. (Being a summary of notes collected by him as Honorary Commissioner for the South Australian Government.*)

Sicily, the Home of the Lemon.—Sicily is a triangular island, with a narrow coastal plain bordering a central mountainous plateau, rugged and largely forest-clad, terminating on the east in the black, fissure-furrowed, lava-covered slopes of volcanic Etna. On the north coast is Palermo, the largest town, and chief center of the lemon industry. Messina on the east coast to the north of Etna, and Catania to the south of the same mountain, divide the major portion of the remaining trade. The Australian lemon trade is chiefly in the hands of Messina merchants, and the fruit is sent via Naples, Brindisi, or Marseilles. Sulphur, citric acid, oil of lemon, and sumac chiefly pass through the trade channels of Genoa or London, or both.

Sicily is preëminently the home of the lemon. It does well in many other places, but it reaches perfection in Sicily. Why? The question is a most important one, and I have thought over it a great deal. The St. Michael orange, the Jaffa orange, or the Sicilian lemon, even when grown from trees raised in other places and taken to other parts of the world, generally, for the time at least, possess the outward form and general characteristics, but lack the fine quality, of the luscious fruit which has secured a world-wide reputation. There is a close relationship, not at all understood, between local conditions and the product of the plants. A close study of the problems of fruit culture has led me to think that while we should introduce all new and desirable varieties of fruits from all parts of the world, because we never know which will prove particularly valuable under our conditions, we should pay a great deal more attention to the improvement of our own varieties. I must not, however, discuss the whole question now. It is only necessary to emphasize the fact that the conditions of soil and climate in Sicily are particularly suited to the lemon, and that by generations of experience the

*Published in "Garden and Field" of Adelaide, South Australia; five chapters, commencing in the December, 1898, number.

Sicilian has learned how to deal with lemons better than any one else. It does not follow, however, that the whole of Sicily is adapted to lemon culture, or that the lemons grown in the various districts are of equal quality.

Mountain and Coastal Lemons.—A study of the varying conditions in Sicily, when considered in relation to the varying conditions in South Australia, leads to valuable lessons. Speaking generally, Sicilian lemons are known as mountain-grown lemons and coastal or plains lemons. This distinction, however, does not always mean that the lemons were grown among the mountains, but rather that they were grown in soil corresponding to the soil of the mountain lemon districts. As a rule, the coastal plains consist of a light sandy soil, often with a gravelly subsoil. The hillside soils are stronger and consist of a well-drained clay loam, and it is on these soils that lemons of the best quality are produced. The fruit so grown is more solid and more juicy, and altogether of finer quality. Speaking of this, the United States Consul at Messina, Mr. Jones, said: "The soil has a great influence upon the maturing and keeping qualities of oranges and lemons. The fruit ripens earlier on light sandy soil than on clay soil. Fruit grown on light sandy soil can not be left long on the trees without losing quality through becoming dry and spongy, whereas on clay soils it is sometimes allowed to hang from December or January until April. The fruit grown on sandy soil is smaller and of a paler yellow. That grown on the clay soils is larger and keeps better. Trees on clay soil resist drought much better." As an example, it may be mentioned that the fruit grown in the groves to the southwest of Palermo district is much more highly prized than that from the groves on the northwest, the sole difference being the clay and sandy characters of the soils. "Mountain lemons," which is synonymous with fruit grown on loamy clay soil, bring as much as one third more than "coast fruit," which is grown on light sandy soil. The superiority is always attributed to the soil more than to the elevation. "Fruit produced on the plains of Portello, the soil of which is clay, brings the same price as that grown on the heights of Monreale," about the beauties of which and the wonderful mosaics of the Cathedral, I hope to have something to say at another time.

Climatic Conditions.—From what I have just said it will be gathered that the lemon lands of Sicily may be divided into two classes—first with respect to soil, and second with respect to altitude. The coastal zone embraces the narrow coastal plains and the lower portions of the valleys up to 1,000 or 1,500 feet above sea-level. The mountain region includes the higher valleys and hills from 1,500 to about 3,000 feet above sea-level. Beyond this the climate is too moist and the frost too severe for lemon culture. This wide range of altitude within a limited area is an important factor in the production and marketing of lemons. The fruit near the coast ripens first, and the lemon harvests succeed one another as one proceeds into the interior. It will be readily seen that it is difficult to summarize the climatic conditions of a range of country such as I have indicated. The best I can do is to give the range of temperature of Palermo, which is on the north coast. Ordinarily the thermometer ranges from about 34° Fahr. in winter to 95° Fahr. in summer. The average for the year is about 70° Fahr. Occasionally it rises as high as 104° Fahr., and sinks as low as 30° Fahr. There is not, however, much difference between Palermo and Adelaide in temperature, but the climate of Palermo is more humid than ours, and the contrasts less sudden. The hot south wind of Sicily comes from the deserts of North Africa, but it has to travel over the moisture-laden surface of the Mediterranean, so that when it reaches Sicily, although it is hot, it has lost the parching power of our north wind, fresh from the almost treeless plains of the vast interior of Australia.

The year may be divided into a wet and a dry period. During the winter, or from the end of September to April, the prevailing winds are strong and constant, and bring a large amount of moisture. The fall during the six months named averages 22 inches, and the average for the year is between 25 and 30 inches.

SICILIAN LEMON CULTURE.

The methods of culture of the lemon in Sicily vary more or less in different districts under different conditions. It is impossible to describe all the varying details, so that it will be necessary for the reader to consider my remarks as the prevailing conditions. My notes are the result of careful inquiry

and observation, extending from the coastal region well up into the mountains, and I have verified them as far as possible by reference to the scanty literature on the subject. This is almost entirely confined to more or less brief references to the subject in British and American consular reports. The most complete account of Sicilian lemon culture I have seen is that by Acting-Consul de Garston, made in 1895. Some of the statements in some of these reports appear to me to be a little misleading, in consequence, I think, of the writers not being familiar with fruit culture, and so misunderstanding the information given by growers, but they are valuable in many respects.

The Nursery.—For convenience and clearness, I will divide the life of the tree into two periods. These are clearly marked, but very unequal in duration. The first is the nursery period, and extends over from five to six, and sometimes seven years. The second is the management of the tree in the lemon grove. The usual care is taken to secure a suitable plot of ground for the seed-bed, but I did not find the practice, followed by our nurserymen, of raising seedlings in frames, to be in operation. Formerly young trees were largely raised from layers or cuttings, but this practice is almost discontinued, because the trees are considered less robust and more subject to disease. Up to within the last twenty years the stocks were raised from lemon seed, but now the bitter orange, *Citrus bigaradia*, is almost always used. I think it is called *Cedrangoli amari* by the Sicilian growers. The dry seed from this stock is, I believe, sold at from 1.50 lire to 2.00 lire per kilogram (a kilo is about 2.2 pounds, so that the seed costs roughly 8d. per pound). The bitter orange is a free, vigorous grower, and possesses a hardy constitution not subject to disease. The seed-bed, having been carefully prepared of sandy loam, is divided into rectangular plots, each surrounded by a raised border or bank, so arranged that water can be run into each for irrigation purposes and the plot flooded. About a quart of orange-pips are sown on a plot about ten feet by two feet, and are covered with about one inch of sandy soil. The pips are planted in spring (March or April), and are frequently soaked in water before sowing. When sown, the plot is well watered, and it is kept moist during the whole of the summer until the first autumn rains, by watering every four days at least. The young plants show in about two

months, and are set out in the nursery in the following spring, when about eighteen inches high.

Method of Culture.—The amount of labor involved in raising a lemon tree and bringing it into bearing appears to be many times greater than with us, and I think we expect to obtain crops two or three years earlier than does the Sicilian, who does not bud his stocks until the fourth or fifth year, and does not expect them to bear until they are eight years old. In this connection it should also be mentioned, that if he waits three years longer he expects his trees to give him a crop for from forty to one hundred years. It is stated that in some cases both orange and lemon trees in Sicily live to be two hundred years old. In thinking over this I am led to ask, Do we force our trees too much? Were the stocks used on our old trees of a poor quality? Or why do our old trees cease to produce good fruit and die so much earlier than those of Sicily? I do not know, but these questions may be worth considering. The nursery is very carefully chosen, the two main considerations being the soil and the sunny aspect. After being thoroughly well worked it is divided into small plots, each with a raised mound of soil. These plots are not of uniform size. In some districts what is called the "Mettere a Casella" (planting in a cell) system is adopted. In this system the nursery is divided into small cells or plots about eighteen inches square, and a year-old seedling, generally about eighteen inches high, is planted in each corner of the cell. Each plant is tied to a straight stick, and so made to grow as straight as possible. At the beginning of the third year alternate plants are taken out and replanted. This is called planting in "piantonaio." In the fifth year the stocks are usually budded. I was struck with the fine, large, tall, straight saplings which the stocks formed in their fifth year.

In other districts a somewhat different method is followed. The plots are much larger. Each one is surrounded by a mound of soil, and is placed end on to an irrigation channel, so arranged that the water can be run onto the plots one after the other for the frequent irrigations. In these plots the seedlings are set out at a distance of not less than eighteen inches. The plants are carefully tended and watered every week during the first year, and every second week afterward. In the fifth year

they are tall, well-grown trees of, say, an inch in diameter, and are then grafted or budded. Sometimes this is done in the nursery, and sometimes the saplings are set out in their permanent position first. In either case the bud or graft is made about four feet from the ground. The methods followed are in no important point different from those followed here. The most frequent practice is to use the shield-bud method in early summer, and when this fails, to bud again in autumn, and allow the bud to remain dormant until spring.

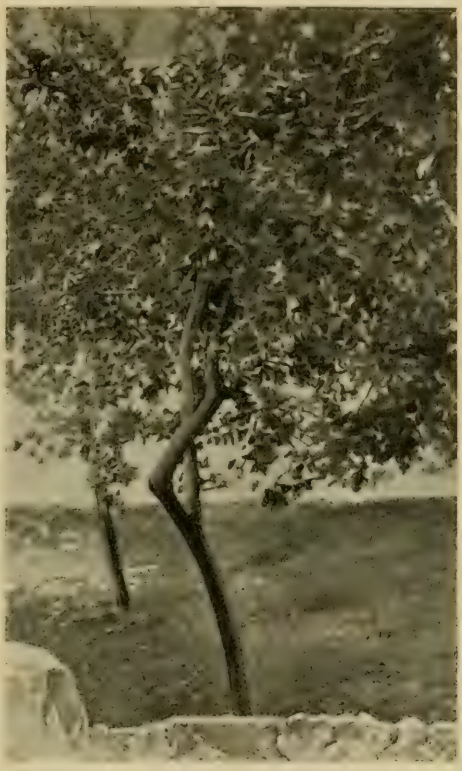
The land for the lemon grove is well prepared, and in the hot months of July and August the "formelle," or holes for planting, are dug about three feet deep, and in the late autumn, or early spring, the saplings are removed from the nursery and set out. Before planting, the trees are often made to undergo a peculiar treatment, called the "*Ordeal of Darkness.*" They are dug up from the nursery and put in wicker baskets filled with loam and conveyed to a dark room, where they are kept away from the light for about fifteen days. They are then exposed to half-light for five days, and then placed in an exposed, but shady spot, for a month. Should a tree show signs of sickness it is again conveyed to the dark room for eight or ten days more. It is said that trees subjected to this ordeal seldom, if ever, fail to take speedy root and thrive. The trees are planted at from twelve to fifteen feet apart, and the rows are placed as nearly north and south as can be managed.

How Trees Are Trained.—The system of training the trees with a high, straight stem, and planting closely together, renders it necessary to prune trees much more than is done in South Australia. The trees meet overhead, but one can walk upright under the main branches. Sunlight and a free circulation of air are essential to the lemon, therefore the trees are kept open by systematic pruning and trimming, so that in an old grove there is an even distribution of fruit over the whole area.

Annual Crops Between Trees.—It is the custom to grow cereals, vegetables, peas, beans, lupins, and other crops between the trees for some years. Quite frequently, too, vines or cotton plants are grown in the young lemon groves. Of course, such groves receive much hand cultivation, regular manuring, and liberal cultivation. When the development of

the lemon trees prevents the further cultivation of annual crops, the work assumes a regular character.

