

EDWARD C. GREEN



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In Texas

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Citrus fruits

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THE POSSIBILITIES OF CITRUS CULTURE
IN TEXAS

by

EDWARD C. GREEN, B. S., '97.

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THESIS

THE POSSIBILITIES OF CITRUS CULTURE IN TEXAS.

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There is being conducted in Texas to-day one of the most extensive horticultural experiments ever attempted with so little assurance of ultimate success.

In 1909 it was estimated that no fewer than 1,000,000 orange trees had been planted in the "Gulf Coast Country" between the Sabine River and the Rio Grande, and it is possible that during 1910 and 1911 another 1,000,000 orange trees have been planted. The land generally thought of as the citrus belt is a strip varying from ten to forty miles in width paralleling the coast and the valley of the Rio Grande up as far as Sam Fordyce.

The sudden and rapid development of orchard planting may be traced largely to the activities of real estate sale promoters, nurserymen and railroad industrial agents. There is comparatively little data from orchardists not directly interested in land schemes or in the business of propagating citrus nursery stock for sale. The newspapers and horticultural journals have been benefited by the advertising campaigns and, hence, have responded by aiding the propaganda in every manner. Two years ago there were so many boni fide orchardists and so

much interest among business men who contemplated planting orchards on an extensive scale that an authoritative statement as to the possibilities of orange growing in the Texas Gulf Coast was asked of the United States Department of Agriculture. For the purpose of preparing such a statement a conference of the Department pomologists and others was held February 20th, 1909, in the office of Dr. B. T. Galloway, Chief of the Bureau of Plant Industry, Washington, D. C., and the report of the conference was published in circular form. It was decided at this time to detail Mr. Floyd S. Tenney, a pomologist, to visit Texas and inspect the territory. This was subsequently done and his report was so adverse to the orange industry and was received with such bad grace by the parties interested in the citrus orchard development that the Texas Commissioner of Agriculture, Honorable Ed. R. Kone, secured the services of Professor H. Harold Hume, Secretary of the Glen St. Mary Nursery, of Florida, and an acknowledged authority on citrus fruits, for the purpose of checking up the report of Mr. Tenney, and, if possible, to secure a more favorable statement. Mr. Tenney's report was not only from the standpoint of the grower alone but from the broader basis of production as related to market and consumption. He

says,- "The Satsuma industry in Texas may be considered as yet in its experimental state. The indications are, however, that with the exception of occasional hard winters, this variety will prove generally hardy." He states that the marketing of the Satsuma type of orange in limited quantities has met with considerable success, but that the successful marketing of great quantities in the large cities of the country does not appear very hopeful in view of the fact that they would have to compete with the larger and superior oranges of the Pacific Coast and the Imperial Valley. He stated that,- "There no doubt is a field in Texas and nearby states which could dispose of considerable quantity of this fruit at prices sufficiently high to encourage its growing in considerably larger quantities than the bearing trees have yet yielded. The general impression which I gathered from seeing trees of the common round orange, the pomelo and the lemon is that the coast country of Texas averages too cold for the commercial planting of these varieties."

Professor H. Harold Hume's report is embodied in Bulletin No. 3, New Series, Texas Department of Agriculture, and his conclusions are as follows:

"Basing conclusions on the information at hand and considering the whole matter in relation to climatic conditions, citrus fruits have been, are being and will be grown in the Gulf Coast region of Texas. Satsuma oranges on Citrus Trifoliata stock can be produced in unlimited quantities; other varieties of citrus fruits can be grown on Citrus Trifoliata stock. The main crops of oranges grown in coastwise Texas will be Satsuma and other early or medium-early varieties and the only fruit with which it will come in competition is the "Valencia Late" from California, of which there is not enough to supply the present demand."

Mr. Gilbert Onderdonk, a veteran horticulturist and nurseryman of Nursery, Texas, having observed Texas conditions for a period of over fifty years has written a bulletin entitled, "Pomological Possibilities of Texas," and therein he states his conclusions regarding the prospect of citrus development in this state. "And now the writer offers his final conclusions upon the subject of practicability of orange industry of Southern Texas. He believes that from our Eastern boundary to Corpus Christi we have a Gulf Coast belt in which a prudent manager could realize about six or seven crops in ten years after the fruiting age of his trees is attained. He believes

that from Kingsville on toward the border beyond Raymondville the average would be one more crop in ten years, and on the Rio Grande he believes that nine crops could be produced in ten years beginning with the bearing year."

From the above observations of orange experts and trained horticulturists it would appear that there is little question as to the probable success of the Satsuma orange on Trifoliata stock throughout the coast country wherever said stock is congenial to soil conditions. As to the extent of the success that may be expected from raising standard oranges, grape fruit and lemons there seems to be some doubt, except in the case of Mr. Onderdonk who believes that such of the hardier varieties of round oranges as have the ability to recuperate rapidly and return to bearing within a period of one year after freezing down will prove commercially satisfactory. Investigation as to what may be expected under Texas conditions will involve a careful study of the climate and soils of Florida, Louisiana and California as compared with that of Southern Texas, and the history of citrus culture from the earliest time to the present in these states should be carefully considered before a conservative decision can be reached.

