

# Freeze Injuries to Citrus

## tests during 1949 reveal facts important to growers of Valencia oranges and Marsh grapefruit

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**Valencia oranges and Marsh grapefruit** showed a remarkable recovery from the effects of the freezes of the winter of 1948-49.

Tests extending from February 28th through October 10th, 1949, were made on oranges picked and analyzed from predetermined plots every two weeks, in addition to general observations, storage tests and separator tests. The following statements refer to Valencia oranges, except where the grapefruit is specifically mentioned.

There were variations in the results of tests on the fruits from the different plots but, as a rule, the percentage of freeze injury in the fruits decreased as the season advanced.

Many more segments were frozen in the stem end than in the center of both Valencia oranges and grapefruit. To determine accurately the extent and severity of freeze injury, both stem end and center cuts were made.

Some of the early characteristics of freeze injury to the pulp, such as a water-soaked appearance, a gray or milky color and hesperidin crystals usually disappeared within one to three months. The same held true for gelatinized juice sacs, except in fruits that were badly frozen.

Wavy segment walls and the light yellow grainy or granular condition of some of the vesicles showed no tendency to disappear.

Where a portion of a segment or even one or two entire segments were killed and the shrunken tissues left hollow spaces, the remaining noninjured seg-

ments enlarged and partially or completely filled the spaces.

The presence of surface injury on the peel was the exception rather than the rule. Excessive peel thickness was not a common characteristic of the frozen fruits examined. Evidence of albedo—white portion of peel—injury was exceptional.

The average volume in milliliters of juice per fruit and the percentage of juice per fruit on a weight basis, for both non-frozen and frozen fruits, increased as the season advanced, with the possible exception of the last test, made on October 10th.

Total soluble solids and total sugars increased in both nonfrozen and frozen fruits from the time of making the first test in February until about the middle of August and then began to decrease. Juice volume, total soluble solids and total sugars were always greater in non-frozen than in frozen fruits.

Total free acids decreased rapidly in both nonfrozen and frozen fruits from February 28th to April 25th. They decreased very little after the latter date. In several instances they temporarily increased.

Granulation in the 1949 crop of Valencias was much less severe than in most years. This situation is of special interest because many growers and others have been of the opinion that granulation is caused by low temperatures.

Under the conditions which prevailed during the spring, summer and early fall of 1949, mature Valencia fruits in the plots remained on the trees from early

May until the middle of August without showing a decrease in quality. There was a small decrease in quality from the middle of August to October 10th, the date of the final picking.

Freeze injury in the Marsh grapefruit tests, based on number of frozen segments, was much more severe on those borne on the outside of the tree than on those borne on the inside.

Concentrations of total soluble solids and total sugars were higher in nonfrozen than in frozen Marsh grapefruits, whether borne on the outside or the inside of the tree.

There were no consistent differences in the concentrations of free acids among the grapefruits, whether frozen or non-frozen or borne on the outside or inside of the tree.

Response of nonfrozen and frozen oranges and grapefruits to the effects of the different temperatures and humidities in the cold storage room and in the large, aerated room were not great enough to outweigh the natural differences that are always found in a series of samples from different sources.

Measurements of specific gravity of the oranges and grapefruit and measurements of juice on both a volume and a weight basis showed the X ray and water separation of nonfrozen and frozen fruits to be more efficient than separation by hand at the grading belt.

Weather conditions following the nights of low temperatures were such that there was appreciable recovery in a rela-

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### BITTERNESS

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Juice produced from fruit grown on the sour orange and sweet orange rootstocks were only of fair quality initially and developed the stale flavor of preserved juice very rapidly.

The fruit grown on the rough lemon rootstock resembled the others in appearance and size, and were their equal in this respect, but the juice was very different organoleptically—in composition as it effects flavor. In addition to the rapid development of bitterness it possesses little to no orange aroma and flavor and becomes stale quickly on standing.

From an over-all general quality standpoint the trifoliolate orange rootstock produced fruit which yielded juice that was consistently ranked superior in these tests.

These tests appear to open up a new field for study. They further indicate the necessity for cooperative investigation in horticulture and its related branches particularly in studies involving the development and introduction of new varieties or the reevaluation of old varieties. No longer can studies involving size and shape of tree or vine, yield of fruit per acre, disease resistance, climatic adaptation, its behavior during shipment, etc., serve solely to evaluate a variety. Studies

involving organoleptic evaluation of the fresh product and its ability to retain its desirable organoleptic properties and structure during the many different methods of preservation now possible, must be included in the general plan. Specialists trained in genetics, plant physiology, horticulture and food technology or enology should team together in their work.