Irrigation.—Wherever possible, irrigation takes place at regular intervals through the summer months. In the mountains this is done by gravitation from the mountain streams, and the irrigation ditches are always a prominent feature in the lemon grove. Usually each tree stands in the center of a basin, formed by a small mound of soil, and into this basin the water is run at intervals. On the lower lands I found artificial means of raising water were used, and I was struck with the extent and completeness of the steam pumping plants in some of the larger plantations. I think there must have been many miles of concrete channels. These channels were sometimes five or six feet above the level of the ground, and were carried on concrete walls about eighteen inches thick. When it was necessary to cross one of the roadways which divided the grove into regular blocks for convenience of gathering the crop, and other work, an earthenware inverted siphon was used, carrying the water under the road and up the other side. Except for the siphons, these channels reminded one of the old Roman aqueducts on a small scale. The first irrigation is given in June, when the fruit from the



Sicilian lemon tree, showing method of pruning.

early bloom is the size of a pea, and the trees are still in bloom. In dry districts perhaps nine other waterings will be given.

Pruning and Trimming.—In a former article, in speaking of the training of lemon trees in Sicily, I used two terms—"pruning" and "trimming." These must be explained, or they may lead to misunderstanding.

By trimming ("rimondaments") is meant the removal of all dry twigs, suckers, water shoots, stunted or rank growth, and

Sicilian lemon trees planted on side hills.

twigs which have borne and become exhausted. This is done in the winter, and should be carefully attended to every year.

In addition to this about every three years the trees are gone over more thoroughly, and thinned out after the main crop is gathered. This is called pruning, and should not be required to any great extent if the trimming has been properly done. The object is to maintain an open tree, into which light and air can freely penetrate as a preventive of disease and so that the fruit may be evenly distributed on the inner as well as on the outer branches.

It must not be understood that the Sicilian lemon trees are pruned with open centers, for that would be quite misleading.

The trees are usually trained with a main trunk stem, from which the branches put out at irregular intervals. The pruning simply gives an airy, open-branched tree, which is necessary, because the trees are planted so closely together—from twelve to sixteen feet—that the branches meet and interlace, so that if the tops were not kept open light and air would be excluded. Again, by allowing the trees to grow into one another it becomes necessary to cut away all the lower limbs and to train the trees with high trunks, in order that the workmen and pickers may pass beneath. In giving these reasons I am in a measure theorizing, because the Sicilian does not know why he does this or many other things, except that his father and grandfather did the same. I did find a few groves where the trees were planted at from eighteen to twenty-four feet apart, and then they were allowed to assume much the same shape as those to be seen in the Payneham and Marden orangeries. This was particularly noticeable in a large orangery of about one hundred acres that I visited about six miles from Palermo, in connection with the Villa Elleanora del Principe di Scalea. The tendency is to give more room to the orange trees than to the lemon trees.

The lemon groves are generally surrounded by stone walls about five feet high, but often eight or nine feet high. The latter I gather were originally built as a protection to the people in the lawless condition of the country. This idea is also seen in the character of the buildings. At present the walls serve as protection from winds. I found them a nuisance, for they often necessitated my stopping my driver and going inside, when, had the walls been low, I could have satisfied myself by looking over.

Cultivation and Fertilization.—The care taken of Sicilian lemon groves varies as greatly as does the attention given to fruit trees in all countries I have visited. As a rule, however, they are generally well cared for, and an immense amount of labor is expended on them. I was informed that notwithstanding the low wages of from 1s. to 2s. a day for men, the average cost of working a lemon grove is not less than 650 lire per hectare. This is equal to about £10 an acre, and I was informed that near Catania the expense was sometimes three times that.

The soil is dug or hoed from three to five times a year. The Sicilian hoe is like a small shovel on a bent handle. In January or February the soil is dug fairly deep, and the trees are manured. In April the soil is stirred again, and the "conche," or embanked basins, are formed. In June it is dug again for weeding. Lemon trees are manured every year in some groves, every other year in others, and every third year in perhaps the majority. The decomposed droppings of different animals, decayed litter and leaves, bones, ashes, etc., are used as they are available, and in some cases artificial manures are applied.

A year after the tree is planted the soil is cleared away around the base, commencing at a distance of perhaps two feet and to a depth of a foot or fifteen inches, and into the trench are emptied two baskets of compost, weighing perhaps forty or fifty pounds. The trench is then filled up, and the earth placed to form a mound around the tree. A similar method is followed in applying manure to old trees, but the trench is made at a greater distance from the base, according to the size of the tree. For old trees, from eighty to ninety pounds of compost are applied to each tree. Manure is best applied in winter or in early spring. Autumn manuring is considered to affect unfavorably the quality of the lemons.

In driving through the country, and in more closely inspecting many groves of varying areas in different localities, no fact more strongly impressed me than the very striking difference in the healthiness, cleanliness, and freedom from disease of orchards and trees, often on adjoining properties. When a grower, from want of capital, laziness, or bad management, does not irrigate, manure, and cultivate his grove, the trees tell even the passer-by of the neglect. The generality of the lemon groves are well cared for, the trees are healthy and the fruit clean. In some localities I found the lemon round scale fairly frequent, but no systematic treatment with insecticides is practiced.

CROPS.

I have already referred to the succession of crops, and to the fact that as the lemon is cultivated over a considerable range of climate, the lemon harvest continues for many months. It was pointed out that the April blossoms produced a crop of lemons in October, those of May in November and

December in any given locality. The October fruit is known as "primo-fiore," or choice fruit; and that ripening in November and December is nearly as good. The fruit of these three months constitutes the most abundant crops as well as the best fruit. The June blossoms produce fruit which ripens in January and February, and is of second quality. The July blossoms usually fall off, and little notice is taken of them. Blossoms in August give fruit in March, which is of poor quality; while September blooms give fair quality lemons, which are gathered in April and May, and are very valuable on account of the season. Trees which blossom in October, November, and December produce what are known as bastards, or poor quality lemons, which are gathered in June, July, and August.

The Lemon Harvest.—The grower bases his calculations on the October to December crop, and the first gathering of the lemon harvest is made in October. Many of the lemons at this time are not ripe, and care is taken to pick only those which are fully three inches in diameter. All under that size are left for the November gathering. Practiced gatherers gauge the fruit with the thumb and second finger. This first crop is the most valuable, and is very carefully selected and packed for immediate shipment.

The second gathering takes place in November, and is as good as that of October. If properly gathered, selected, and packed, it will keep for months. The fruit is lighter in color and harder to the touch than the October gathering. The pickers gather all fruit which is ripe, whatever its size, and all fruit which has reached the standard size, whether ripe or not. The first quality fruit not immediately salable is often put away in cases until March, when it is repacked and will keep for some time. All small or damaged fruit is used for making oil of lemon, citric acid, or candied lemon peel, which industries will be described farther on. The November fruit is especially valuable for essences, citric acid, and lemon juice. In a well-cared-for lemon grove I was informed that from three fourths to seven eighths of the fruit was suitable for shipment, the rest being used for essences, etc.

The fruit gathered in December on the plains and lower lands near Palermo is inferior to that gathered in November, only

about five eighths being suitable for export, the balance being used for peel and essences.

The January fruit is of still less value, only three eighths being fit for packing. The fruit gathered at this time is fully ripe and quite yellow. The inferior fruit of this month's gathering is largely cut into halves, packed in brine, and exported for lemon-peel making.

The balance of the crop is gathered in February, and is called "old fruit." It is of inferior quality. Nothing is now left on the tree except the green fruit from the August blossoms. Fully three fourths of the February gathering is used for essence, acid, and peel.

Out-of-Season Crops.—I was much struck with what are called out-of-season, or extraordinary, crops. In one grove I visited, one half was bearing a fine crop of lemons ready for the second gathering. On the other half there was hardly a ripe lemon, but the trees were carrying a good crop of fruit about one fourth grown. I found that it was a fairly common practice to force the trees into bearing such crops. Sometimes peculiar climatic conditions will do it, but usually it is the result of special cultivation and irrigation. If trees are deprived of irrigation during the hot months of July and August, and then abundantly watered in September, a prolific amount of blossom will generally result, producing a valuable May crop. This can not be done every year, for the tree suffers from the deprivation mentioned, and takes a season to recover its normal condition. Still, the May fruit being of fairly good quality and valuable on account of the demand, realizing as much as 30s. and 40s. for one thousand lemons, the temptation to force crops is considerable, the price compensating for the scanty succeeding crop.

GATHERING, PACKING, AND STORING LEMONS.

In the preceding pages I have dealt at considerable length with the general features of the cultivation of the lemon tree in order to produce the splendid fruit for which Sicily is so famous. So important is this industry that the British Consul at Rome says that four fifths of the total lemon and orange trade of Italy is confined to the Island of Sicily. The magnitude of the trade, nearly the half of which was, until a few

years since, with the United States, is due to the inherent quality of the fruit, owing to the peculiarly favorable climate, the care paid to the cultivation of the tree, and the skill and care of the Sicilian in handling the fruit. I have often been asked how the lemons are cured in Sicily in order to keep so long and well. People can hardly realize the truth that, in the sense understood by the questioners, they are hardly cured at all.

A Succession of Crops.—All Sicilian lemons will not keep. Lemon trees bear a series of crops, there being, however, a main crop of the finest and best quality fruit. It is the best of this crop only that will keep well and long.

I have described how the lemon is grown on varied series of soils and at different altitudes, from sea-level to 3,000 feet up the mountainous interior of the island. As the main crop ripens on the sea coast from October to December, and the same crop continues to mature later and later as we ascend the mountains, I may state that the main crop is ripening in different districts from October to February. Then it must be remembered that the good fruit will hang on the trees without serious loss of quality for three months, so that it may be stated that the chief lemon harvest may be extended from October to May. It is, however, not considered good, for either the fruit or the trees, to allow the lemons to hang too long, because the fruit will keep better if properly packed and stored. In this connection it must be remembered that the weather during all these months is cool, and that is, next to care in picking and handling, the most essential condition for success in keeping lemons—or indeed any fruit.

Keeping Qualities Depend on Soil, etc.—I must not omit to mention that the keeping qualities of lemons depend a good deal on the soil and situation in which they are grown. Lemons grown on light, sandy soil deteriorate quickly. They get dry and spongy, and will not stand shipment well. On the other hand, lemons grown on loamy clay, or loam with well-drained clay subsoils, such as predominate in the mountainous lemon districts, keep much better. So great is this influence that lemons grown on these soils sell at one third higher price than those grown on the sandy land. "Mountain," *i. e.*, fruit grown on the loamy soils with clay subsoil, is

firmer and keeps better. Fruit-dealers mark the best fruit "M," meaning "Mountain." Here is a sample quotation, which indicates the difference in price of the different grades: "Mountain," 25 to 50 lire per 1,000; "Hilly," 21 to 27 lire per 1,000; "Plains," 17 lire per 1,000. I may, in this connection, here repeat that the ideal situation for a lemon grove is on "deep loamy clay land, well drained, open, and exposed to the rays of the sun all the year, trees planted in rows running north and south, sheltered from strong winds and frosts, water always available."

How Lemons are Handled.—I was fortunate in being in Sicily during the gathering of the main crop, and therefore saw the lemons at their best. I knew care was taken in handling the fruit, but I was hardly prepared to find how much. In connection with many cultural operations the use of such implements as the Planet cultivators, in the hands of intelligent Australian workmen, and drawn by our horses, will more than compensate for the cheap labor of the Mediterranean; but when it comes to handling fruit, the cost of labor is simply prohibitive of the same care and attention. The wages paid are, for men, 1s. 3d. to 1s. 10d. a day; for women, 3d. to 6d. The Sicilian handles lemons as gently as eggs, from custom, and he does it quickly. But let me describe what I saw of the picking and handling of lemons for export. I could not follow the one parcel of fruit; but as I saw each operation repeated, I think my description is in every general particular correct.

Picking.—The picking is done by men, women, and girls. The pickers have small wicker baskets, holding from one and a half to two gallons, and lined with soft canvas like bran bagging, in the form of a bag hardly resting on the bottom. They pick the lemons with the fingers, breaking off from one to three inches of the twig with the lemon. In going over the trees they take—(1st) All lemons, no matter how green, which are three inches in diameter, and three and one half ounces in weight or over. The pickers learn to judge the size and weight with wonderful accuracy, using the thumb and finger as a gauge. (2d) All lemons which are turning yellow, whether they reach the standard or not.

Snipping and First Grading.—The pickers take their baskets to the roadways, where the foreman sits with several women and a number of baskets of about a bushel capacity lined with canvas. The lemons are taken one by one from the pickers' baskets, and the stem is snipped off close with the same pattern of snips used by lemon-gatherers in California and Mildura. If apparently perfect, and of large size, it goes into No. 1 basket; if perfect but smaller, into No. 2; and so on, about four grades being made. The defective or lower quality fruit goes off at once, and is used for extracting oil of lemon, or making citric acid or lemon peel.

Drying.—The good fruit of first or second grade is at once taken to the fruit house, where it is spread out on the floor (if the floor be stone, mats are spread over it). The depth and length of time they remain depend on circumstances. The object is to allow the moisture to evaporate from the skin, but care must be taken that the lemons in the bottom layer do not heat. They may be piled from one to three feet, and remain from twenty-four hours up to six days.