According to C. Hart Merriam, in Bulletin No. 10, Division of Biological Survey, United States Department of Agriculture: "The southernmost portion of Florida, a very small portion of southernmost Texas and a narrow strip along the Colorado river in Arizona and California are classed as tropical. Certain portions of the lower austral and of the gulf strip of the lower austral are satisfactory for growing citrus fruits." Professor R. H. Rolfs of Florida states that, "citrus fruits may be produced where the temperature does not fall below 19 degrees or rise above 100 degrees F." Dr. Wm. C. Richardson, before the Florida State Horticultural Society, in 1908, in an article on the Climatology of the Citrus, says, that, "the Isotherm of 70 may be said to be the centre of the citrus belt of the Northern Hemisphere and that the limits of citrus culture vary from between the 25th and 35th parallel of latitude." The normal surface temperature for a year places the 70 degree Isotherm through the central portion of the Peninsula of Florida, through Texas on a line practically with Corpus Christi and Laredo and through Arizona and California in a loop following the valley of the Colorado river to approximately one degree north of the International boundary line between the

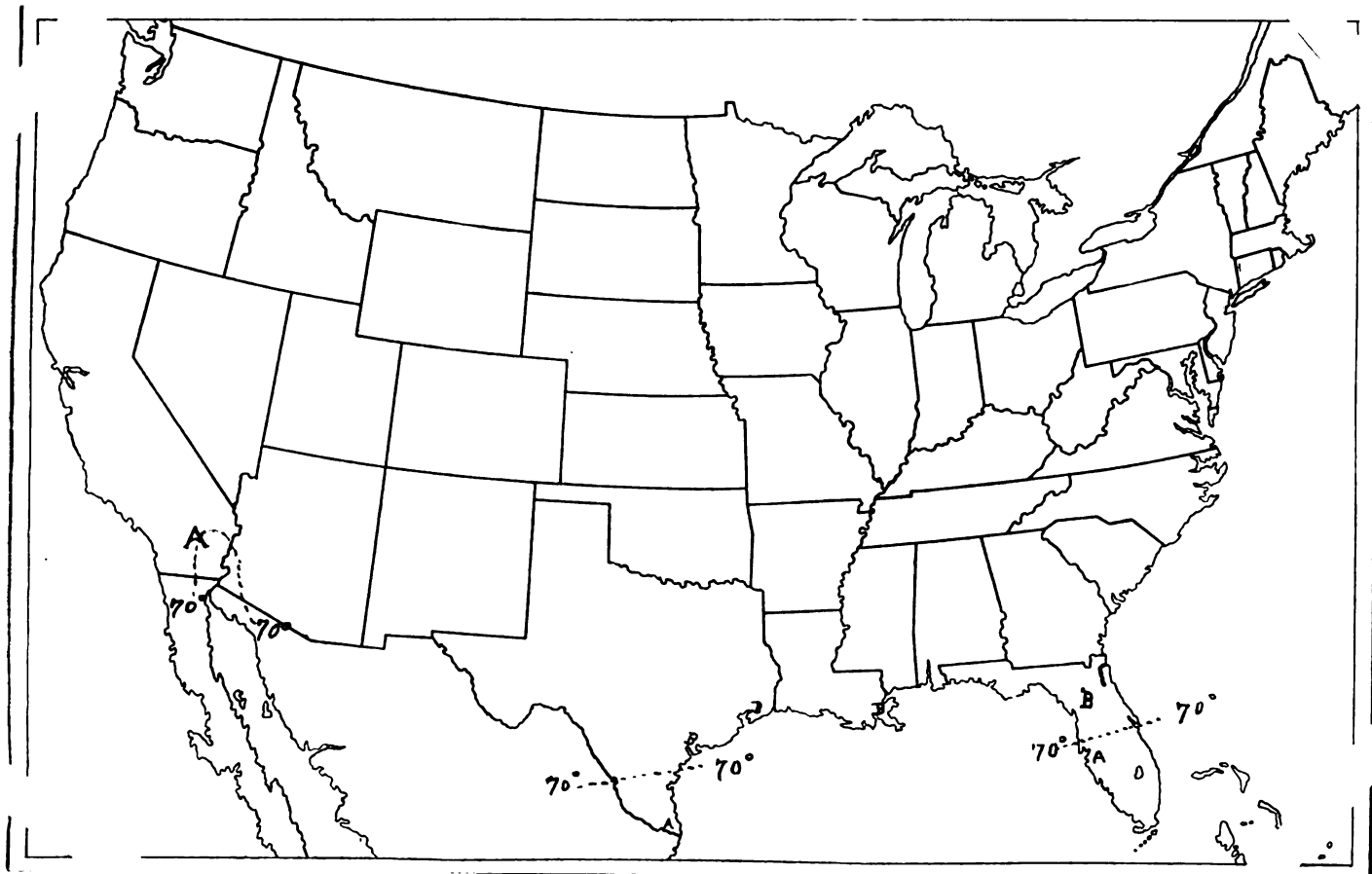


PLATE I. Showing Isotherm 70 degrees F.

(U.S. Weather Bureau Bulletin "Q".)

- A. Regions in which standard citrus fruits are grown.**
- B. Regions in which Satsuma oranges are grown.**

United States and Mexico. *

The above indicates in a general way the area in the United States which possibly may be adapted to citrus growing. There are now to be considered in this connection the climatic condition of various localities due to topography, the presence of ameliorating effect of adjacent bodies of water, forests, and such other conditions as might affect the possibilities of citrus fruit production. From the history of citrus culture many indications may be obtained from which deductions may be made.

Historical.

Oranges were introduced into California by the Franciscan monks about 1769, and as the state developed trees were planted throughout the southern part of the state. The founding of the Riverside Colony in 1871 marked the beginning of great horticultural activity, and in 1880 orange culture had assumed commercial importance and developed with great rapidity. ** In 1889 it was estimated that 3,500,000 orange trees had been planted, nearly one-half of which were then bearing. The Thermo Belt, considered the best for citrus fruits, extends from San Diego to Tehama, nearly seven hundred miles long and from two to twenty-five miles wide, the altitude varying from thirty to eighteen

* Bulletin "Q", Weather Bureau, United States Department of Agriculture.