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lyzes. There are, however, commercial dust mixtures available in which little deterioration of the tetraethyl pyrophosphate occurs within a period of several weeks after they are prepared. Only such products should be used, because to approach satisfactory control practically all the aphids in a treated field must be killed.

## Effect of DDT

It has been generally recognized that applications of DDT to melons on many occasions have resulted in an increase in the aphid population. However, it is desirable that a program be developed in which DDT can be used because it is so effective against *Diabrotica* beetles and the melon leafhopper, *Empoasca abrupta* De Long. Both of these insects are very destructive to melons and if not controlled may greatly injure the crop. During 1948 and 1949 extensive investigations were conducted and it was found that under some conditions DDT can be applied without resulting in a severe loss from aphids. On numerous occasions the environmental balance was not adversely affected. It is certain, however, that the amount of DDT used should be held to a minimum and treatments should be properly and thoroughly applied so that both the *Diabrotica* beetles and the leafhopper are nearly eliminated from the field. However, in order to guard against complications frequent applications of DDT to control these insects should be avoided. During the early stages of growth a material such as cryolite should be used to control *Diabrotica* beetles. Later when the leafhopper population develops to a level to justify control, an application of DDT can be made. It was found that 30 pounds of a 3% dust or a spray containing approximately two pounds of 50% wettable powder per acre will adequately control the leafhopper as well as any *Diabrotica* beetles present. Such a practice need not result in a serious dislocation of the environmental balance. During the 1949 season insect population trends were followed in a number of fields that received a DDT treatment. Subsequent to treatment in fields at Brentwood, Contra Costa County, and at Woodland, Yolo County, there was an increase in the aphid population, followed rather closely by an increase in the predator population. Although the aphid population showed evidence of becoming destructive the threat failed to develop because of the rapid rise in the predator population. The end result was almost perfect biological control. Of the predators present ladybird beetles appeared to be the most important. They were able to establish themselves in the fields rather shortly after the DDT was applied. For example, at Brentwood a 3% DDT dust was applied on July 25th and yet four weeks

later the predator population had risen to a sufficiently high level to clearly indicate that it was going to suppress the aphid population. Another example was encountered at Woodland where a melon field was treated with a DDT spray on July 27th. No aphids were observed in a survey conducted on August 5th, but a survey one week later revealed the beginning of an infestation, which gradually increased until September 2d. At this time there were localized areas of severe infestation, but these spots were heavily populated with predators and the aphid population was practically destroyed within the next 10 days. The above illustrations clearly demonstrate that predators are able to establish themselves in a field within a relatively short time after it has been treated with DDT.

The rapid rate at which the predator population increases under favorable conditions is truly remarkable, and if the host population has reached a fairly high level just before it is suppressed the predators are present in great abundance. However, once the aphid is controlled there is a tendency for a rapid dispersal of the predators, and they largely leave the field. Where it is evident that natural enemies are in a position to control the aphid, applications of insecticides that are likely to destroy the environmental balance should be avoided, if this is at all possible.

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## JUICE

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Potassium in juice was increased by the fertilization with potassium.

At Riverside, the application of potassium in the fertilizer caused a significant decrease in the calcium content of the juice. The application of phosphorus also reduced the calcium. When phosphorus and potassium were applied together, the decrease in calcium content of the juice was highly significant. The application of manure likewise reduced the calcium content, and high nitrogen from calcium nitrate failed to increase the calcium content. At Claremont, these treatments caused no significant differences in the calcium concentration in the juice.

## Correlations

It was found in the Riverside and Claremont experiments: 1, that a negative correlation existed between the phos-

phorus content and the acid content of the juice; 2, that a positive correlation existed between the potassium content and the total acid content of the juice; 3, that a positive correlation existed between the phosphorus content of the juice and the percentage of juice of the whole fruit; and 4, that the ascorbic acid content of the juice was negatively correlated with the concentration of phosphorus in the juice.

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## FREEZE

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tively large percentage of the freeze injured fruits. The weather conditions were also such that the concentration of soluble solids in the juice did not become so high and the acids did not get so low as in most years.

Young, immature, freeze-injured citrus fruits make a more nearly complete recovery than mature or nearly mature fruits. Under southern California conditions therefore, Valencia oranges, immature lemons and Marsh grapefruit have a better chance to recover than Navel oranges which are usually mature at the time of the low temperatures.

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*The detailed results of this investigation will appear in the near future in the form of a University of California Bulletin.*

## SUGAR BEET

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night temperatures, as well as day temperatures, must be considered in growing a crop of sugar beets successfully at a high nutrient level.

At harvest the beets in this experiment will be analyzed for their sugar content and perhaps the results of the sugar analyses will be as startling as the differences observed in the growth of the beet plants themselves.

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