Sorting and Wrapping for Market.—When dry, the lemons are carefully sorted over, all defective fruit being put aside. The sound lemons are wrapped in tissue paper, carefully packed in boxes, and taken to the warehouse of the merchants, who may either store the fruit or ship it.

Storing Lemons.—If fruit is to be stored it is kept in cool stores, and carefully gone over every three weeks. Each lemon is unwrapped, examined, and if sound rewrapped and put back, but if it shows any signs of not keeping it is taken away. I believe lemons are also stored in dark underground grottos or cellars without being wrapped and cased, but I did not see one. When this method is adopted, I understand the fruit is gone over every week or two, so that, put into a sentence, the art of preserving lemons in Sicily is to handle them frequently with care, and remove all showing signs of decay.

Packing for Export.—I had much difficulty in gratifying my determination to see the operation of packing for shipment. This was in marked contrast to the freedom I was allowed in visiting the orchards and watching all operations there, including the drying and packing for market. I felt that the

excuses made were not genuine, and at Palermo waited a full week over my time for departure in order to break down the opposition which had hitherto baffled me. At length I obtained free entry to several packing-houses and was able to take several photographs of the well-built, well-lighted, beautifully clean, conveniently arranged packing-rooms of Señor B. Mercadante. I should say that I was greatly indebted to this courteous gentleman for many kindnesses and much information. At the time of my visit (beginning of January), the best lemons were coming from the interior, although I saw splendid fruit being gathered in the hills about ten miles from Palermo. The price quoted then was 7s. a case of 300, C. I. F. to New York. The price paid in Palermo for mountain lemons, he said, varied from 7s. to 16s. per 1,080. Mr. A. P. Brown, the representative of the Bronte estates, and manager of the Palermo ice works, Mr. Seymour, the American Consul, and Mr. Weiner, the genial proprietor of the Hotel de France, also assisted me greatly. A drive and picnic with the latter to his wine cellars and chateau at Pareo, in the mountains, is one of the most pleasant of my recollections.

I am, of course, all through describing the preparation of the best lemons which have made the name of Sicily famous. When lemons are to be exported they are taken either direct from the lemon groves, or from the stores, as described, to the packing-houses. Here the boxes are opened, the lemons unwrapped and carefully examined. The sorters are experts. A lemon with a blemish which could not be distinguished except as the result of continued practice, is at once detected and put aside. The fruit is regraded, because from the time of gathering it has shrunk considerably.

The work is thus divided: (1st) Girls unpack and unwrap the lemons, putting them into lined baskets; (2d) The experienced graders (men) sort them, putting them into other baskets; (3d) Another set of girls wrap them in fresh tissue paper; (4th) Boys carry the baskets to the packers; (5th) Expert packers pack them into the various sized boxes required by the different markets. This packing is one of the smartest and cleverest things I have seen in connection with any branch of the fruit industry. The fruit is handled with particular care, but is packed very closely. As the box becomes full it is noticed that the fruit in the middle is higher than at the sides,

and when the last layer of lemons is put on, the outside fruit stands about half an inch above the sides of the box, but the middle is fully three inches above. The boxes are made of very thin beech wood, and in order to make them hold together wooden hoops are nailed over. It requires much skill to fasten down the lids, for it involves the bending of the cover, and the elasticity of the wood is sufficient to occasionally draw out the nails. When nailed down this elasticity prevents any movement of the fruit, and allows for shrinkage, which is, however, not great after the lemons have been

Assorting and packing lemons in Sicily, showing lined baskets used for the purpose.

stored. Lemons cut in November and packed three hundred in a box will by February have shrunk so that three hundred and sixty will pack into the same box. It is this November crop (ripening in November near the coast, and on to February on the mountains) which keeps the best, so that shipments of it are frequently made to New York up to May. It is this crop, but not usually the first grade of it, which is sent to Australia.

The subject dealt with in this chapter is of considerable importance, and I regret that my inquiries have not enabled me to give readers a simple, cheap recipe for storing lemons

from September to January in South Australia. It can be done easily enough with the aid of cool chambers; and provided lemons of the desired quality are plentiful and cheap, it should pay to do so. If my conclusions that our lemon country will yet be found in the hills, or southeast, be correct, it may be that grottos may be tunneled into the hills, where the fruit can be kept at a temperature not exceeding 60° Fahr. until midsummer. In the cool chambers they should be kept at 40° to 45° Fahr.

MANUFACTURED PRODUCTS OF THE LEMON.

Lemon Juice.—There are two qualities, "agro crudo," which is the natural juice of the lemon, and "agro cotto," which is the juice in concentrated form, and keeps much better than the other. The juice after being pressed from the poorer quality lemons is left to settle for a time. It is then boiled in large tinned copper pans one third full. While boiling it is frequently stirred with an iron rod having the knob end wrapped in canvas to prevent it damaging the bottom of the copper, and to keep the sediment from sticking. As the quantity decreases the coppers are replenished from supplementary coppers, kept hot for the purpose, so that the process of evaporation shall not be checked. When the required density is attained it is poured into vats to cool, and is finally drawn off into casks for export. The original volume is reduced by this process to about one eighth, and the concentrated liquid should contain about thirty per cent of citric acid.

Citrate of Lime.—Until recently the manufacture of citric acid was almost neglected in Sicily; but of late years the industry has been developed to a greater extent. Still most of the lemon juice is either sent away in the concentrated form above described, or is changed into citrate of lime, this substance being readily made and is easily carried. The value of the citrate depends largely on the purity of the chalk employed. "The concentrated juice is first clarified with whites of eggs, and warmed. It is then drawn off and filtered into tinned boilers, in which it is heated nearly to boiling point and thoroughly saturated with finely powdered chalk, which is added gradually to the liquid while it is being continuously stirred until the effervescence caused by the admixture of the

carbonate of lime has ceased, when the deposit of citrate will be approximately complete; the remaining residue of acid citrate is reduced with lime milk. The liquid is now drawn off, and the solid, insoluble citrate is compressed and dried."

Oil of Lemon.—Every one is familiar with "essence of lemon," but comparatively few know that the "essence" is really spirits of wine, in which is dissolved a greater or less proportion of oil of lemon, obtained from the rind of lemons. If a fresh lemon be examined, it will be found that the skin contains vast numbers of oil cells, and when the rind is cut off and bent the oil is seen to fly off in minute drops. The separation and collection of this oil is one of the important industries of Sicily.

Practically the work is done entirely by hand, and is carried on at night-time, because, I believe, the oil is so delicate that a very brief exposure to sunlight causes it to oxidize, and so lose its delicate aroma.

Fruit intended for the manufacture of oil of lemon need not be of the first quality; but it is necessary that it be outwardly and inwardly sound, healthy, and fresh, so that punctured fruit, windfalls, and defective fruit are used for manufacturing lemon juice, and not for oil of lemon. The lemons are so sliced that the rind is to a large extent freed from the pulp, and is in fairly large but not unwieldy pieces. I do not know whether my experience is in any way unusual, but I found very great difficulty in obtaining admission to an oil of lemon factory. Time after time I tried and failed; but at last I was able to make a bargain with a Sicilian merchant, who desired to open up trade, to give him the information and introduction he desired on condition that he obtained permission to visit, and acted as my guide to, one or two oil of lemon factories. It may be that I did not see the best, for they were not the cleanest places I have seen; and, indeed, were in marked contrast to some of the lemon-packing stores. The very strong smell of ammonia indicated a sanitary condition not desirable.

I found that the sliced rind was first soaked for perhaps twenty minutes in cold water, it being considered that this renders the expression of the oil more easy. The workmen sit in rows, each with a small glazed earthenware dish on his knees and a larger vessel of lemon rind at his side. In his

left hand he holds a small sponge, and with his right hand he picks up the piece of rind and, with a deft circular movement, rotates it against the sponge, at the same time bending it backward to break the oil glands, and so force the oil onto the sponge. The operation is very quickly done, but when performed by a skilled hand completely exhausts the supply of oil of lemon. When the sponge is saturated it is squeezed into the bowl. There is at first a large proportion of lemon juice, etc., with the oil; but this sinks to the bottom and the oil is poured off, filtered, and as quickly as possible put into copper "carboys" for exportation. The method of payment is, as a rule, peculiar, each workman being paid in proportion to the weight of oil he extracts from each thirty-five kilos of rinds.

Salted Lemons.—Walking along the wharf the day after my arrival in Palermo, I saw some hundreds of large casks, which, I was informed, were filled with salted lemons. Further inquiries showed that large quantities of lemons are exported in this form to Leghorn, Genoa, Britain, and other parts of Europe, to America, and even to Australia, chiefly for making candied lemon peel. Although the finest fruit is never thus dealt with, lemons to be salted must of necessity be sound. The fruit is usually halved, and then soaked in salt water for from three to seven days prior to shipment. On arrival at its destination it is soaked in fresh water repeatedly until all the brine is removed. The salt preserves the peel satisfactorily, but removes the essential oil, so that the fine flavor of the fresh lemon is quite lost. For this reason only fruit which can not be used on the island or profitably shipped fresh is dealt with in this way. The fruit is halved merely to insure a thorough preservation of the rind by an equal saturation of the inner and outer surfaces.

Candied Lemon Peel.—As far as I could learn, no candied lemon peel is prepared in Sicily. In "The Sayings of Agur" it is written—

> "There be three things which are too wonderful for me;
> Yea, four, which I know not:
> The way of an eagle in the air;
> The way of a serpent upon a rock;
> The way of a ship in the midst of the sea;
> And the way of a man with a maid."—PROVERBS.

To these I would add the way of trade on the sea, for there appears to be no known law by which one can understand why certain industries establish themselves in given localities. Why, for example, should the candied citron and lemon peel industry become centered in Leghorn? The lemons and citrons are all imported from Corsica, Sicily, Calabria, and even from Tunis, Tripoli, and Morocco. The fuel comes from England, the sugar is imported from Egypt, the wood for the boxes from Trieste, and the earthenware vessels from Florence. The peel is sent away to Britain, Germany, America, etc. I can not learn of any special advantage which Leghorn possesses; but there this particular branch of the candied fruit industry is centered, and so it is necessary to leave Sicily for a time with the salted lemons and note the treatment they receive in Leghorn.

The first process is the separation of the fruit from the rind. Women sit around a big vessel, skillfully gouge out the pulp with the thumb and forefinger, and throw the rind into a vessel ready to receive it. The rind is then soaked for several days in cold, fresh water to remove the salt. It is then boiled in copper vessels for one or two hours for the double purpose of removing any remaining salt and softening the rind. It should now be soft enough to absorb the sugar readily.

The absorption of sugar takes fully eight days, for the essential principle is that the process must be very gradual and slow. To this end it is first treated with a weak solution, but as the process goes on the solution may be gradually strengthened, for the power of absorption grows. Fresh rind absorbs with great difficulty; and if at once plunged into strong syrup the process is slow and irregular, whereas if repeated at once with a strong solution it becomes permeated with that, and further absorption is more easy. I have repeated this because it is the essential principle in making candied peel or candied fruits.

The candying-room is fitted with rows of immense earthenware vessels, after the fashion of the ancient wine jars of the Romans. These are perhaps four feet high and thirty inches in diameter, with short necks and wide mouths. For description, the jars may be grouped into sets of eight, and as what goes on in one set goes on in all other sets, it will save confusion to consider the room as having only eight jars. As each jar will

hold many hundred pounds of syrup and peel, the workmen find it easier to manipulate the syrup than the peel. Each jar is furnished with a simple perforated wooden well, in which a simple suction pump is inserted, so that the syrup can be pumped from one jar into the adjoining one.

Supposing jar No. 1 is the one which has just been filled with peel brought direct from the copper boiler before mentioned, then No. 8 will contain peel in the last stage of candying. A syrup of thirty degrees strength by the particular densometer used is prepared and poured into jar No. 8. Here it remains for a day, and then having been weakened by the amount absorbed by the peel, it is pumped into No. 7, and next day from there into No. 6, and so on, so that when it comes to No. 1 it is weak, as is required by new peel. At each operation the density is tested, and should it get too weak it is strengthened. In this way the process is to a large extent self-regulating.

A slight fermentation often takes place in the jars, and this is considered beneficial if it is not allowed to go too far.

After the eighth day the fruit is removed from the jar, and boiled in a syrup of a density of forty degrees in large copper vessels over slow coke fires, the peel being gently stirred with a wooden paddle to prevent its adhering to the vessel.

When taken from the fire it is spread on coarse wire netting over wooden troughs, into which the surplus syrup drains while the peel dries.