** U.S. Soil Survey of San Bernardino Valley, California.

hundred feet above sea level. The output of oranges in 1908 and 1909 averaged 14,000 carloads per year. *

Oranges were found wild in Florida when the first permanent settlements were made. In the central portion of the state wild sour oranges were usually found in locations where they were fully protected by the surrounding towering oaks.

"In 1859 Judge Day, of Micanopy, started the first orange grove of this area by budding the sweet orange upon the wild sour stock, which had hitherto been considered worthless. The fruit at this early date met with a ready sale and the profits of the orange growing industry caused its rapid expansion." **

From 1865 to 1870 sweet seedling oranges along the St. Johns river attracted considerable attention, and it was noted subsequently that upon the removal of the natural protection afforded by the live oaks, which occurred in conjunction with the orange trees, the wild groves were injured or destroyed soon after from the effects of cold. *** Interest in the citrus culture in Florida developed very slowly and a serious set back occurred during 1886 when a three days blizzard occurred seriously injuring orange trees down to the 29th parallel of

* Cyclopaedia of American Horticulture -Bailey.
** U.S. Soil Survey, Gainesville Area, Florida.
*** Cyclopaedia of American Horticulture -Bailey.

latitude. For six years after the freeze of 1886 injurious frosts occurred regularly. Notwithstanding the frosts orange growing developed, and planting were made with great enthusiasm until December 1894, when a severe cold defoliated the trees as far south as the Manatee river, and the following February a freeze occurred which killed most of the trees to the ground from Tampa north and more or less injured the trees south of this locality. The effect of this freeze was to practically destroy the Florida citrus industry through the north half of the Peninsula. Since then other orchards have been developed, more attention being paid to local conditions and to the protection of the orchards by various means, and a large degree of success has been met with by the most careful growers.

In 1727 the Jesuits were granted a tract of land near New Orleans, Louisiana, on which they conducted a model farm. "To these Jesuit fathers Louisiana is indebted for the introduction of the orange, fig, sugar cane and indigo." * From this period forward sweet seedlings have been grown in the delta of the Mississippi river. No attempt, however, at commercial orcharding was made prior to the last few years. The cold of February 1895 killed nearly all sweet seedlings, the

* U.S. Soil Survey of the New Orleans area, Louisiana.

temperature going to 15 degrees F. at New Orleans. Only the hardy Japan oranges on the Trifoliata stock escaped. In February 1899 nearly every grove in the state was killed by the severe freeze which occurred at that time.

In Texas citrus trees were grown from the time of the earliest settlers, and this was probably the result of throwing out or planting the seeds about the homes of the early settlers and the plantation owners. Trees exist that are known to be thirty-five years old, and at the home of S. I. Bryan, in Brazoria County, there are old seedling trees said to have been planted by Mrs. Wm. Joel Bryan fifty-five or sixty years ago. Mrs. S. I. Bryan has known these trees for forty-three years and in this period they have been frozen down three times.* There are many other instances of old seedling orange trees in various places along the Gulf Coast from Beaumont to the Rio Grande and in practically all cases the trees have been grown about the homes of people having a love for horticulture and in most instances there is little doubt but that some protection from cold was given when necessary. About fifteen years ago a few Satsuma oranges on Trifoliata stock were planted

* Citrus Fruits in Texas, H. Harold Hume.

along the Gulf Coast and as these came into bearing some six years later considerable interest was attracted to them and for the last six or eight years the planting of this variety has gone steadily forward. Round oranges and some grape fruit and lemons have been planted in a small way. In 1899 all orange trees in the state were killed to the ground, with the exception of a few old sweet seedlings which were standing in exceptionally good locations. It is reported by Mr. D. Onderdonk, that in 1887 orange trees were seriously injured down as far as Brownsville. Mr. A. T. Potts, Superintendent State Sub-experimental Station, Beeville, Texas, states, that round oranges and grape fruit on Trifoliata stock were killed to the ground in February 1909, and have been killed to the ground each year since. Satsuma oranges on Trifoliata stock have been but slightly injured during these freezes.

Climate.

In considering the possibilities of the citrus culture in Texas, it is necessary to compare the climatic conditions here with those of that section of California where citrus culture is on a safe and commercial basis, and comparison should also

be drawn with that section of Florida in which citrus culture on a commercial scale exists. In California, Riverside may be considered the centre of the safe citrus growing territory, and even in that section weather conditions are sometimes sufficiently severe to seriously injure fruit and even young trees. The weather records for the station at Redlands, which is but a few miles from Riverside, show that the annual mean from 1898 to 1903, inclusive, is 64 degrees F. and the absolute minimum 25 degrees F. During this period the lowest temperatures encountered by months were January 26 degrees F., February 25 degrees F., November 32 degrees F., December 27 degrees F. At Los Angeles the annual mean for the period from 1894 to 1903, inclusive, was 62 degrees F. The absolute minima by months were January 30 degrees F., February 28 degrees F., November 34 degrees F., December 30 degrees F. The temperature dropped below 32 degrees F. five times during this period.

In Florida the section of country considered most safe for citrus culture is in the neighborhood of Hillsboro County. The ameliorating effect of Tampa Bay on the surrounding country makes the growing of standard round oranges and of pomelos

possible. The weather records at Tampa for the period from 1894 to 1903, inclusive, show an annual mean of 72 degrees F., and an absolute minimum of 19 degrees F. By months the absolute minima are as follows: January 27 degrees F., February 22 degrees F., November 32 degrees F., December 19 degrees F. During this period the temperature dropped below 30 degrees F. nineteen times. At Barto, in Folk County, for the period from 1895 to 1903, inclusive, the annual mean was 72 degrees F., the absolute minimum 18 degrees F. The absolute minima by months were as follows: January 18 degrees F., February 22 degrees F., November 28 degrees F., December 27 degrees F. During this period the temperature dropped below 32 degrees F. forty-five times.

