CALIFORNIA GROVE OF WASHINGTON NAVEL ORANGES

The orange industry in California represents one of the most highly perfected and organized horticultural industries in the world, and this grove near Riverside, California, gives a good idea of how the Washington Navel is grown in that state. (Frontispiece.)

WASHINGTON NAVEL ORANGE

Important California Citrus Fruit Originated in Brazil Nearly a Century Ago,
Brought to United States in 1869—Comparison of Culture in California and Brazil—Importance of Bud Mutations¹

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THE Washington Navel Orange is one of the most interesting and important horticultural varieties in existence. The facts concerning its origin and introduction into the citrus districts of the United States and other countries are well established. The development of the culture of this variety on an extensive commercial basis has occurred well within the history of men now living. The recollections of these men concerning its early propagation, methods of planting and culture, are clear and well defined. While many of the men and women who were directly concerned in the introduction of this variety into the United States have passed away, they have, fortunately for posterity, left permanent records of some of their experiences in this connection.

The following paper is an attempt by the writer to bring together the available information concerning the origin and development of this variety. A study of the facts should be of intense interest to all plant breeders and others who are concerned in the development and improvement of our horticultural varieties. The historical data presented in this paper relating to the origin and development of the Washington Navel Orange in Brazil were collected by an expedition sent to that country by the U. S. Department of Agriculture in the fall of 1913, consisting of P. H. Dorsett, Wilson Popenoe, and the writer. The facts mentioned in the discussion of the introduction and development of the navel orange in the United States have been secured from papers and

reports in the possession of the U. S. Department of Agriculture, and from first-hand interviews with some of the men and women in southern California who took part in this work.

ORIGIN

The Washington Navel orange originated at Bahia, Brazil, as a bud sport from the Portuguese variety of orange, *laranja selecta*, or the "select orange." This variety was undoubtedly introduced by the Portuguese into Brazil very soon after the colonization of that country. According to V. A. Argollo-Ferrão,² the navel orange appeared as a bud sport of the *laranja selecta* variety and was discovered and first propagated by a Portuguese gardener at Bahia in 1822. This account of the origin of the Bahian navel orange was confirmed by all other available information. The fathers or grandfathers of some of the orange growers at Bahia were personally acquainted with the circumstances connected with the origin and propagation of this variety and this knowledge was handed down to their sons and grandsons.

From the first, the seedless fruits of the navel orange trees were highly prized by the Bahians. The superior qualities of these fruits attracted general attention. The growers of the parent *laranja selecta* variety, recognizing the importance of the seedless navel fruits, planted that variety exclusively, as soon as trees were available for this purpose. At the present time the Bahian navel orange has practically supplanted all other varieties of oranges

¹ Read before the twelfth annual meeting of the American Genetic Association on August 3, 1915, at Berkeley, Cal.

² *Inspeccoria Agricola do 11º Districta, Bahia, Brazil.*

grown in Bahia, with the exception of a sour or bitter variety, called *laranja de terra* (*Citrus vulgaris* Risso), which is grown for the production of seeds used for raising stocks. At Rio de Janeiro, commercial orchards of the *laranja selecta* variety are still cultivated by some of the farmers in agricultural districts near the capital. In the first orchard of this variety visited by the writer, a tree was found having a limb sport bearing typical navel orange fruits, while the remainder of the tree bore the regular seeded *laranja selecta* orange. Other similar cases were observed, tending to confirm the history of the origin of this variety as related by the Bahian orange growers and others. The navel orange variety in Brazil is called *laranja selecta de umbigo*, or the "select orange with the navel." This name in itself tends to confirm the established history of the origin of this variety.

NAVEL ORANGES IN BRAZIL

The Brazilian expedition found that the principal navel orange district in Brazil is that of Bahia. A few trees of this variety were found growing in the orange groves near Rio de Janeiro. We were informed on good authority that limited plantings have been made in some interior districts of Brazil, but in no case has the development of the industry reached such extent or importance as in the Bahian district. We found growing at Bahia about 50,000 bearing navel orange trees and about an equal number of trees which had not as yet reached the bearing age. A typical tree is shown in Fig. 1. Inasmuch as the trees are usually planted at the rate of about 100 per acre, there were about 1,000 acres of bearing and non-bearing navel orange trees in the Bahian district.