The final operation is the candying, or covering the surface with candied sugar. For this purpose sugar is dissolved in a little water in a copper boiler, and the dry peel is immersed and boiled for a short time over a slow fire. It is poured from the coppers onto the wire, and again dried, the sugar this time forming candy or crystals over the surface, and it is ready for the packing-room.

Citric Acid.—This is manufactured from the citrate of lime. The citrate is mingled with a liquid composed of six parts of water and one part of pure sulphuric acid. The latter decomposes the citrate of lime, unites with the lime to form sulphate of lime, or gypsum, and liberates the citric acid in solution in the water, from which it is separated by evaporation in pans. The crystals are afterward redissolved, and purified with animal carbon and hydrochloric acid.

THE CITRON.

Citrus medica cedra, Linn.

The citron grows and fruits well in California wherever the lemon thrives. The tree is easy of culture, and the preparation of the rind simple, therefore there is hardly any reason why the California-grown citron, were it accorded the same protection that the orange and lemon now have, should not supplant the imported.

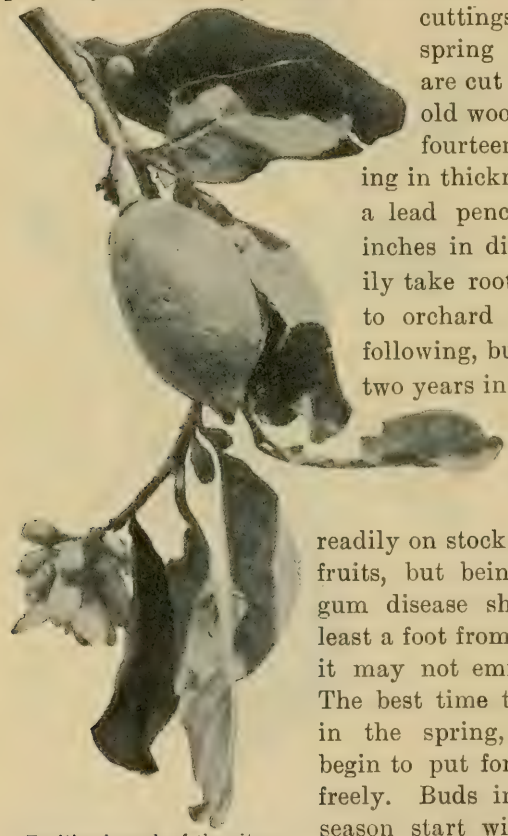
THE CITRON—PRIMAL TYPE. (*Citrus cedra vulgaris.*)

The fruit of the citron is generally oblong, or of conical shape and swollen, more or less striped or furrowed, and particularly large. The skin is of the color of the lemon, and is very aromatic. Some varieties are very smooth, while others are covered with warty excrescences and very thick and highly scented. The pulp is less acid than that of the lemon, and quite bitter. The flowers with their delicious perfume are purplish outside and white within; leaves subserrate; young branches violet tinged. The tree blooms at all seasons of the year, and is very susceptible to frost, as much so as the lime.

Most varieties of the citron have "two rinds," *i. e.*, the outer one, thin, with miliary glands full of very fragrant oil; the inner, thick and white, very sweet and agreeable. It is for this inner rind that the citron is valued, and it is used extensively in cookery, both in its candied and preserved forms.

PROPAGATION.

The propagation of the citron is quite simple, and is multiplied by cuttings, by budding, or grown from the seed. The cuttings are planted in the spring of the year. They are cut from one or two year old wood and from eight to fourteen inches long, varying in thickness from the size of a lead pencil to one or more inches in diameter. They readily take root and can be moved to orchard form in the spring following, but are generally left two years in the nursery in order to obtain a better and stronger root-system.



Fruiting branch of the citron—reduced.

The citron takes readily on stock of any of the citrus fruits, but being susceptible to the gum disease should be budded at least a foot from the ground, so that it may not emit roots of its own. The best time to bud the citron is in the spring, just as the stocks begin to put forth and the sap flows freely. Buds inserted early in the season start with vigor, and by fall have a large and thrifty top.

The citron root is quite delicate and brittle, more so than that of the lemon. While the cutting system is one of the quickest ways to grow the citron, budding on hardier stocks, such as the sweet orange, is most preferable.

THE CITRON OF COMMERCE—LEMON, OR SORRENTO—Reduced One Third.

From Seed.—The seeds of the citron germinate quite easily, but much care is required to be successful in raising seedlings. After the seed is washed out of the fruit it is kept moist and never allowed to get dry, for in drying the kernel loses its power of germination. The seed is planted in the spring after all danger of frost has passed, either in prepared seed-beds or in boxes. It is sown broadcast and covered with an inch of leaf mould mixed with sand. Great care must be taken from this time on that the soil be kept moist and yet not too wet, as the seeds rot easily. The seeds germinate in about a month, or longer if the weather be cold. The following spring the plants are planted in nursery row.

VARIETIES.

Numerous varieties have been introduced, many of which are yet in the experimental state.

Lemon, or Sorrento (Plate XXII).—This variety was among the first introduced, and has fruited regularly ever since. Shape oblong, like the lemon, with a very pleasant aroma, which is much esteemed. Skin bright yellow, smooth and very glossy; inner skin white, coarse and thick, with very little trace of bitterness. Pulp very bitter and deficient in juice. The fruit grows irregularly, some very large and others very small, the largest weighing from three to five (or more) pounds each.

Lyman.—A Florida variety, said to be very good.

Orange.—A round citron.

Other varieties grown here:

Pomo de Adamo	Testa de Turco	Dulcis	Sulcata
Macrocarpo	Limonzania	Florentina	Costata
Incompio	Cornuta	Elongata	Glabra
Pireltone	Salodiana	Rugosa	Simoniformis
Cedro Vara	Plena	Romana	Parra

PREPARATION OF CITRON RIND.

The fruit before assuming a yellow color, and also when bright yellow, is picked and placed in barrels filled with brine, and left for at least a month. The brine is renewed several times, and the fruit allowed to remain in it until required for use, often for a period of four or five months. When the citrons are

to be candied they are taken from the barrels and boiled in fresh water to soften them. They are then cut into halves, the seed and pulp are removed, and the fruit is again immersed in cold water, soon becoming of a greenish color. After this it is placed in large earthen jars, covered with hot syrup, and allowed to stand about three weeks. During this time the strength of the syrup is gradually increased. The fruit is then put into boilers with crystallized sugar dissolved in a small quantity of water, and cooked; then allowed to cool, and boiled again until it will take up no more sugar. It is then dried and packed in wooden boxes.

Cross-section of citron, showing pulp and thickness of rind—reduced one half.

COMMERCIAL IMPORTANCE.

So far the citron consumed in the United States is imported from Europe. Most of it is shipped to Eastern houses and by them prepared for market. In this way importers avoid the payment of a duty on same. The citron commonly used by confectioners, bakers, and candy-makers is imported already prepared.

For several years there have been regular importations of citron in brine coming in large hogsheads, almost entirely from Leghorn. It has come to two houses in New York and to four houses in Chicago, all of whom put it through the process of candying or sugaring. It costs about four cents a pound landed in New York in the brine. I am informed that the yearly demand for the United States equals about 12,000 cases of some 250 pounds each after it has been candied.

In answer to an inquiry regarding importations and prospective competition from California-prepared citron, the following interesting data were obtained:

CHICAGO, August 23, 1899.

MR. B. M. LELONG, *Sacramento, Cal.:*

DEAR SIR: Yours of 1st received and contents fully noted. The citron that we import to this country is mostly grown on the isle of Corsica, some being shipped from Messina, Italy, and some from Greece, but that shipped from those countries is not considered as good as that which is shipped from Corsica. The price generally rules from 12 shillings and 6 pence up to 18 shillings and 6 pence, cost and freight, N. Y. We do not know of any citron grown in this country. It would be a saving to the trade west of the Rocky Mountains, but it would not be if shipped east of the Rocky Mountains, as the freight would be more than the freight from the isle of Corsica.

Yours truly,

SPRAGUE, WARNER & CO.

CHICAGO, August 16, 1899.

Horticultural Department, State Board of Horticulture, Sacramento, Cal.:

GENTLEMEN: Your letter regarding citron has been handed the writer, who is manager of our citron department.

The amount of citron imported annually into America is about two thousand tons. The firms who are curing or manufacturing citron from raw citrons that are imported in brine are: Hills Bros. Company, New York City; Andrew L. Causse, New York City. The Chicago manufacturers are Sprague, Warner & Co., Franklin MacVeagh & Co., J. B. Inderrieden & Co., and ourselves.

The best quality of citron is raised in Corsica, the next best quality in Greece, and the poorest in Sicily. We understand the culture of citron is very difficult and that the trees require the most constant care and attention, and even then failures of crop are frequent. As to whether it can be produced successfully in California is of course a question that we can not answer. This is about all the information that we can think of that would be of service to you.

Yours very truly,

REID, MURDOCH & CO.

NEW YORK, August 12, 1899.

B. M. LELONG, *Secretary State Board of Horticulture, Sacramento, Cal.:*

DEAR SIR: In due course of mail we received your esteemed favor of 28th ult., relative to citron, and in reply can tell you that for several years there have been regular importations of citron in brine coming in large hogsheads, almost entirely from Leghorn. It came to two houses in this city and to three or four houses in Chicago, all of whom put it through a process and candied (glacé) and sugared it. We understand it costs about four cents a pound landed here in the brine, and there is no duty on it. The demand for this whole country yearly, we are told, equals about 12,000 cases of some 250 pounds each after it has been candied. We are unable to ascertain whether it is a profitable business or not, although one would judge that it would not have been continued during late years if it had been found unprofitable. One of our informants, a man pretty well posted, says he does not believe one penny profit is made, but none of these people care to give it up, hoping for better times, etc.

Trusting that this is the information you desire to have, and always at your service, we remain,

Very truly yours,

SGOBEL & DAY.

CHICAGO, October 14, 1899.

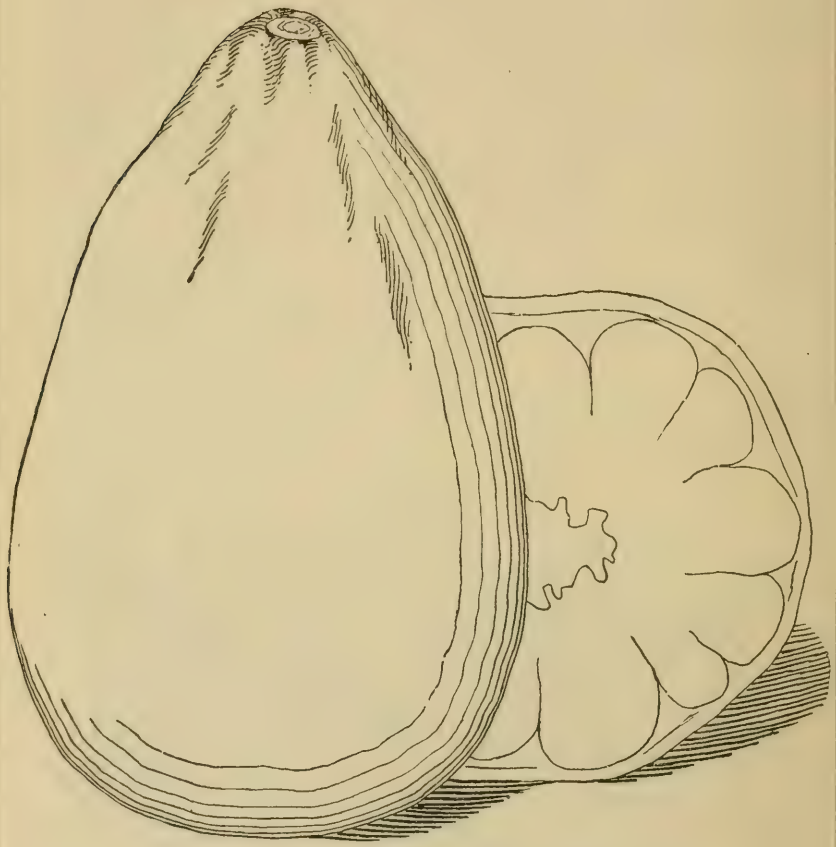
MR. B. M. LELONG, *Secretary State Board of Horticulture, Sacramento, Cal.:*

DEAR SIR: We should have replied to yours of July 28th before this. However, we wanted to give you positive information as to whether there were any established houses in the East who were preparing the citron of commerce for market. We are now in a position to inform you that this article, which is shipped from Europe in brine, is very small and shipped only as an experiment, which, as far as we can learn, has been a failure. The citron commonly used by confectioners, bakers, and candy-makers is imported already prepared. This, however, should not prevent California growers from raising citron in that State in larger quantities than they do now, and preparing it for market right in their own State. Like a great many industries, California would soon head the list as a citron-producing State and would no doubt at no distant date supply the demand of at least the United States.