In Texas, at Brownsville, the southernmost point in the state, the weather records show from 1894 to 1903, inclusive, the annual mean to be 73 degrees F., and the absolute minimum 12 degrees F. By months the minima are as follows: January 20 degrees F., February 12 degrees F., November 28 degrees F., December 15 degrees F. During this period the temperature dropped below 32 degrees F. upon sixty-six different occasions and to 20 degrees

F., or below, eleven times. *

From the mere comparison of the above records it would seem that the outlook for standard oranges on sweet seedlings or sour stock is not very good, even in the southernmost point of Texas, in that the weather records show greater cold and more of it than in Florida where severe injury occasionally occurs, or in California where slight injuries to trees and even severe injury to fruit have been recorded. Not only the actual degree of cold but the phenomena accompanying the severe weather has much to do with the effect on the citrus. Cold driven by high wind, especially when not accompanied by rain, has a much more injurious effect than still cold or cold accompanied by rain. In the case of California, winds accompanied by cold are usually not of high velocity and frequently from year to year, during the period when cold occurs, fog and moisture accompany the drop in temperature. In Florida the cold is usually accompanied by wind but owing to the wooded nature of the country and the prevalence of tall trees the citrus groves are protected, naturally, to some extent.

In Texas the cold is almost always accompanied by high northerly or northwesterly winds; the south-

* Data obtained from Bulletin "Q", U.S. Weather Bureau.

ern portion of Texas contains practically no high trees, the growth of the country being cactus and "chapparal", averaging possibly ten feet in height, and there is practically nothing for three hundred miles to stop the sweep of the "norther", as it is locally known. It has been noted by the writer, however, that probably one-half of the severe cold spells are accompanied by rain which freezes on the exposed trees as it falls, and as a rule in such cases severe injury does not result.

Among other climatic conditions considered in relation to citrus growing is the weather preceding the period in which cold is likely to occur. Citrus trees are capable of withstanding considerable cold provided they are in a dormant or nearly dormant condition. When cool weather prevails during a period of weeks and is then followed by a severe drop in temperature the trees appear to have prepared themselves to some extent and the injury is rarely severe. However, when the temperature has been high and conditions favorable for growth, orange trees respond quickly, and when such a period is followed by severe cold or even a moderate drop below thirty-two degrees F. severe injury is almost certain to follow. The latter condition is the

one which most usually occurs in Texas, and this fact added to the further consideration that the southernmost point in Texas is much colder than either Florida or California, together with the fact that native trees sufficiently high to form natural wind breaks are absent, lead the writer to the belief that the successful growing of round oranges on standard stocks is not feasible in southern Texas. However, the greatest hope of the Texas promoters of citrus planting is not based so much on standard round oranges, grape fruits and lemons as it is on the hardy Japan orange, "Satsuma", grown on the cold resistant Trifoliata stock. It is their expectation also, that certain varieties of round oranges and pomelos which are congenial to the Trifoliata stock can be grown throughout the Gulf Coast country. So far as the Satsuma orange on Trifoliata stock is concerned, it has been demonstrated that this can be grown throughout north-central Florida, in the delta of the Mississippi river and in favored localities close to the Gulf through Louisiana and Texas. The Satsuma belongs to the "Mandarin" group of oranges and when dormant, owing to the effect of the stock on which it is budded it is very resistant to cold. A

mature tree would probably endure under these conditions as low a temperature as 12 degrees F. and still live. However, a temperature of 28 degrees F. destroys any fruit on the tree, and a temperature of 20 degrees F. usually destroys all fruit buds regardless of the dormancy of the tree. The pomelos and round oranges on Trifoliata stock never become so resistant to cold as does the Satsuma. At Beeville in 1909, a four year old variety orchard of grape fruit which the preceding fall had borne a good crop of fruit was killed to the ground, in 1910 it was again killed to the ground and this past January the trees were again killed to where the soil had been mounded about the stems. Throughout the Texas Coast country during the past winter all unprotected grape fruits and round oranges on Trifoliata stock were severely injured and in most cases the trees killed to the ground or to the trunks. In cases where artificial protection was given, such as fire-pots, or where natural protection, such as wind-breaks or adjacent bodies of water existed, the trees came through with comparatively slight injury.

Satsuma oranges on Trifoliata stock are successfully grown in Florida from Glen St. Mary

south, wherever soil conditions are satisfactory. According to the weather records from 1894 to 1903, inclusive, at Jacksonville, which may be considered the northern limit of Satsuma on Trifoliata stock, the annual mean was 69 degrees F., the absolute minimum 10 degrees F. The minima by months were: January 15 degrees F., February 10 degrees F., November 26 degrees F. and December 14 degrees F. During this period the temperature fell below 32 degrees F. ten times. The climate of this section is such that the trees are prepared to some extent for severe weather,- cool is followed by cooler through the fall and winter so that the trees reach the maximum state of dormancy.

In Louisiana, at New Orleans, during the period from 1894 to 1903, inclusive, the annual mean was 69 degrees F., and the absolute minimum for this period was 70 degrees F. By months the minima were as follows: January 15 degrees F., February 7 degrees F., November 29 degrees F., December 20 degrees F. The temperature during this period falling below 22 degrees F. five times. At Port Eads for a similar period the annual mean has been 70 degrees F., the absolute minimum for the period 10 degrees F., and the minima by months were: January 25 degrees F., February 10 degrees F.,

November 36 degrees F., December 28 degrees F.
The temperature has fallen below 22 degrees F.
three times during this period. The section
half way between these two points is considered
satisfactory for raising Satsuma oranges on Trifol-
iata stock and they are injured by cold very rarely.