The development of this industry has been encouraged by the Brazilian Government, and particularly by the city of Bahia. We were told that

within this municipality there are about 35,000 acres of land suitable for planting oranges. The city has established an experimental farm for the purpose of investigating methods of propagation, culture, and handling oranges for the benefit of citrus growers. Liberal inducements are given to prospective planters in the way of long time, low rentals and facilities for transporting and selling the crops. A strong effort is being made by the municipality of Bahia to encourage an export trade, particularly to the larger cities of South America, so that the existing demand for this fruit can be supplied.

Under present conditions the culture of the navel orange at Bahia is a profitable undertaking for the growers, the fruits retailing in the city of Bahia for an average of about 3 cents each. A typical Bahian navel orange is shown in Fig. 2. The expense of clearing the land, planting the orchards, and bringing them into bearing is frequently made up by the profits from the culture of mandioca³ between the rows of orange trees. The bearing orchards are cultivated by scraping off the weeds from one to three times a year with a heavy hoe, or "enchada." About the only fertilizer used is barnyard manure. All of the growers of the larger orchards maintain dairies in connection with their farms, mainly for the purpose of securing manure for use in their orange groves. This manure is carefully conserved and is usually applied by burying it in heaps between the trees; on hill-sides it is buried some distance above the trees, usually under the drip of the branches. It was the unanimous testimony of Bahian orange growers that mottle leaf and chlorosis of citrus trees could be cured by the liberal use of manure. Insect enemies and fungus diseases are not controlled artificially except in the case of ants. The ant colonies in the orchards are destroyed by digging them out or more recently by fumigation.

³ Mandioca is the Brazilian name for the manioc or cassava (*Manihot utilisissima* Pohl., Euphorbiaceae), one of the important food plants which is native of South America. It is widely cultivated for its roots, which sometimes weigh as much as 30 pounds and are 3 feet long. They are ground up, and the bitter, poisonous juice which they contain is expelled by drying on heated plates; the resulting product is known to almost every one in the United States under the name of tapioca.

NAVEL ORANGE TREE AT HOME

Typical specimen in the grove of Col. Frederico da Costa, Matatu, Bahia, Brazil. The navel orange of California was brought from Bahia, where it is believed to have originated as a bud sport about 1826. (Fig. 1.)

The oranges are usually picked by men climbing the trees, breaking off the spurs to which the fruits are attached, and dropping them to the ground. They are then collected into heaps; assorted into two grades, one consisting of the large, and the other of the small, fruits. The fruits are then loaded into boxes or packs and carried on horse or mule-back to the markets; or in some cases the buyers come to the orchards from the city and carry baskets of the fruits on their heads to the city. The steamships that call at Bahia take a considerable portion of the crop for use on their tables. A small quantity of navel oranges is now exported to Rio de Janeiro, Buenos Aires, and other South American cities, but not enough,

we were informed, to supply the demand in those cities for this variety.

The navel orange orchards at Bahia are located on the higher lands and are given no irrigation—the annual rainfall at Bahia is about 50 inches a year, so that under normal conditions irrigation is not needed. We were told that in dry seasons the crops were comparatively light, while the best crops are produced during the wet seasons. The principal crop ripens in May, June and July, a period corresponding to our winter or the California rainy season. Another crop ripens in December, January and February, while on some of the trees ripe fruits are found the entire year. Our observations in this connection led us to the conclusion that

NAVEL ORANGE OF BAHIA

This fruit is a good sample of the navel orange as it still grows at the place of its origin. The skin is relatively thin and the navel rudimentary. Its quality is very good, although investigators differ on the question of whether the navel orange at Bahia is a fruit superior to the navel orange of California. (Fig. 2.)

this habit of fruiting was characteristic of certain types of the navel orange, one type having the habit of ripening its fruit in the winter, another type bearing ripe fruits in the summer, while a third type bears ripe fruits throughout the year, similar to the habit of the Eureka variety of lemon in California.

INTRODUCTION TO UNITED STATES

The Bahian navel orange was introduced into the United States through the efforts of the late William Saunders, Horticulturist and Landscape Gardener for that division of the Patent Office corresponding to the present United States Department of Agriculture. In his reports on this project, he mentions the fact that he learned from a woman correspondent of the existence of a seedless variety of orange at Bahia, about 1868. Through correspondence with the American consul at Bahia, Mr. Saunders secured a shipment of the seedless orange trees, but during the long voyage from Bahia to New York the trees died. Mr. Saunders again wrote the American consul and asked for another shipment of these trees, giving minute directions for the packing of them and their care in transit. Preparatory to the arrival of this second shipment, Mr. Saunders secured some seed from oranges in the Washington market and grew seedlings in the Government greenhouses. When the second shipment of trees arrived, they were in poor condition, but some buds were found to be alive: these were transferred to the seedlings in the greenhouse and a number of orange trees were successfully grown in this manner.