Yours truly,

JOHN ZUCCA & CO.

French method of protecting the limbs of the Citron and its fruit.



CASTLEMAN LIME—A MONSTER. A hybrid—Lime × Pomelo.

THE LIME.

Citrus limetta, Risso.

The lime is naturally a straggling bush or tree, and is frequently trimmed into hedge form; it grows from ten to fifteen feet high. The fruit is small, round or ovate, or depressed, with a bitter rind. The juice is much "sharper" than that of the lemon.

The lime is more susceptible to injury from frost than the lemon, and should not be planted except in locations absolutely free from danger of frost, and on this account it is not grown successfully except in the warm belts and sheltered localities.

Since the Government placed a duty of one cent per pound on foreign citrus fruits, very few limes are imported. This should stimulate the planting of the lime in our suitable localities.

The lime is very easily propagated from seed. The seeds always germinate without much difficulty, and the plants come true from the seed; the seeds "sport" only in exceptional cases. It is also budded on the orange.

The tree does not resent pruning as the lemon does, and may be fashioned into any shape to please the fancy of the grower. It is well, however, to consider the natural habit of the tree and to leave it as much in bush form as possible. The lower limbs that rest on the ground and all superfluous and interfering wood should be removed.

The methods of planting and cultivating the lime are similar to those required for the lemon. Like the latter, the fruit should be picked before it ripens, but does not require processing before being shipped to market. Lime trees are planted fifteen or sixteen feet apart, and begin to bear at the fourth year, being in full bearing at eight.

VARIETIES.

IMPERIAL.—Fruit large, about the size of the Genoa lemon, with strong acid, few seeds. Tree tender, wood brittle, but very productive and a good, thrifty grower; fruits all the year round; not as thorny as the Mexican, and not as susceptible to frost.

Imperial Lime—natural size.

MEXICAN.—Fruit small, very popular, identical with the imported limes in our markets. Tree dwarf, and suitable for hedges, but very susceptible to cold.

TAHITI.—Fruit large, coarse, and of inferior quality.

PEAR-SHAPED.—Fruit large, pyriform, of a pale yellow color, with smooth, thin skin, and a strong aroma, partaking of the shaddock. Pulp juicy, with strong acid; seeds few and small. Tree very large and hardy—ornamental sort, undoubtedly a "sport." Grown by I. A. Castleman, of Riverside.

Cross-section of Imperial Lime—natural size.

BEARSS.—A superb variety, seedless or almost so. Fruit large, about the size of the Imperial, nearly round, with a thin, tough skin. Flesh tender and very juicy, acid somewhat mild. Grown by J. T. Bearss, of Porterville.

Miscellaneous Varieties.—The following varieties have been introduced in recent years, principally from Florida:

JEWISH.—A small conical lime.

GENOESE.—Large, like a lemon in shape.

FLORENTINE.—Hybrid.

MONSTER.—Fruit extra large, resembles a lemon.

SALO.—A small, round lime.

PERSIAN.—A large, coarse lime; inferior.

CITRONELLA.—A large, coarse lime, with thick rind.

ASSAM.—Said to be a strong grower.

FLORIDA SEEDLING.—A large lime, the size of a lemon, quite coarse.

OTHER VARIETIES.—Valentine, Knatta, Kaghazir, Sour Kurna, Sour Turan, Sour Rangpur, Sour Jamberi, Sour Galgal, Sadaphal, Verucene.

Cross-section of Bearss Lime—natural size.

BLOSSOM OF DOUBLE-FLOWERED BERGAMOT ORANGE,
From which Neroli is manufactured.

PRODUCTS OF THE CITRUS.

Although there are innumerable varieties of the citrus, which, owing to their inferiority, are worthless for cultivation, yet all, or nearly all, have merit in one way or another. In Europe every part of the tree is utilized for various purposes. The flower, the leaf, the pulp, the rind, the wood—all enter into articles of commerce. R. C. Haldane, in his work, "Subtropical Cultivations and Climate," London, 1886, gives the following formulas, which I quote, with due thanks to the author:

"**Orange-Flower Perfume.**—In the early morning the blossoms are collected as soon as the petals begin to fall, by shaking the tree over a sheet spread on the ground. A tree yields from two to ten pounds of flowers. The perfume is generally extracted by enfleurage, as follows: A frame is required six feet high, thirty inches wide, and twenty inches deep; in this grooves are cut to allow trays one and a half inches deep to run. These trays are covered with wire gauze. Between every two trays there is a sheet of stout glass, framed; on this, grease or vaseline is thickly spread. The whole should be as air-tight as possible. Every morning fresh flowers must be put in the wire-gauze traps; and this is continued for a month or two, when the grease is removed.

"The grease is made as follows: Melt equal parts of beef-suet and lard, or mutton-suet, beef-suet, and lard, well together. Pound well in a mortar and wash until perfectly clean. Melt over a slow fire, adding three ounces of powdered alum and a little salt to each hundredweight. Heat the grease until it begins to bubble, and then strain into a deep pan and let it clarify for two or three hours. The clear grease is then put on a charcoal fire, and three quarts of rose water and half a pound of powdered gum-benzoin added; it is gently boiled, and all scum taken off till it ceases to appear. Put the grease in deep pans to cool; when solid remove any water there may be in it, liquefy, and pour into vessels for future use. Besides grease,

glycerine, vaseline, and paraffine are all used. Formerly, instead of using grease in enfleurage, oiled linen was employed to absorb the odor and afterward squeezed in a screw press.

"A superior system is by employing Piver's pneumatic frame, which has on the top two bellows which send a constant current of air through the flowers. The most primitive is the Spanish, which consists of two bowls—the upper one, or cover, being lined with grease, while the lower holds the flowers.

"To extract the perfume from the grease, or 'pomade,' as it is called after being scented, chop up eight pounds of pomade, put it in one gallon of sixty over-proof alcohol, and let it remain for one month at summer heat.

"**Essence or Extract of Orange-Flower** is prepared by tincturation. Four ounces of orange-flowers are steeped in one gallon of alcohol until all the perfume has been absorbed by the spirit. This preparation is also known as extract of neroli.

"**Essential Oils of Orange** are expressed thus: The peel is cut from the pulp in three longitudinal slices, leaving the pulp in a triangular shape. The peel and pulp are kept separate. Next day the outer surface of the peel is bent convexly, and pressed four or five times against a flat sponge held in the left hand of the workman. From time to time the oil is squeezed from the sponge into a vessel, from which it is drawn after the watery fluid separates from the oil. Four hundred oranges yield from nine to fourteen ounces of oil. The pulp is distilled for the small amount of essential oil it contains. When lemons are thus treated, the pulp is pressed until the lemon juice is all extracted, and then distilled.

"**Petit-Grain Oil.** – Prepared from young tender shoots and leaves of both Sweet and Seville oranges, the latter being most valuable. The oil is obtained by distillation with water.

"**Neroli, or Oil of Orange-Flower.**—Obtained by distilling the flowers of the sweet and bitter orange with water. The bitter orange gives a superior oil. It is very fluid, is lighter than water, in which it is slightly soluble. One hundred pounds of flowers give from three to six ounces of neroli. It is generally adulterated with alcohol or essence of petit-grain. Essential oils of orange, lemon, or bergamot are better extracted

by aid of an implement known as the *ecuelle à piques*, a saucer-shaped vessel of pewter about eight inches wide, with a lip on one side. The bottom is armed with numerous brass pins about half an inch high, which stand upward. The center has a tube five or six inches long, and half an inch in diameter, closed at the farthest end. The whole resembles a shallow funnel. The peel is rubbed against the pins by hand, and when the tube is full of oil it is emptied into another vessel.

"**The Peel of the Bitter Orange** is used in medicine as an aromatic tonic, but more frequently for counteracting the nauseous taste of other medicines. The most common forms are syrup of orange, tincture of orange, and confection of orange.

"**Oil of Lemon.**—It is extracted from green fruit by pressing the rind against a sponge, or by the *ecuelle*. An inferior oil is produced by rasping the peel of the fruit and distilling with water. One hundred fruit should yield from two and one half to three and one half ounces of oil. The lemons are sometimes scarified and thrown into hot water, and the oil skimmed off.

"**Citric Acid.**—Is obtained from lemon juice by saturating it with chalk or whiting until effervescence ceases, by which citrate of lime is formed. This is precipitated, the supernatant liquid run off, and the precipitate well washed. The precipitate is then treated with dilute sulphuric acid; sulphate of lime and citric acid are the results. The former sinks, and the clear solution is evaporated in leaden boilers and then crystallized—the crystals being purified by being again dissolved and re-crystallized."

Uses to Which Lemons May Be Put.—A firm of lemon-packers in Italy gives the following as among the uses to which lemons may be put:

"During the last influenza epidemic in London, the Board of Health of said city advised the public to make free use of lemons to combat said epidemic.

"A warm lemonade, taken in bed, will immediately produce an abundant perspiration, and a positive relief from a cold.

"A few drops of fresh lemon juice added to drinking water will kill any microbes and greatly help digestion.

"Lemons used in a bath will act as a disinfectant, clean the pores of the skin, hence revive their action.

"Lemon juice is also universally known as one of the best remedies for rheumatism; and when diluted with warm water and salt and sniffed up the nostrils and used as a gargle is an excellent cure for catarrhal affections.

"No cuisine is perfect without lemons, and this fruit is a necessary condiment to nearly all viands."

Orange Wine.—Take one part orange juice, well strained, one part water, three pounds sugar per gallon. Any kind of sugar will do, and the darker the sugar the richer will be the color of the wine. For each ten gallons put up keep about one gallon of the same for refilling the casks during fermentation. Lay casks on the side, fill full, and leave bung open. Do not let it be exposed to much cold. Fill up the casks every day, from the quantity kept out, as the scum is thrown off, and watch closely, until the wine passes through the stage of alcoholic fermentation. This will usually require from ten to twenty days, or longer, if the weather is cool, and can easily be determined by scum ceasing to rise, and the cessation of brisk fermentation. When it arrives at this stage, place the bung in loosely. Watch closely for a few days, and as active fermentation ceases, put the bung in fast. Let it stand two months, then rack off carefully into clean casks. If perfectly clear, seal and let it stand six months, when it may be bottled. If not clear, it should be racked off a second time in two months after the first time, and sealed for six months before bottling. Be sure your casks are full, for contact with the air will cause the wine to pass into acetic fermentation. Considerable wine from oranges has been manufactured in Florida, and the demand for it has been very good at $5 per gallon. The wine continues to improve with age.

ESSENCES AND LEMON JUICE.*

"**Essences.**—With three strokes of his sharp knife the cutter peels the lemon lengthwise and lets the peel fall into a tub under the chopping-block. He then cuts the lemon in two and throws it from his knife into a bucket. He works with wonderful rapidity and fills from ten to twelve tubs with peel a day and is paid 5 cents a tub, weighing 77 pounds. His left hand and right index are protected with bands of osnaburgs or

*Report of Wallace S. Jones, of Messina, "Fruit Culture in Foreign Countries," 1890.

leather. Decayed fruit is not peeled, as its oil cells, being atrophied, yield no essence.

"Fresh peel is soaked in water fifteen minutes before the essence is extracted. Peel that has stood a day or two should remain in soak from thirty to forty minutes, that it may swell and offer a greater resistance against the sponge. The operative holds a small sponge in his left hand, against which he presses each piece of peel two or three times—simple pressure followed by rotary pressure. The women employed in this work run a piece of cane through their sponges to enable them to hold them more firmly. The outside of the peel is pressed against the sponge, as the oil glands are in the epicarp. The crushing of the oil cells liberates the essence therein contained. The sponge, when saturated with the essence, is squeezed into an earthenware vessel the operative holds in his lap. He is expected to press the peel so thoroughly as not to overlook a single cell. This is ascertained by holding the pressed peel to the flame of a candle; should it neither crackle nor diminish the brilliancy of the flame the cells are empty. This process yields besides the essence a small quantity of juice and feccia (dregs). The separation of the essence, juice, and feccia soon takes place if the vessels are not disturbed; the oil floats on the juice and the dregs fall to the bottom. These three products derived from the peel have no affinity with one another. As the essence rises to the surface it is skimmed off, bottled, and left to settle for a few days. It is then drawn off with a glass siphon into copper cans, which are hermetically sealed.