In Texas, Houston is considered the centre of
the Satsuma orange growing section and the greatest
development is taking place in what is known as the
Houston-Galveston District. At Houston the
annual mean for the period from 1894 to 1903, inclu-
sive, was 69 degrees F., the absolute minimum 6
degrees F. By months the minima were as follows:
January 18 degrees F., February 6 degrees F., Nov-
ember 30 degrees F., December 15 degrees F. For
this period there is no record given in Bulletin
"Q" of the number of times the temperature has
dropped below 22 degrees F., hence this report is
not comparable to those of the two states previously
given. However, it is shown in the United
States Weather Bureau Records that the temperature
dropped below 32 degrees F., during this period,
on one hundred and twenty-six separate occasions.

At Beeville, which may be considered the
southernmost point in which Trifoliata stock
flourishes in Texas, the weather records from 1895

to 1903, inclusive, show an annual mean of 70 degrees F., and an absolute minimum of 5 degrees F. The minima by months were as follows: January 19 degrees F., February 5 degrees F., November 30 degrees F., December 14 degrees F. At this station the temperature dropped below 32 degrees F. during this period, one hundred and twenty-eight times, and the records for January, February and March 1901 and for February 1902 are missing.

By comparison of the above records it would seem that the Satsuma orange on Trifoliata stock will probably be grown successfully in Florida south of Jacksonville, in southernmost Louisiana and in the Gulf Coast of Texas, wherever soil conditions are satisfactory for the Trifoliata stock.

Soils.

Citrus fruits thrive on a great variety of soils. However, for the purpose of comparison it may be well to select as a standard the soil of the best areas in the heart of the safe orange growing section of California.

There are two types of soil which seem to be especially suited to growing of citrus fruits in California; One, the Maricopa sandy loam, is a chocolate brown to black sandy loam six feet or

more in depth, loose, open and porous under cultivation, but in its native, undisturbed state often quite compact. "This soil is devoted almost exclusively to the growing of citrus fruits, to which it is especially well adapted, not only because of its situation in the "frostless belt" but because of its depth and strength." * The mechanical analysis of the Maricopa Sandy Loam is as follows:

Small gravel,-----	13.6	%
Coarse sand,-----	17.5	%
Medium sand,-----	9.8	%
Fine sand,-----	21.2	%
Very fine sand,-----	13.8	%
Silt,-----	17.0	%
Clay,-----	6.9	%

The other type of soil is that upon which the cities of Redlands and Riverside are built, and in which is contained some of the best orange groves in the state. This is known as the "Placentia Sandy Loam", and is a micaceous, sticky, slightly plastic, reddish brown sandy loam, eighteen inches to six feet or more in depth and underlain by a hard compact clay like hard pan of the texture of Fullerton sandy adobe. Much of this soil is in the frostless belt, is well drained and when irrigated is one of the best citrus fruit soils in the valley. The mechanical analysis of the Placentia Sandy Loam is -----

* U.S. Soil Survey of the San Bernardino Valley, California.

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as follows:

Small gravel,-----	6.1	%
Coarse sand,-----	10.1	%
Medium sand,-----	7.5	%
Fine sand,-----	21.2	%
Very fine sand,-----	18.0	%
Silt,-----	25.8	%
Clay,-----	11.2	%

Another California soil mentioned in the United States Soil Survey of the Los Angeles area, is the "Sierra Adobe" and of this it is said: "The location of this type along the foot hills gives it a certain exemption from frost, and with water the citrus fruit and winter truck industries have a bright future." The following is the mechanical analysis of this soil, which is given largely for the purpose of showing that citrus fruits do well even in a very tight and compact soil:

Organic matter,-----	.94	%
Fine gravel,-----	.94	%
Coarse sand,-----	3.2	%
Medium sand,-----	3.38	%
Fine sand,-----	10.26	%
Very fine sand,-----	45.42	%
Clay,-----	19.28	%

In Florida the soil for the most part is of a very sandy nature. Good orange groves have been produced on several types of the sandy lands, and on the heavier types of soil which occur in ridges and are known as "Hammock Lands." There are various grades of this hammock land, but in general it is characterized by a dark sandy top soil vary-

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ing from a few inches to about five feet in depth. The sub-soil is a stiff calcareous drab clay which passes into limestone at varying depths. One of the soils contained in this general classification is called "Portsmouth Sandy loam," and is considered one of the most desirable for oranges and grape fruit although the same fruits are produced satisfactorily in the southern part of the state on very loose and sandy soils. The mechanical analysis of the Portsmouth sandy loam is as follows:

Surface soil first twenty-five inches,

Small gravel,-----	.5 %
Coarse sand,-----	8.1 %
Medium sand,-----	20.1 %
Fine sand,-----	44.7 %
Very fine sand,-----	16.9 %
Silt,-----	5.6 %
Clay,-----	3.1 % *

Sub-soil twenty-five to thirty-six inches,

Small gravel,-----	.4 %
Coarse sand,-----	8.8 %
Medium sand,-----	18.8 %
Fine sand,-----	34.7 %
Very fine sand,-----	.8 %
Silt,-----	2.6 %
Clay,-----	26.7 %

In Louisiana it is probable that the "Yazoo loam" is most satisfactory for orange growing. This soil is a yellow to light brown silt of a depth from five to seven inches, and when not plowed too wet is of a loose and powdery constituency. This type of soil occurs on the ridges

* U. S. Soil Survey, Gainesvilles area, Florida.

and higher strips of ground in southernmost Louisiana. The Yazoo loam near New Orleans is devoted chiefly to market gardening, dairies and nurseries. The nurseries make a specialty of oranges and semi-tropical fruits and flowers. The following is the mechanical analysis of the Yazoo loam:

Organic matter,-----	1.59 %
Coarse sand,-----	.16 %
Medium sand,-----	.12 %
Fine sand,-----	.60 %
Very fine sand,-----	12.12 %
Silt,-----	69.56 %
Clay,-----	17.44 % *

From the above analysis it will be seen that this type is a very heavy and rich soil.

