# Orange Fruit Size and Yield

## 31-year study of interrelationship of temperatures and orange fruit size and yield indicates influence of some climatic factor

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**Of the principal citrus areas** of the world, only California seems to have a serious problem in small sizes of orange fruits.

The differential between fruit sizes in California and other areas has not been accounted for on the basis of the nutritional status of the tree or on the basis of some specific soil condition.

A previous study of the fruit-size problem in California during the period from 1932 to 1952 revealed that there were marked and simultaneous shifts in Valencia orange fruit size in 12 major southern California citrus districts. The close similarity in yearly fluctuations in these districts suggests that climatic factors may be a chief cause of size variations.

Strengthening this point of view is the fact that the size-fluctuation patterns of Valencia oranges in Tulare County—where the climate is considerably different from that of the south coastal area—are much different from the patterns in south California. Other studies have also suggested a relationship between fruit size and weather in California.

To obtain more information about temperature effects upon orange production in California, a statistical analysis was made of the relationships between mean monthly temperatures and size and yield of navel and Valencia oranges.

The data used in this study were obtained from records of an East Highlands orchard which includes 487 acres of navel orange trees about 55 to 60 years of age, and 106 acres of Valencia orange trees about 45 years of age, as of 1953. The orchard continued under the same management during the period of study, and the practices followed are considered to be those of a good program for the district.

Records for size and yield for navel oranges cover the period from 1914 to 1953, inclusive. Size data for Valencia oranges cover the period from 1917 to 1953, while the yield records are for the period from 1921 to 1953. During the crop years of 1918, 1937, and 1949, complete records were not available owing to excessive heat in the summer of 1917 and severe freezes in 1937 and 1949.

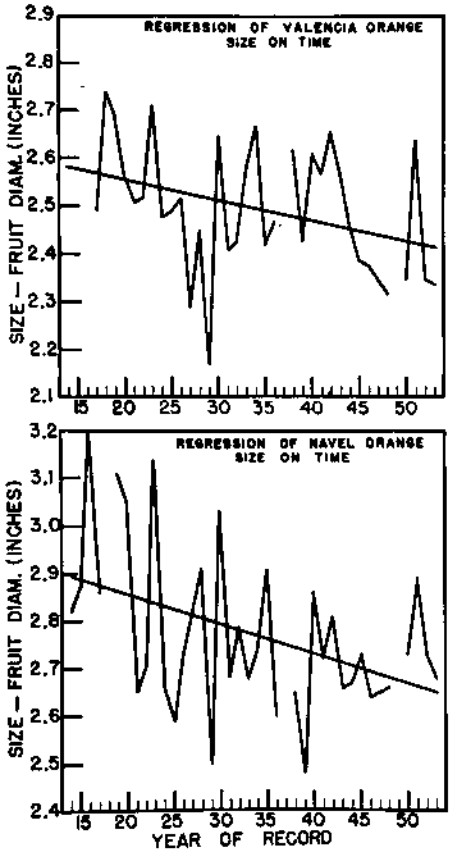
To facilitate a study of the relationship of Valencia and navel orange size and yield to temperature, the same period of record, 1921 through 1953, was used.

Diameter measurements of the oranges were made, so far as possible, on fruit from the same trees from season to season.

Mean monthly temperature records of the United States Weather Bureau for Redlands, California, were used in the statistical calculations, and—since East Highlands is only about four miles from Redlands—it is assumed that the temperature records are applicable.

The climate of the East Highlands area may be classified as the Mediterranean type. The winters are usually mild, with a modest amount of rain. The summers are warm to hot and nearly dry. Because the average annual rainfall of about 16″ is not enough to support tree growth, an additional 20″ to 30″ of water are applied annually by irrigation.

**Linear time trends of Valencia orange sizes from 1917 to 1953 and of navel orange size from 1914 to 1953**




**Average Mean Monthly Temperature (°F) at Redlands, Based on Data 1920 through 1952.**

| | | | |
|---|---|---|---|
| January | 50.2 | July | 76.3 |
| February | 52.5 | August | 76.1 |
| March | 55.4 | September | 72.3 |
| April | 59.3 | October | 64.8 |
| May | 64.3 | November | 57.8 |
| June | 69.3 | December | 52.3 |

## Time Trends

An earlier study of the same orchard showed a significant downward trend in fruit size of both Valencia and navel oranges over a period of years. Five years of additional current information were used in this study, and time trends were fitted to the size data for both Valencia and navel oranges.