"The yield of essence is very variable. This industry is carried on five months in the year. Immature fruit contains the most oil. From November to April, in the province of Messina, one thousand lemons yield about 14 ounces of essence and 17 gallons of juice. An operative expresses three baskets of lemon peel (weighing 190 pounds) a day, and is paid 20 cents a basket. The essence is so valuable that the operatives are closely watched; they are most ingenious in secreting it about their persons. Six men work up eight thousand lemons a day; two cut off the peel while four extract the essence, and obtain 136 gallons of lemon-juice and seven pounds of essence. In the extraction of essence, defective fruit—thorn-pricked fruit, fruit blown down by the wind or attacked by rust—is used. This fruit is sold by the "thousand," equivalent to 260 pounds, and

thus classified: First, mixed lemons, as they come from the groves during December and January, of good quality but not always marketable, often from top branches; second, lemons from March blooms; third, lemons refused at the packing-house; fourth, dropped fruit; fifth, shriveled or deformed fruit. Prices do not depend exclusively upon the classification of the fruit; the locality where it was grown is taken into consideration. Lemons grown on clay soil yield more essence and juice than those grown on sandy or rocky soil. The essence of sour orange, mixed with the essence of lemon, produces an aroma similar to that of the essence of bergamot; the latter is much used by confectioners in flavoring ice-creams, etc.

"**Raw and Concentrated Lemon Juice.**—Lemons are peeled, cut in two, and pressed. If the juice is to be exported raw, only perfectly sound lemons can be used; but if the juice is to be boiled down, one fifth of the lemons may be of an inferior quality and two fifths of them pretty well decayed. The juice from sound lemons is yellowish in color, and gives a pleasant aroma; its density decreases with age. With all classes of lemons the yield of juice and its acidity vary considerably from month to month. The amount of juice increases from October to April, its acidity and density decrease, and the same is the case with the density of the essence, owing to the winter rains.

"An addition of five per cent of alcohol will prevent raw lemon juice from spoiling. Lemon juice is adulterated with salt or tartaric acid. Raw and concentrated lemon juice is exported in casks of 130 gallons capacity. It requires 1,500 lemons to yield 26 gallons of raw juice, while it takes 2,500 to yield the same quantity of concentrated juice, and 200,000, more or less, according to their acidity, to give a cask.

"The value of lemon juice is governed by its acidity. The rule is that concentrated lemon juice shall show 60 degrees of acidity. (The juice extracted from the bergamot or the sour orange must show 48 degrees, or one fifth less than that derived from the lemon; it also sells for one fifth less than lemon juice.) Formerly a citrometer, known as Rouchetti's gauge, was used to ascertain the per cent of acidity; now, however, resort is had to chemical analysis, which is more satisfactory to both seller and buyer. Lemon juice is used in the printing of calicoes."

ORANGE AND LEMON ROT.*

The cause of the rot of oranges and lemons is the growth, through their substances, of a mold fungus known scientifically under the name of *Penicillium digitatum*. The growth of this plant within the fruit causes a softening and breaking down of the tissue, a very characteristic change in the flavor of the juice, and, sooner or later, a very pronounced discoloration of the affected part. The fungus belongs to a genus consisting of a number of well-known species, all having much the same manner of growth and producing decays on various substances. The name "blue mold" applies to the whole group. The best known species is *Penicillium crustaceum*, or, as it is more commonly called, *Penicillium glaucum*. This species is one of the common forms of rot-producing fungi that attack deciduous fruits, but it is probably even better known from its attack upon all manner of substances in the household, such as cooked foods, clothing, etc. While *Penicillium crustaceum* is thus found in a great variety of situations, it appears that *Penicillium digitatum* attacks only citrus fruits, confining itself wholly to these.

The rot of citrus fruit is not usually a disease of the orchard. In lemons the infection occurs almost entirely in the curing-house; and in oranges, as a rule, after they are packed and on their way to the East. Navel oranges, however, very often come into the packing-house badly infected by the disease. The trouble begins at the navel end, and may be scarcely visible from without; though commonly a slight split, or perhaps a little gum, will indicate the point of entrance of the fungus. In this case the trouble clearly arose in the field, and even began before the fruit was ripe. It is usually confined to a limited part of the fruit, perhaps the upper end of one or two sections, and very often produces spores within the cavity caused by the shrinkage of the affected tissue, so that the affected part may be badly discolored. In any citrus fruit a

*By C. W. Woodworth, in University of California Bulletin No. 139.

bad wound of the surface is apt to be followed by the development of the disease in the tissue just beneath, with the general characteristics specified above as occurring in Navels.

In the packing-house or in transit the point of attack may be the navel end, but it is more commonly where two fruits are pressed together. Usually only one of the fruits so touching is affected at first, though after it becomes thoroughly rotted the disease usually communicates to the other. If the conditions are favorable to the growth of the fungus, it may spread from a single affected fruit to all those adjacent, and in time to the whole box.

This disease, being entirely a matter of the fruit and belonging particularly to ripe fruit, evidently always gains its entrance to the fruit from the outside and never from the tree. The conditions necessary to accomplish this are:

First—That the spore of the fungus should rest upon or near the surface of the fruit. It may be carried there by the wind, or by touching decayed fruit upon which the spores are being produced.

Second—Sufficient water upon the surface of the fruit to cause the germination of the fungus.

Third—The right condition of temperature. The fungus will grow in such a range of temperatures, however, that this condition may be considered to be practically always present.

The germination of the spores of the fungus is thus seen to be much the same as the germination of the seed of a higher plant.

The reason that the navel end is particularly liable to the attack of the rot fungus is that in case a drop of moisture finds its way within this structure, it is less liable to rapid evaporation, and so favors the germination of any spores that may also find their way there. The same explanation accounts for the common abundance of this fungus in fruit with broken skin. The point at which moisture will accumulate and remain longest when fruit is sweating after packing, or while it is stored in the packing- or curing-house, is the point where the fruit touches an adjacent fruit; and at this point, therefore, the germination of the fungus most commonly occurs.

If sufficient refrigeration is maintained, the fruit will be entirely safe from the attack of the fungus; but the cold temperature is likely to condense a large amount of water upon

the fruit, and as soon as the temperature is allowed to rise to the point where the fungus can grow, the conditions are extremely favorable for its rapid germination. The presence of water upon the fruit is always essential for the entrance of the fungus; and if fruit taken from refrigeration is immediately thoroughly dried by arranging for sufficient ventilation, there would be no greater susceptibility on account of the cooling.

The use of ventilated cars, or the ventilation of the curing-house, is chiefly calculated to prevent the rot by carrying off the moisture that may accumulate on the fruit in the sweating process, or on account of the rapid lowering of the temperature. The cooling that is accomplished by the evaporation of this moisture is sometimes thought to act like refrigeration, and may, it is true, slightly decrease the rate of growth of the fungus after it germinates, but can not produce a temperature low enough to prevent its germination and growth. Certainly, the important matter in ventilation is the rapid removal of any condensed moisture that may gather on the fruit. If this moisture is removed promptly enough, so as not to give time for the germination of this mold fungus, the fruit will not decay, but will stay sound until it would ultimately dry up and mummify.

Wrapping in tissue paper is an extremely efficient means of decreasing danger from rotting. The reason for this is that the paper absorbs water very freely and will take up a very considerable quantity. The paper will have to become very wet before it will give up enough to the spores of the fungus to permit them to germinate, and so it regulates the matter to a large extent; because when the temperature falls the paper merely becomes moist, and when the temperature rises this moisture is evaporated, and if there is fair ventilation it will be carried off and the fruit never become really wet. If the fruit sweats too much, however, owing to poor ventilation or rapid lowering of temperature, the paper will not be sufficient to prevent the accumulation of the water on the fruit and the germination of any spores that may be there. Only within certain limits, therefore, is the wrapping of fruit a preventive of infection by the fungus.

It is a common practice to throw decayed fruit in a pile in the immediate vicinity of the packing- or curing-house; and here it continues to decay and produce countless millions of

spores, which are freely carried by the wind, and to this is due the thorough infection of the atmosphere referred to above. There is no means better calculated to disseminate the disease than this practice. Fruit should never be allowed to become "blue." By the time it reaches the white-mold stage it should either be destroyed by fire, or, what is probably more feasible, be buried so that it will not be turned up by plowing, or in any other manner.

In practically all parts of the State, the long, dry summer period affords a very available time for the thorough disinfection of the packing-house. The mold spores can be killed by protracted drying, and it should be the practice to so thoroughly air all packing-houses during the hottest and driest part of the summer, that they will be entirely free from the fungus for the beginning of the next year's campaign.

Sulphur should be burned so that the fumes will come in contact with every part of the inside of the packing- or curing-house. Usually these buildings are not tight enough to permit of very thorough work, so that no prescription of the amount to use can be safely made. The material is not expensive, so that the best policy is to use it very liberally whenever the presence of the fungus in quantity is known or suspected to exist in the house.

INSECT PESTS AFFECTING THE CITRUS.

The insect pests that affect the citrus are numerous, but are now easily kept in subjection by artificial means, aided largely by their natural enemies—parasitical and predaceous.

In combating insect pests California has taken the lead over every State and country in the world, and it is to be hoped that through the fostering care accorded by the people the State will not revert to primitive methods of allowing injurious insect pests and tree and plant diseases to be introduced and obtain a foothold in our orchards.

The life of insects is divided into four periods: First, the *ovum* (egg), which is motionless, and apparently lifeless; Second, the *larva* (grub), which is active, voracious, and grows rapidly, but without wings; Third, the *pupa* (chrysalis), which is incapable of locomotion, and is in color and outward form entirely unlike the larva from which it proceeds; Fourth, the *imago* (perfect insect), which is active, has wings, does not increase in size, and which lays eggs for future generations, thus perpetuating its kind. The mode in which the life of an insect is passed and the different species of trees it infests differ very widely in the various stages of its existence.

The fructification of citrus trees in particular is mostly accomplished by different species of insects, which convey the pollen from tree to tree, and also from the stamens to the stigma of the same tree. On the other hand, there are multitudes of baneful ones, which injure tree, fruit, etc., and are only checked in their progress by other insects that prey upon them, or by artificial means.

SCALE INSECTS.

Family COCCIDIDÆ.

"Male and female larvæ similar, apterous, naked or covered, active. Females in all stages apterous, metamorphosis semi-complete, naked or covered, active or stationary; rostrum usually present in all stages, sometimes absent in adult; feet sometimes absent after larval stage; tarsi, where present, monomerous; feet, where present, ending in a single claw, eyes somewhat absent.

"Male pupæ apterous, naked or covered. Adult males with two wings and two halteres; metamorphosis complete; rostrum present in larva and pupa, always absent in adult; tarsi monomerous, feet ending in a single claw; abdomen terminating in a spike, which forms the sheath of the penis; eyes present in adult; ocelli often large, sometimes exceeding three in number."—W. M. Maskell, F.R.M.S., "The Scale Insects," New Zealand, p. 37.

This group of insects is of the utmost importance to horticulturists, as but few trees are exempt from its attacks. While the study of economic entomology is comparatively new in California, its incipiency dating back but a few years, these insects have attracted wide attention, as nearly every branch of the fruit industry has felt their effects more or less. In this State there is a great diversity of industries in the fruit line, and trees and plants have been imported from almost every country. Upon them many injurious species of insects have been brought in.

The pernicious scale, or "San José" so called, which does not affect the citrus, but deciduous trees principally, was the first species of this group which gave this important study its incentive. It made its presence felt in Santa Clara County as early as 1878. Whence it came is not definitely known, but was no doubt brought here on cuttings or trees. As very little was then known of this species, effective measures were not adopted for its suppression, and it spread to adjoining orchards and was afterward taken to other counties on nursery trees. For a time it threatened to be a menace to the deciduous fruit industry, and it appeared as if its progress could not be checked; but effective measures were discovered for its suppression in the way of insecticides, and lately, beneficial insects have accomplished great good in practically exterminating it throughout the State.

In 1868 another species, the cottony cushion scale, was brought into our State on plants from Australia, its natural home. This species played great havoc in many sections, especially to orange and lemon orchards. Every means possible were applied, and for a time it baffled the combined wisdom of scientists and fruit-growers. It was not that the insecticides applied did not kill the pest, but because all insects could not be reached, enough escaping to reinfest the tree. Here again nature came to our relief. The *Vedalia cardinalis*, Mulsant, in one season reduced it to such an extent that it can no longer do injury. Where this scale appears in isolated localities

and where the Vedalia do not appear, colonies of the Vedalia should be procured.

In 1872, the *Aspidiotus aurantii*, Maskell, was introduced, also on trees from Australia. These were planted at Los Angeles, and subsequently some were taken to Orange, from which localities the pest spread. This species was described by Prof. Maskell, and was imported into New Zealand from Sydney, thus settling the question as to its source. Prior to 1880, little or no damage was done by this pest. The greatest injury and spread occurred between 1880 and 1890. While no effective parasite that preys on this species has been found, the discovery of the hydrocyanic acid gas treatment has proved a great boon to the citrus industry, through which means the pest is kept under control.