A former neighbor of Mr. Saunders in Washington, residing in Riverside, Cal., Mrs. L. C. Tibbetts, learning of the success of this introduction, wrote to Mr. Saunders asking for some of the trees. When the trees were ready for distribution in 1873, two were sent to Mrs. Tibbetts and most of the remainder to Florida, which was thought to possess more nearly ideal conditions for the growth of this variety. The two trees received by Mrs. Tibbetts were planted in her dooryard and were carefully tended by her personally until they

came into fruiting. When the first fruits ripened on these trees, Mrs. Tibbetts invited her neighbors to assist her in testing them. These neighbors and Mrs. Tibbetts decided that this orange was superior in many respects to any then grown in Southern California and made every preparation to propagate this variety as rapidly as possible. Further experience confirmed the judgment of these pioneers, and as a result, the navel orange soon achieved a wide reputation on account of its superior quality, seedlessness, and other valuable characteristics. The trees sent to Florida proved to be somewhat unsatisfactory, particularly on account of low production in comparison with other varieties then grown there. While a small acreage of navel oranges is cultivated in Florida, this variety has never achieved any great commercial success or importance in that State.

ORIGIN OF THE NAME

Mr. Saunders distributed the navel orange trees under the name of the Bahian Navel orange, marking the origin of this variety in Bahia. The first important commercial orchards planted in California were grown near Riverside, and for a time the variety was known locally as the Riverside Navel orange. Later the successful introduction of this variety into other districts in California led to a general discussion of an appropriate name for the variety and at a public meeting called for this purpose, the growers united upon the name of the Washington Navel orange for the variety. This name was adopted in recognition of the fact that the variety was introduced and the first trees in this country were propagated by the Agricultural Department at Washington, D. C.

DEVELOPMENT OF THE INDUSTRY

The general introduction and development of the navel orange industry in California has occurred within the last forty years. From the two original trees planted by Mrs. Tibbetts in 1873, which are still living and producing fruits at Riverside, the industry has grown in California until at the present

NAVEL ORANGE OF CALIFORNIA

The skin of the California product is thicker than that of the Bahia fruit, the navel is much more highly developed, and the fruit has also a much higher and warmer color, externally, than does the orange of Bahia. Some of the changes that have taken place in it, during the forty years since it was introduced, may be ascribed to differences in climate and soil; others are imputed to further bud mutations. (Fig. 3).

time there are about 100,000 acres of this variety cultivated in the State. A typical Washington navel orange is shown in Fig. 3; a typical productive form Washington navel tree is shown in Fig. 4; and a typical Washington navel orange grove near Riverside, Cal., is shown in the frontispiece. The crop of navel oranges is about 25,000 carloads of fruit each year, containing about 10,000,000 boxes of oranges. From California, trees of this variety have been sent to Japan, Australia, South Africa, and other foreign citrus districts. In those regions the variety has become commercially important and its culture is being rapidly extended, so that it is becoming one of the leading citrus varieties of the world. The Washington navel orange in California has been the foundation upon which the citrus industry as a whole has been developed.

METHODS OF PROPAGATION

The methods of propagation of the Washington navel orange in California are similar in many respects to those practiced at Bahia. In California the variety is usually budded upon stocks from the Mission Sweet Seedling orange. In some districts it has been propagated upon stocks grown from grapefruit, the Florida sour orange, and the Florida rough lemon seeds.

TYPES FROM BUD MUTATIONS

In 1909 the writer began a series of observations on the behavior of this variety under different soil and climatic conditions in California. In the study of these trees, it was found that numerous diverse types of trees and fruits existed. Some of the striking types of trees were distinguished by their habits of growth, density of foliage, and other easily discernible characteristics. A close study of some of the trees disclosed the fact that they bore characteristic fruits. The variation in these types of the Washington navel orange, both as regards trees and fruits, was so marked that it was thought for a time to be due to a mixture of varieties. Later it was discovered that frequently

trees grown from a single navel orange bud produced several characteristic types of fruits. In some cases this variation was found to occur as limb sports, in which case both the fruits and foliage on these sporting limbs were characteristic of the types to which they belong. In other cases these variations were found as single fruits.