In what is known as the Houston-Galveston District, the predominating type of soil is the "Houston black clay," and it is on the highest and best drained portion of this soil that the Satsuma orange on Trifoliata stock is most generally grown. The soil is a black or drab clay six to ten inches in depth and underlain by a drab of yellow waxy clay. When well cultivated, is quite friable and has the texture of clay loam. The mechanical analysis of this soil is as follows, first six inches:

Organic matter,-----	3.88 %
Gravel,-----	.2 %
Coarse sand,-----	.56 %

*U.S. Soil Survey, New Orleans area, Louisiana.

Medium sand,-----	.34	%
Fine sand,-----	1.7	%
Very fine sand,-----	6.16	%
Silt,-----	38.44	%
Clay,-----	52.4	%

Sub-soil six to thirty-six inches consists of,

Organic matter,-----	2.37	%
Gravel,-----	.32	%
Coarse sand,-----	.4	%
Medium sand,-----	.24	%
Fine sand,-----	1.06	%
Very fine sand,-----	3.82	%
Silt,-----	37.1	%
Clay,-----	57.	% *

The type of soil of southernmost Texas which is generally considered most promising for citrus culture is that which lies on the higher land bordering the river bank or the "resacas" and which is known as "Laredo silt loam." This soil is very floury when dry and has a tendency to bake after irrigation unless properly cultivated. Its depth varies from twelve inches to several feet, possibly as much as sixteen feet in some situations. The mechanical analysis of the Laredo silt loam is as follows:

Fine gravel,-----	.1	%
Coarse sand,-----	.3	%
Medium sand,-----	.6	%
Fine sand,-----	8.9	%
Very fine sand,-----	32.8	%
Silt,-----	43.7	%
Clay,-----	13.9	%

By scanning the above descriptions and mechan-

* U.S. Soil Survey of the Brazoria area, Texas.

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ical analyses of soils it will be seen that they vary from very light to extremely compact soils, and on all these types oranges of some sort are known to grow successfully so far as the productions of the tree is concerned. However, it should be stated here that in not all cases are the same stocks used, for example,- in California practically all oranges are grown on sweet seedling, sour, or pomelo stocks; in Florida sour stock is used chiefly in the southern part of the state and Trifoliata stock in the central and north-central portion; in Louisiana and in the Houston-Galveston District of Texas practically nothing but Trifoliata is used, while in southern Texas the sour is used to the exclusion practically of all other stocks. The presence of alkali in soils appears to have a marked effect on certain stocks. The sour orange thrives where sufficient alkali exists to entirely destroy the growth of Trifoliata. (See illustration on plate #2.) However, this bad effect on Trifoliata may be due to the character of the alkali present in the soil of the Rio Grande valley, for in California Charles H. Shimm in speaking of the experience of the growers in the vicinity



PLATE 2.

Small leafless trees in foreground are Citrus Trifoliata planted three years ago. Large orange trees in same row in background are sour stock same age and when planted were the same size of the Trifoliata. Sour stock flourishes while Trifoliata stands still or dies.

of Tulare states, that,- "Trifoliata grows and fruits in alkali soil, hence it is recommended as a stock for gardeners in that locality." * The alkali reported as present in the territory referred to by Mr. Shimm is known as the "black alkali", i.e., carbonate of soda, whereas the alkali of the Rio Grande valley is chiefly common salt and chloride of lime. It may be that the Trifoliata stock endures the alkaline carbonates, but not the alkaline chlorides.

In relation to the soils it would appear that although the oranges of the finest quality are produced on the California type, as above described, still good oranges are grown on many kinds of soils varying in character from coarse loose sand to fine silty clay, and on the whole, the matter of soil is of minor importance as compared with that of climate. In California the soil type, which is almost entirely monopolized by orange growers, appears to lie in nearly frostless regions of the foot hills.

Local Conditions.

Although as above shown the climate conditions of southern Texas indicate that the opportunity for raising citrus fruits does not compare favorably

* See California Experiment Station Bulletin 138.

with California, nor yet with certain portions of southern Florida, still the fact exists that sweet seedling oranges have been grown and fruited in Texas for many years. It is true that these trees have been frozen down to the ground, or at least severely injured from time to time, still the trees prevail and live to again produce fruit. As a general rule these old seedlings are found enjoying some local environmental condition which makes possible their continued existence. Photos taken by Professor H. Harold Hume and published in his bulletin entitled "Citrus Fruits in Texas" show sweet seedling trees growing on the banks of the Neches river near Beaumont. In this illustration the presence of forest trees are shown in the back ground. Where citrus trees are partly surrounded by taller trees they apparently derive considerable protection, as was the case in Florida where removal of the native oaks caused the death of sweet seedling trees which had attained a large size and considerable age under their protecting influence. In the same manner the effect of adjacent houses save tender trees which without the benefit of the latent heat given out by the buildings and the wind protection afforded by them



PLATE 3.