In 1872 the *Aspidiotus citrinus*, Coquillett, was also introduced, from Japan, into the San Gabriel Valley, on orange trees. At first the insect made slow progress, and was not considered a very serious pest. Between the years 1883 and 1889 it spread very rapidly, in fact alarmingly, throughout the valley. In 1889 a parasite of the genus *Coccophagus* was discovered preying upon the scale, and it is now kept in subjection.

Other species, the *Mytilaspis citricola*, Packard, and *Mytilaspis Gloverii*, Packard, have been introduced on nursery trees, principally from Florida, but as yet they have been confined to those trees in certain localities and have not spread. Numerous other species are continually being discovered on plants and trees imported from many parts of the world, and promptly destroyed by Quarantine Officer Craw at San Francisco

SPECIES IN CALIFORNIA.

Genus ASPIDIOTUS, Bouche.

This genus includes species of *Diaspina*, in which the scale of the female is circular or nearly so, with the exuviæ at or near the center, and the scale of the male somewhat elongated, with the larval skin at one side of the center or near one extremity. The last segment of the female usually presents four groups of spinnerets; in a few species there are five groups, and in some they are wanting.

The following species of this genus infest citrus trees in California:

(1) Red scale—*Aspidiotus aurantii*, Maskell.
(2) Yellow scale—*Aspidiotus citrinus*, Coquillett.
(3) Oleander scale—*Aspidiotus nerii*, Comstock.

(1) Red Scale.

A circular, flat scale, known by the popular name of "red scale," from the color of its shell.

Scale of female is light gray, quite translucent. Female light yellow in adolescent stages; as it reaches maturity becomes brownish. Viviparous.

Ventral view of insect. Red scale on leaf.

Scale of male resembles female, except that it is only one fourth as large. Male light yellow, thoracic band brown; eyes purplish black.

This insect is the worst enemy to citrus culture in California. It attacks the trunk, branches, leaves, and fruit. So far no effective parasites are known to attack it, excepting predaceous insects, which do not increase rapidly enough to check its progress.

Treatment.—Rosin solution (formula No. 1), and gas treatment (formula No. 4).

(2) Yellow Scale.

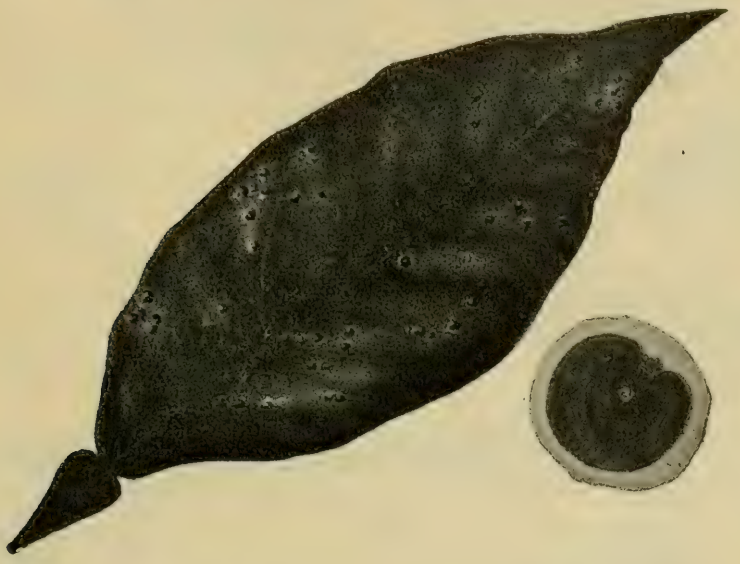
A small yellow scale, infesting citrus trees in the San Gabriel Valley, Los Angeles, Sacramento, Oroville, and Marysville.

This species differs but slightly from *A. aurantii*, excepting in habits and color.

Scale of female circular, body pale yellow. Male smaller than female, nearly circular, white, marked with irregular yellow spots. Viviparous.

This species only attacks the leaves and fruit, seldom the wood. Supposed to have been introduced from Japan in 1872.

Treatment.—Rosin solution (formula No. 1), and gas treatment (formula No. 4).



Yellow Scale on leaf. Ventral view of insect.

(3) Oleander Scale.

A small whitish scale infesting the oleander. It attacks oranges and lemons; does not infest the trees to their material injury, although harmful to the fruit.

Scale of female flat, whitish or light gray, and with exuviæ central or nearly so. Female nearly circular in outline. Scale of male slightly elongated, with larval skin nearly central, snowy white; diameter, .04 inch. Oviparous.

This species has often been mistaken for the true "red" scale when on lemons, as it assumes a pinkish tint.

Treatment.—Rosin solution (formula No. 1), and gas treatment (formula No. 4); kerosene emulsion has also given satisfactory results.

Genus LECANIUM, Illiger.

Females naked, flat or convex, viviparous or oviparous, propagating without ovisac, arboreal.

The following species have been discovered in this State:

(1) Black scale—*Lecanium oleæ*, Bernard.

(2) Soft scale—*Lecanium hesperidum*, Linnæus.

(3) Hemispherical scale—*Lecanium hemisphæricum*, Targioni.

(1) Black Scale.

(Fig. 6, Plate XXVI.)

A blackish-brown scale, very common throughout the State. Infests nearly every kind of tree and plant. It is more troublesome on the olive, next to which citrus trees suffer the most from its attacks.

Adult female dark brown, nearly black, nearly hemispherical in form, often quite as long as broad; average length, 4 mm. to 5 mm.; average height, 3 mm. Eggs long, oval, 0.4 mm. in length, color yellowish. Larva flat and six-jointed.

Undoubtedly European, and infests a greater variety of plants than any other insect of this group. There are several parasites that attack it, and with the aid of predaceous ones, especially the *Rhizobius ventralis*, recently introduced, it is kept in check in some localities to a considerable extent. It is most troublesome in the coast and bay regions. As this scale has but one brood a year, which is hatched during the summer, it is greatly reduced in number by the heat in the interior regions.

Treatment.—Rosin solution (formula No. 2), kerosene emulsion (formula No. 3), and gas treatment (formula No. 4). On all trees which do not shed their leaves the gas treatment is the only remedy found to efficiently destroy this scale. When properly applied it should destroy over 99 per cent. The washes and sprays are with difficulty made to reach over 80 or 90 per cent of the tree area. The remaining live scale soon reëstablish themselves.

(2) Soft Scale.

A dark brown, oval scale, infesting citrus trees and ornamental plants.

Adult female, 3 mm. to 4 mm. long; yellow, inclined to brown

Fig. 1—Lemon branch infested by the Mealy Bug (*Dactylopius adonidum*)—Reduced one half.

Fig. 2—Branch of lemon infested with the Purple Scale (*Mytilaspis citricola*)—Natural size.

upon disk, shape elongate-oval, nearly flat, smooth and shining. Antennæ seven-jointed, legs slender and long. Young larva oval, long. Viviparous.

This species is not a serious pest and is easily subdued. There are several parasites that keep it in check, so much so as to prevent its doing material injury.

Treatment.—Rosin solution (formula No. 1), and kerosene emulsion (formula No. 3).

(3) Hemispherical Scale.

A dark brown, hemispherical scale; infests citrus trees principally—the lime the most. The scale settles on the limb and on the leaf, mostly on the latter along the midrib, but along the margin the most. The average length of the adult female is 3.5 mm., width 3 mm., height 2 mm. The shape and proportions vary greatly, according as the scale is formed upon leaf or twig.

Treatment.—Kerosene emulsion (formula No. 3).

Genus MYTILASPIS, Targioni-Tozzetti.

Female and male puparia similar, or nearly similar, in shape, but the male puparium is smaller. Puparia elongated, generally more or less mussel-shaped or pyriform, usually convex, more or less curved, pellicles at one end. Male puparia not carinated. Five groups of spinnerets in the female, but the groups are sometimes continuous.

The following species are found in this State:

(1) Purple scale—*Mytilaspis citricola*, Packard.

(2) Long scale—*Mytilaspis Gloverii*, Packard.

(1) Purple Scale.

(Fig. 2, Plate XXV.)

A long purple scale; infests citrus trees principally. In Florida it is a very troublesome pest, and was introduced into California about fifteen years ago on trees imported from that State.

Scale of female long, more or less curved and widened posteriorly, brown, with exuviæ of same color; length, .12 inch. Female yellowish white. Scale of male usually straight, or nearly so, of same color as scale of female. Egg white, arranged irregularly under the scale.

Treatment.—This scale is somewhat difficult to destroy, and will only yield effectually to the gas treatment (formula No. 4).

(2) Long Scale.

This species, like the preceding one, is very common throughout Florida, and is usually associated with *M. citricola*. It infests citrus trees principally.

Scale of female differs from *M. citricola* in being much narrower, color light yellow, varying to light brown. Female, body light purple. Eggs white when first laid, become tinged with purple before hatching, and they are arranged in two rows, in a regular manner. Scale of male similar in form to that of the female.

Treatment.—Like the preceding one, this scale is difficult to destroy. Use the gas treatment (formula No. 4).

Genus ICERYA, Signoret.

Antennæ eleven-jointed, body covered with a cottony matter of several shades of color, and with a secretion of still longer filaments. Skin with rounded spinnerets and with long, scattered hairs. Antennæ of nearly the same size throughout their whole length, and with a long pubescence. The digitules of the claw elongated and buttoned; of the tarsi as simple hairs. Genital apparatus terminating in a tube internally, with a reticulated ring, and without hairs at its extremity. Antennæ of the larva six-jointed, with a very long pubescence and with four hairs upon the last joint much longer than the others. Lateral lobes of the extremity of the abdomen with a series of three very long, frequently interlaced bristles.

Cottony Cushion Scale (*Icerya purchasi*, Maskell).

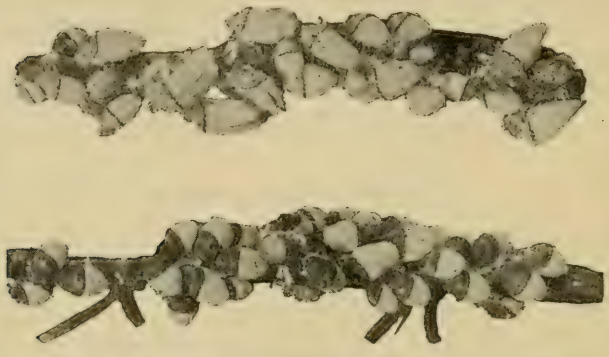
A cottony-like insect, infesting citrus trees and ornamental plants.

Adult female dark orange red, legs and antennæ black, covered with yellowish powder. Egg-sac white, tinged with yellow, and is ribbed longitudinally, and longer than the body of the insect, filled with loose cottony mass containing the eggs. Egg oval in shape, red, 0.7 mm. long. Newly hatched larva reddish brown; antennæ six-jointed; begins in a short time to excrete tufts of yellow waxy matter along the dorsal surface

of the body and lateral margins. The young creep along at first, then settle along the underside of the leaves and on the branches, which they seem to prefer, but after passing through the second or third molt migrate to other parts of the tree.

Since the introduction of the Australian ladybirds, *Vedalia cardinalis* and *Novius Koebelei*, which devour it, this scale is no longer considered a pest.

Treatment.—When spraying is desired, formula No. 1 or No. 3 will be found effective.



Two distinct forms of Cottony Cushion Scale. (After Craw.)

Genus DACTYLOPIUS.

To this genus belong the insects commonly known as mealy bugs. The antennæ of the female are six-jointed in the larva, and eight-jointed in the adult. The male larva has seven-jointed antennæ. The tarsi are furnished with four digitules and the anal ring with six hairs.

Mealy Bug (*Dactylopius adonidum*, Signoret).

(Fig. 1, Plate XXV; Fig. 2, Plate XXVII.)

This mealy bug has made its presence felt in some portions of the State. It congregates in large numbers in portions of the tree, especially among the clusters of fruit.

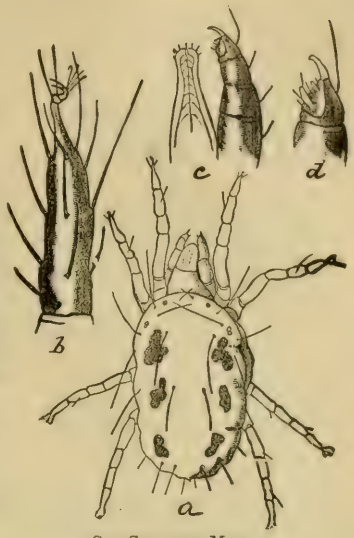
Treatment.—This insect is effectually destroyed by the ordinary washes used for scale, and by the ladybird *Cryptolæmus montrouzieri*, lately introduced. This ladybird is as effectual in destroying the mealy bug as the *Vedalia* and *Novius* are in devouring the cottony cushion scale.