IMPORTANCE OF TYPES

Systematic investigation of this subject was begun about this time for the purpose of discovering the extent and importance of the diversity of types arising from bud mutations. Plots of about 100 trees each were selected in representative orchards and careful performance records secured from each tree in these plots. After six years' systematic study, conclusions can be safely drawn as to the significance of bud mutations and the importance of the types of the navel orange originating from these mutations. It has been proven that the diverse types of the navel orange existing in the California orchards have originated from bud sports. The trees of these types have characteristic habits of growth and the fruits borne by these trees are of very widely differing commercial value.

FREQUENCY OF BUD MUTATIONS

The occurrence of these diverse types is very much more frequent than has heretofore been supposed to be the case. They are of great and vital importance to the growers from a commercial standpoint. One of the characteristics of some of the unproductive and undesirable types of trees is unusual vigor of growth. Frequently these trees stand out in orchards several feet in height above the neighboring trees and have a spread several feet in excess of that of the standard tree. These inferior trees also frequently produce an unusual number of so-called suckers, or very vigorous vegetative growth, which has heretofore been highly prized for propagation. As a result of this condition, there is little doubt but that in the successive propagations of the past years, an increasingly large proportion

CALIFORNIA NAVEL ORANGE TREE

The culture of the crop in southern California is in most respects very markedly different from that in Brazil. The trees usually get better care, more fertilizer and abundant irrigation, and therefore are likely to produce a larger yield than those in Brazil. (Fig. 4.)

of the trees have been propagated from the more vigorous growing, and as a matter of fact, least desirable type of trees for fruit production, both as regards quantity and commercial quality of the crop. In other words, there has been a steady deterioration in the characteristics of production of the variety from the propagation of these inferior and undesirable fruiting types.

Performance records of typical trees of the eleven common types of the Washington navel orange under comparative conditions for six years have established fairly well the behavior and the value of the trees of these types. The undesirable types, without exception, have been successfully top-worked, using budwood from select trees of the best types. The select

"AUSTRALIAN" NAVEL ORANGE

This peculiar form of the Bahia Navel seems to be the product of a bud sport or mutation similar to the one that produced the original seedless navel. The branch here shown is from a standard Bahia Navel orange tree in the grove of Col. Frederico da Costa, Matatu, Bahia, Brazil; similar specimens can be found in almost any part of the world where the variety is grown. On the whole, this "Australian" mutation is inferior to the standard type which produces it, and wise growers therefore do not propagate from buds of limbs bearing this sort of fruit. (Fig. 5.)

trees of the best types have also been topworked with budwood from the undesirable types, successfully demonstrating without any possibility of doubt that it is possible to transfer type characteristics from one tree to another by the use of buds selected on the basis of performance records. Propagations have been made from all of the common budsports and these propagations have been so successful as to prove the fact of the origin and development of these diverse types from bud mutations.

At the present time there are extensive commercial individual tree performance records being kept by navel orange growers in California for the

purpose of locating the drone trees of the undesirable types. These inferior trees are being rapidly topworked, using budwood from trees selected on the basis of performance records. Some of the leading nurserymen have adopted the principle of propagation from select trees, propagating only from those trees producing large, regular, and valuable crops of the standard or best type of fruit as shown by actual performance records. It has been commercially demonstrated in this way that a valuable type of the navel orange can be isolated through bud selection based on performance records.

It is also believed as a result of the

evidence accumulated in the course of these observations, that the variation in this type can be controlled by bud selection, so that by this means the variety can be conserved, maintained, and improved.

In the consideration of the practical problem of maintaining the navel orange variety by bud selection, it has been found necessary not only to select trees from definite individual tree performance records, but also to make limb selections as well. This is done by cutting the budwood from the select trees with the ripe fruits attached and using only budwood from the limbs which produce the typical or standard Washington navel orange fruits. This budwood is of the preceding year's growth and while it is of small size, has been successfully used commercially. The buds from this source have been found to produce equally good if not better trees than those propagated from the larger and more rapidly growing wood.

TREE RENEWAL

Of the observations made in the navel and other orange districts of Brazil, one of the most interesting to the writer was the method of tree renewal practiced by the orange growers. We found existing a general belief that after fifteen or twenty years orange trees became unproductive and unprofitable. In such cases the tree tops are cut off and new tops grown from the old trunks. In the case of badly diseased and dying trees, they are cut back severely, sometimes to a point just above the bud union. Where the trees were in fair condition of vitality but decadent, only the smaller limbs are cut off, leaving the main limbs as a framework for the growth of a new top. The amount of tree top cut off is governed by the condition of the trees. The renewed trees were found to be surprisingly healthy, vigorous-growing, and productive. Many of the orange growers claimed that the fruits borne by these renewed trees were of better quality than those borne by original trees.