Row of orange trees bearing fruit having suffered the January freeze without injury. Bamboo tops killed by cold but nevertheless they had sheltered and protected the oranges before losing foliage. Mulberry hedge on right side of photo.

must have suffered from freezes. Further south in Texas, e.g., in the vicinity of Beeville and in another case still farther south near Raymondville, sweet seedlings have endured severe temperatures even when fully exposed. At the Linke orchard near Beeville there are nine sweet seedling trees standing on a high knoll fully exposed to the sweep of the north wind. The trees have had little care until recently and examination shows their growth to have been very slow. These trees as well as the seedlings near Raymondville which are similarly located have endured cold which destroyed partially, or entirely all, the standard oranges and pomelos of their respective neighborhoods. In the Rio Grande valley during the past winter the temperature ranged from 18 degrees F. to 21 degrees F. in different sections. Large, old sour and sweet seedling trees usually growing near houses came through with slight injury. In all cases where young budded groves were exposed to the wind and cold by their location in open and flat country the trees were killed outright or killed down to the earth mounded about their trunks. This is illustrated by the accompanying photographs showing the variety orchard at the South Texas Garden before



PLATE 4.

Orange orchard at the South Texas Garden
at the time of the January 1911 freeze.



PLATE 5.

Orange orchard at South Texas Garden after
being killed to the ground by 21.3 degrees
F. in January 1911.

and after the freeze of January 2nd and 3rd, 1911. Another illustration shows citrus trees of the same age which were protected by mulberry trees on one side and bamboo on the other. This protection enabled the trees to withstand the cold so successfully that not even the fruit buds were injured. They subsequently blossomed and the illustration shows them bearing a satisfactory crop of fruit, considering the size and age of the trees. In an orchard near Brownsville, Texas, belonging to Mr. Mendenhall, four year old oranges came through the cold with practically no injury. His orchard lies on the south bank of a large "resaca", or lagoon, perhaps one hundred and fifty yards wide. During the "norther" a steam like vapor rose from the surface of the water continuously and was driven by the wind through the orchard. There is little question but that this condition saved his orchard.

Artificial Protection.

Several orchardists have provided themselves with fire-pots as a protection against the sudden freezes which occur almost annually. In some instances attempts were made last January to protect orchards by this means and varying results were reported. The cold was accompanied by such high



PLATE 6.

Pomelos in fruit in nursery row. Same age as trees in orchard and passed through the freeze of January 1911 without injury to fruit buds owing to protection of surrounding bamboo and mulberry trees.

wind that good results were not secured in many instances. The fire-pots were given an especially good trial at Mr. W. S. Stockwell's orchard near Alvin, Texas. According to the statements of the man in charge of this orchard, the Hamilton fire-pot holds three gallons of oil and burns at the rate of one gallon per hour. The pots were burned two at each Dugat tree, twelve hours the first night, twelve hours the second night and a portion of the third night, perhaps six hours, making a total of thirty hours firing for the whole period. This would make sixty gallons of oil burned at each tree, and, estimating the cost of the oil at two cents per gallon, which amounts to a cost of \$1.20 per tree, or \$129.60 per acre of 108 trees. This pays for the material alone and does not take into consideration the initial cost of pots, plus the cost of labor for night work. It is probable that the use of fire-pots will prove too costly, unless effective wind-breaks can be used in connection with them.

The history of the early wild oranges of Florida, as well as the data collected concerning the sweet seedlings of Texas, indicates very clearly



PLATE 7.

Lemon trees at South Texas Garden. Came through the January 1911 freeze with only slight twig injury owing to adequate wind-break protection.

that the citrus becomes much more resistant to cold when adequately protected by wind-breaks. To secure sufficient shelter and wind protection, however, requires that the citrus trees be surrounded practically by leafy screens. While this is possible from the standpoint of the farmer or gardener who wishes to supply his table, or at most the local market, with fruit, it is impracticable taken from the viewpoint of the commercial orange grower. It is probable that certain growers who are happily located near bodies of water by utilizing wind-breaks and fire-pots intelligently will grow successfully, even to an extent approaching a commercial basis, several varieties of standard oranges and pomelos.

The Market.

Aside from the practicability of actually growing of fruit there is the further consideration of marketing after its production. This matter with its possible limiting effect should be especially considered in connection with the expansion of the Satsuma growing industry. The Mandarin type of oranges, to which the Satsuma belongs, has always held a favorable place in the public esteem as a fancy fruit owing to its kid

glove feature, and the fact that the sections separate readily thus allowing eating out of the hand.

However, it is doubtful whether this type of fruit could hold its own in general competition with the larger and richer standard round orange.

Professor H. Harold Hume in his book on Citrus Fruits, states, that oranges of the Mandarin type should be grown as fancy fruit only, and that the demand warrants the planting of comparatively few trees in proportion to the larger plantings of standard round oranges. He states that when due attention is given to fertilization, cultivation, grading, etc. the fruit has a place as a strictly fancy article on the American markets; inferior fruit of this type he considers worthless. Professor William A. Taylor, Acting Chief of the Bureau of Plant Industry, states, that the Satsuma, notwithstanding the long period during which it has been grown in this country both in Florida and California, has not yet reached a real carload basis in either state. There has never been a sufficient demand for the fruit in the market to justify plantings that would produce carload quantities.*

Mr. G. Harold Powell, Pomologist in

* See U.S. Department of Agriculture circular, Agricultural Conditions in Texas.

Charge of Fruit Transportation and Storage Investigations, states that the Satsuma orange from Texas would compete with the early Florida fruit (standard orange), and, also, with the Valencia Late from California. The Satsuma is an edible orange for only a short time and would therefore be at a disadvantage in competition with fruit of better quality,* - and he further says in effect, that where round oranges can be produced the Satsuma is not considered worth growing. According to the statement of Mr. Floyd S. Tenney, the commission men of New Orleans find difficulty in disposing of the oranges of Mandarin type which are produced in the delta of the Mississippi river and these men as well as others with whom he talked in St. Louis, Missouri, offer no encouragement for the successful marketing of any considerable quantity of Satsuma oranges.