SIX-SPOTTED MITE.

Tetranychus 6-maculatus, Riley.

This mite was introduced into the lower portion of the State on citrus trees from Florida. In that State it has done considerable damage to citrus fruits. Infested trees may be recognized by a mottled appearance. The mites congregate on the underside of the leaves, usually producing a concavity. The upper surface of the leaves is marked with yellow blotches.

Treatment.—Formula No. 5.



SIX-SPOTTED MITE.
a, insect enlarged; *b*, tarsus; *c*, rostrum and palpus, still more enlarged; *d*, tip of palpus, still more enlarged.

FORMULAS FOR DESTROYING INSECT PESTS AFFECTING THE CITRUS.

The following formulas of insecticides for the destruction of the various pests that affect citrus trees have proved the most effectual in this State:

(1) Rosin Solution.

(For the Red and the Yellow Scale on citrus trees.)

Rosin	20 pounds.
Caustic soda (70 per cent)	7 pounds.
Fish oil	3 pints.
Water, to make	100 gallons.

Place the rosin, caustic soda, and fish oil in a boiler, pour over them about 20 gallons of water, and cook thoroughly over a brisk fire for three hours; then add hot water, a little occasionally, and stir well, until diluted to 50 gallons of hot solution. Place this in the spray tank and add cold water to make the necessary amount. Never add *cold* water when cooking.

(2) Rosin Solution.

For newly hatched Black Scale and Soft Brown Scale.)

Rosin	18 pounds.
Caustic soda (70 per cent)	5 pounds.
Fish oil	2½ pints.
Water, to make	100 gallons.

Prepare as directed in formula No. 1. The black scale generally completes hatching in most sections by September 1st, therefore this formula should be used during that month.

(3) Kerosene Emulsion.

(For Black Scale and Soft Brown Scale on citrus trees.)

Kerosene oil (Pearl, 150° test)	5 gallons.
Common laundry soap	1¼ pounds.
Water	2½ gallons.

Dissolve the soap by boiling in 2½ gallons of water, and while boiling remove to another vessel; add the kerosene, and churn for fifteen minutes, or until a perfect emulsion is formed. Afterward dilute with 6½ gallons of hot water for each gallon of oil, and to the mixture add 2½ pounds of home-made soap dissolved in hot water. Apply at a temperature of 140° F.

(4) The Hydrocyanic Acid Gas Treatment.

(For destroying scale insects on citrus trees.)

This treatment should be used in the night to avoid light, heat, and sea breeze, which neutralize the effects of the gas. The chemicals used for producing the gas are: Sulphuric acid (commercial), cyanide of potassium (98 to 99 per cent), and water.

The following instructions must be carefully observed: First, the tent, which must be air-tight, is placed over the tree; second, the tent is made air-tight around the bottom, by throwing some loose soil over the bottom of the canvas; third, the necessary amount of sulphuric acid, together with the required amount of water, is put in a glazed earthenware vessel, and placed under the canvas, and the cyanide of potassium is added. A piece of sacking or burlap is thrown over the top of the vessel, to spread the gas and prevent it from burning the leaves immediately above the generator. The tree is left covered forty minutes.

The chemicals are to be used in the following proportions, as recommended by the Riverside County Board of Horticultural Commissioners:

Height of Tree.	Diameter of Tree.	Water.	Cyanide C. P., 98 per cent.	Sulphuric Acid, 66 per cent.
Feet.	Feet.	Ounces.	Ounces.	Ounces.
6	4	2	1	1
8	6	3	1½	1½
10	8	5	2½	2½
12	14	11	5	5½
16	16	17	8	9
20	16—20	22	10	12
20—24	18—22	30	14	16
24—30	20—28	34	16	18
30—36	25—30	52	24	28

The cyanide should be used as coarse as possible, so that the chemical action will be less violent. The gas is also generated more evenly, and there is not so much danger of the chemicals boiling over or spattering the tent. As soon as the tent is removed the vessel is rinsed with clean water and prepared for another charge.

(5) For Mites (Tetranychus) on Citrus Trees.

(To be applied in summer.)

Caustic soda (70 per cent)..... 10 pounds.
Sulphur..... 20 pounds.
Dissolve in water..... 20 gallons.

Take the sulphur, mix to a paste—not sloppy—with cold water in a barrel; then add to this wet sulphur 10 pounds of caustic soda (98 per cent), and it will boil the sulphur just like lime slacking; have 20 gallons of water to add to it as it boils, to prevent burning. This is the stock solution. When ready to spray the mites or spiders, put 40 gallons of water in another barrel, and take half a gallon of the stock solution and add to the forty gallons of water, straining it to take out any sediment there may have been in the sulphur. Apply with a spray pump under one hundred pounds pressure.

Kahles'* Distillate Solution.

(For Black Scale on citrus trees; apply in the fall.)

Distillate, 28° (untreated)	5 gallons.
Hot water	5 gallons.
Whale-oil soap	1½ pounds.

The whale-oil soap must first be dissolved in the water. Then add the dissolved soap to the distillate. It is important that the distillate be placed in the mixing vessel first; then place the dissolved soap on top. Attach your spraying pump to the bottom of the vessel in which you are mixing the compound, and keep pumping it out of the vessel through the spraying pump back into the vessel, until the whole becomes of a rich creamy substance. Keep pumping or churning it through the pump until it becomes a complete emulsion, without a speck of free oil in sight, which will take from ten to fifteen minutes. When properly emulsified, it should increase in volume about one third, because it becomes aërified.

If the ground is in good condition, containing proper moisture, and the trees are healthy and growing, you can apply the spray in the proportion of eleven parts of water to one of the emulsion. If the trees are dormant do not use it so strong; say about twelve or fourteen gallons of water to one gallon of the stock compound. Always put your emulsion in the apparatus first, then add the water. The stock compound and the cold water will mix as readily as milk and water, and when finished should resemble milk in all appearances.

When spraying be careful to observe any particles of oil which may not have been thoroughly emulsified, and which rise to the surface. In this event, only use the correct emulsion, and when near the bottom empty the oil off.

About 200 gallons of the stock mixture can be made for $6.25. The distillate costs 5 cents a gallon, and the soap about 5 cents per pound. Two hundred gallons of stock mixture at eleven to one give 2,200 gallons of spraying mixture.

This solution is made the same as the kerosene emulsion, only this distillate contains all the natural oils and strength of the crude oil, nothing being taken therefrom except the asphaltum. Therefore, it is a great deal stronger and stays longer on the trees without evaporating. Eleven to one is the strongest it can be used with safety on citrus trees.

*F. Kahles, Superintendent of Crocker-Sperry Lemon Grove, Montecito.

This remedy is used by Mr. Neff, Superintendent of the Windermere Orchards at La Mirada, but he uses twenty pounds more whale-oil soap, on account of lime in the water at that place. On this account it requires nearly an hour to prepare a perfect emulsion. He also uses warm water to add to the stock solution, as it works better than cold water. Mr. Neff says: "Some *distillates* will kill very large 'black scale,' while another lot of distillates, apparently the same, will not kill any scales larger than a pinhead."

BENEFICIAL INSECTS—PREDACEOUS.

In no part of the world has the value of predaceous and parasitical insects been more fully demonstrated than in this State. The cottony cushion scale (*Icerya purchasi*, Maskell) had gained a very strong foothold here, especially on citrus trees, and the damage done by its ravages can hardly be estimated. Everywhere was noted its resistless and ruthless march. Watchfulness did not guard against its spread. The most heroic treatments proved of no avail. But in the deep night of our despair there came to our relief a minute ladybird, the *Vedalia cardinalis*, which in less than a year entirely freed the orchards of California of that pest, thereby accomplishing a work entirely unprecedented in the annals of economic entomology. In 1892 another ladybird, *Novius Koebelei* (see Plate XXVI), also a foe to this scale, was introduced, although a repetition of the work achieved by the Vedalia was gravely doubted. What energy, science, and money could not perform in years, these minute creatures accomplished in a short period of time, and to those who closely watched their work it seems almost incomprehensible.

These friendly insects are assisted materially by other species, and especially by internal parasites. That other insects with similar instincts could ever be discovered was doubted, but through persistence and faith on the part of the State Board of Horticulture, a further search was instituted, which was rewarded by the discovery of two other species. One, the *Rhizobius ventralis* (see Plate XXVI), is an effective foe of the black scale (*Lecanium olea*), which it is diminishing very rapidly in many sections of the State. This ladybird has proved most effective in the coast and bay counties, where it finds a congenial home. The other species, the *Cryptolæmus montrouzieri* (see Plate XXVII), has proved an effective enemy of the mealy bug.

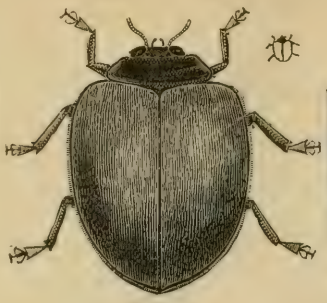


FIG. 1.

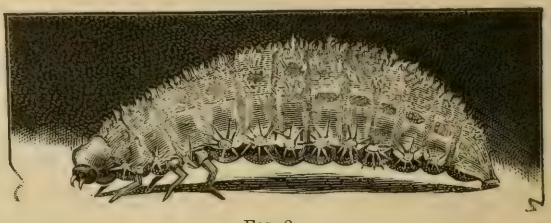


FIG. 2.

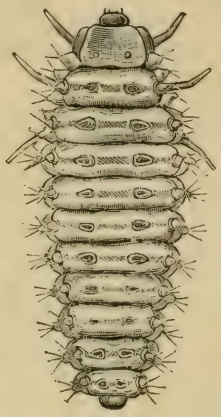


FIG. 5.

FIG. 4.

FIG. 3.

FIG. 6.

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Fig. 1. *Novius Koebelei*—female, enlarged.

Fig. 2. *Novius Koebelei*—larva, enlarged.

Fig. 3. *Novius Koebelei*—male, enlarged.

Fig. 4. *Rhizobius ventralis*—enlarged.

Fig. 5. *Rhizobius ventralis*—larva, enlarged.

Fig. 6. *Rhizobius ventralis*—larvæ at work on black scale (*Lecanium oleæ*).

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LADYBIRDS—NEWLY INTRODUCED SPECIES IMPORTED BY STATE BOARD OF HORTICULTURE THAT HAVE PROVED EMINENTLY SUCCESSFUL.

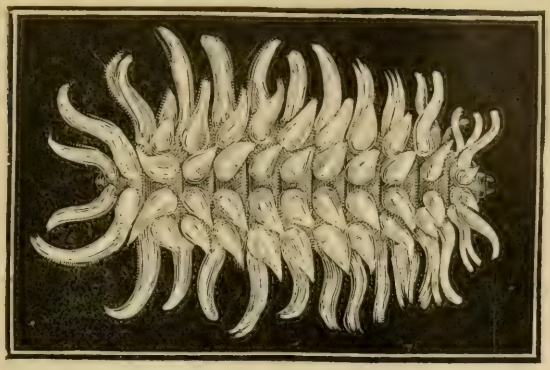

FIG. 1—*Cryptolœmus montrouzieri*—larva, enlarged.

FIG. 2—*Cryptolœmus montrouzieri*—twig showing larva and pupa, natural size.

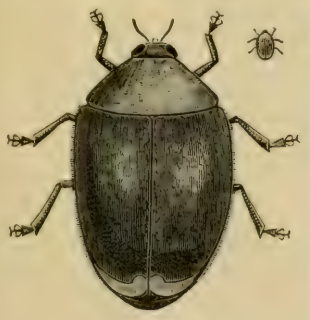

FIG. 3—*Cryptolœmus montrouzieri*—perfect insect, enlarged.

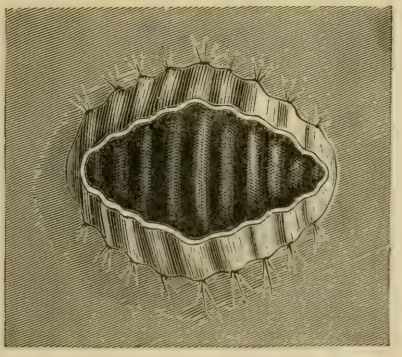

FIG. 4—*Cryptolœmus montrouzieri*—pupa, enlarged.

LADYBIRDS—NEWLY INTRODUCED SPECIES IMPORTED BY STATE BOARD OF HORTICULTURE THAT HAVE PROVED EMINENTLY SUCCESSFUL.