In consequence of this practice of

tree renewal, no very old navel orange trees were found; the oldest was said to be about 40 years of age. However, in some cases, evidence was discovered where such trees had been renewed as many as four times, indicating that the trunks were from 60 to 80 years of age.

The method of tree renewal practiced by the Brazilian navel orange growers is chiefly of interest in that it tends to confirm the soundness of the principle of pruning based on the systematic renewal of the fruit-bearing wood in citrus trees.

BUDDING

Another interesting practice observed in the Bahian navel orange districts was the budding of stocks set in permanent orchard places. While the general method of propagation followed in the past at Bahia has been that of the ordinary nursery, the majority of the newer orchards were found to be propagated by budding the stocks in place. Certain advantages for this method of propagation are claimed by the Brazilian orange growers: *e.g.*, a more rapid growth of the budded tree, earlier fruiting, and greater resistance to diseases, as compared with the ordinary transplanted nursery trees. The stocks are budded higher than is the usual practice in this country—15 or 20 inches above the ground, and are usually about two years old when budded. The budding is done at all times of the year, but is said to be most successful during November, December, and January, the spring and summer seasons in Bahia. A shield bud is used as a rule, the budsticks being about the same size as the stocks to be budded.

BUD VARIATIONS

Bud variations were found in the Bahian navel orange, but apparently are not so frequent as in the California Washington navel orange trees. Distinct types of trees, as shown by habit of growth and other characteristics, were observed in all the orchards examined. On individual branches, leaf variations were very frequent. For instance, the variation of the petiole was particularly noticeable. The petiole

of neighboring leaves varied from broadly winged to wingless, winged on one side and wingless on the opposite side, very small to very large, and from one to three sets of wings. On one of the standard type Bahian navel trees, a sporting branch was found bearing typical flattened and wrinkled so-called Australian navel fruits, as shown in Fig. 5. One entire orchard of several thousand trees was observed planted to the Australian type of navel orange.

In one orchard we found well-established instances of reversions of the navel to the selecta variety of orange. In this orchard the owner, Col. Luiz de Suze Demetrio, one of the leading navel orange propagators of Bahia, told us that three typical fruiting *laranja selecta* trees in his orchard were grown from buds cut from a navel orange tree and propagated on sour orange stocks by himself.

Variability in time of ripening fruits, size, shape, navel characters, color, thickness of rind, amount of juice, character of rag, quality, and other characters, were particularly marked. To the writer, the most interesting observation in this connection was the variation in time of ripening the fruits, indicating the possibility of controlling this character in some measure through bud selection.

Most of the types of navel oranges found in California were observed in the orchards at Bahia.

It may be of some interest to note that the writer has found several of these typical budsports in the fruits produced by the two parent Washington navel trees at Riverside.

In a consideration of the factors involved in the successful development of the navel orange industry in California, the work of the pioneer orange planters must not be overlooked. These men and women settled in a desert. All of the problems incidental to bringing under cultivation this arid land were met with sublime courage, intelligence, and resourcefulness. Most of the settlers were fresh from plentifully watered, fertile lands and established conditions of eastern agricultural sections. The taming of the sagebrush lands, the development of water for irrigation, the discovery of new methods of culture to meet new conditions, needed iron determination and strong faith. How well these pioneers succeeded is shown by the wonderful orchards, perhaps the most perfect of all time, the beautiful homes nestling in the orange groves, and the highly cultured people who are enjoying the results of the efforts of the pioneers. It has been said that the man who causes two blades of grass to grow where one grew before is a public benefactor. What can we say of these pioneer orange growers who caused beautiful and useful orchards to grow where nothing grew before?

Berkeley Meeting of A. G. A.

More than 300 persons attended various sessions of the twelfth annual meeting of the American Genetic Association at Berkeley, Cal., August 2-6.

Two general sessions were held, while those interested in plant breeding met in three sessions and eugenics had one session. The program of every session was crowded.

As many of the papers as possible will be printed in the JOURNAL OF HEREDITY; the rest will appear in various other publications to which they seem most adapted.

It was decided to continue meeting in connection with the American Association for the Advancement of Science.

A Committee on Nomenclature was appointed by the presiding officer, Dr. E. B. Babcock, consisting of Herbert J. Webber, Chairman; R. Ruggles Gates, George H. Shull, W. E. Castle, Raymond Pearl, H. S. Jennings and Paul Popenoe.