Conclusion.

In view of the facts it would seem that commercial orange growing in Texas cannot reasonably be expected. Soils are in the main satisfactory but climatic conditions are not. The temperature records and actual experience prove that standard oranges, pomelos and lemons even on

* See U.S.Dept. of Agriculture circular "Agricultural Conditions in Southern Texas."

hardy Trifoliata stock are killed to the ground throughout the Gulf Coast even to the southernmost limits of the state, and the frequency of these disastrous freezes make citrus culture too precarious to interest the conservative investor. The Satsuma in the Houston-Galveston District can be grown safely and produced in any quantity which the market will take. It is simply a matter of whether or not this small kid glove orange can compete with the round oranges which are liable to be marketed at the same time. In specially favored localities in the Rio Grande Valley it is probable that standard oranges and grape fruits can be produced, even in a commercial way provided skill is exercised and all precautionary measures taken. Although the Trifoliata stock does not do well in the Valley and the Satsuma does not flourish on any other stock than the Trifoliata, still this variety can be produced on its own root (see illustration) and this will furnish a family fruit where the minimum amount of care can be given the trees.

From a domestic standpoint, the writer believes it possible for every farmer in southernmost Texas, and the Gulf Coast, to have sufficient oranges,



PLATE 8.

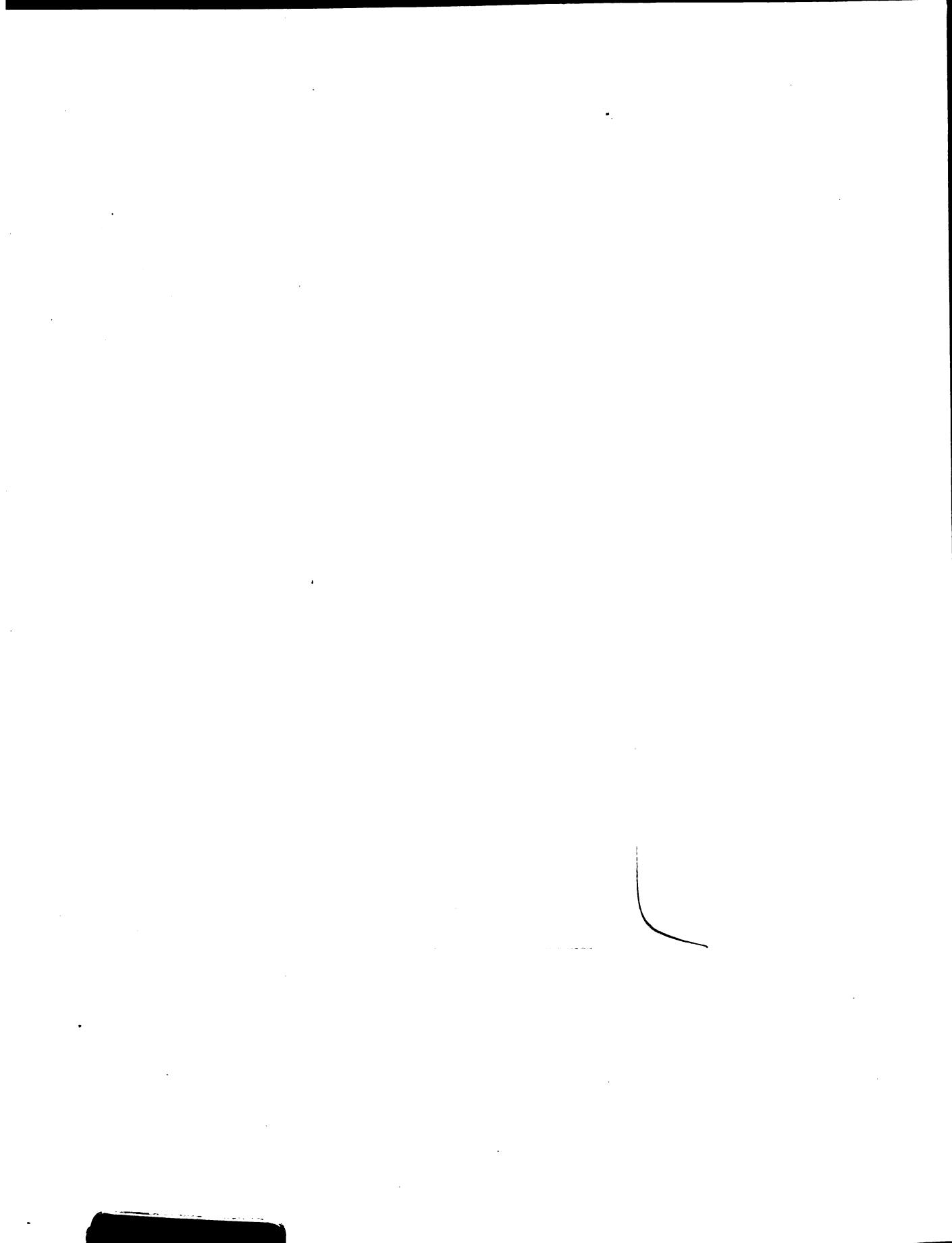
Satsuma orange trees growing in the yard of J. B. McAllen at Brownsville. They endure soil conditions and bear heavy crops of very good fruit.

grape fruits and lemons for his own table. This will necessitate full protection of his few trees by means of wind-breaks and fire-pots, and with such protection there is no question but that crops will be produced probably three years out of five.

From a commercial point of view citrus growing in Texas cannot be recommended.

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