The decrease in fruit size—in this orchard—of both Valencia and navel oranges has not been limited to recent years but has been a steady trend since the trees came into production. If this is generally true of other orchards in southern

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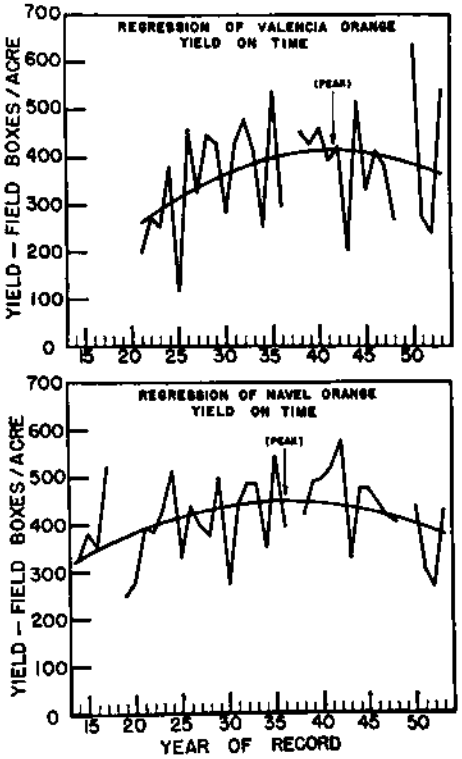
**Time trends of Valencia orange yields from 1921 to 1953 and of navel orange yields from 1914 to 1953 and their representation by polynomials of the second degree.**



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California, it would appear that the maturation of orange trees in this area is a contributing factor in the small-size problem. The decrease in fruit size with time may be a result of the physiological aging of the tree, or such factors as changing soil conditions, increased incidence of disease, increased competition between trees as they grow in size, or a combination of factors.

In the subject orchard, both navels and Valencias showed a gradual yield increase to a peak, followed by a downward trend in yield.

For Valencias, the peak occurred in 1941 when the trees were 30 years of age, whereas the yield peak of the navels occurred in 1936, at a tree-age of 35 years.

This pattern of yield—if it is a real characteristic of aging orange trees in California—may have an important bearing on the decline in yield noted in recent years. The orange trees in southern California may have passed their peak age of production and may be on the downward trend. Further study is needed to verify this pattern of production for southern California in general.

Orange fruit size and yield values used in this study were adjusted to take into account the time trends.

## Fruit Size and Temperature

A comparison of temperature data with those of size and yield shows the effect of the total phenomena associated with temperature and not necessarily the effect of temperature itself. For example, high temperatures in southern California are often associated with low relative humidity, and computed temperature responses may actually be due to associated humidity.

By using a statistical technique which describes the relationships between orange fruit size and temperature at any time during the growing season, it was found that from June following bloom and continuing through January, temperatures warmer than average are positive in their effect on navel fruit size. The six largest fruit-size years for navel oranges were all associated with warmer than average temperatures for the period of June through January following bloom, while the nine smallest fruit-size years had cooler than normal temperatures during this period. Warm fall and early winter temperatures seem to be particularly important for large sizing of the navel. Maximum benefit from warmer than average temperatures seem to occur in October. Temperature variations previous to bloom appear to be relatively unimportant in sizing of the navel orange.

Warm fall and early winter temperatures also appear to be of primary importance in sizing of Valencia oranges. Seven of the nine largest fruit-size years were identified by warmer than normal temperatures for the period of October through January subsequent to bloom, while seven of the eight smallest fruit-size years had cooler than normal temperatures during this period. The time of maximum benefit from warmer than normal temperatures for Valencia oranges is late November through early December. In the Redlands area—for both varieties—the time of maximum benefit from warm temperatures corresponds to the time when the fruit is usually changing from a green to an orange color.

Small sizes for Valencia oranges were especially critical from 1945 to 1953, except the year of 1951. All years of small sizes during this time were accompanied by cooler than normal temperatures in the critical period—October through January. The only large-size year, 1951, had above-average temperatures for this four-month period.

The study also suggests that in the Redlands area, cooler than average temperatures for the entire twelve-month period from September preceding bloom through August following bloom are conducive to larger sizes for Valencias. Seven of the ten largest fruit-size years had cooler than average temperatures for this period, while nine of the eleven smallest fruit-size years were identified by warmer than normal temperatures during this period. However, it was found that the temperature effects previous to bloom are relatively small compared to temperature effects after bloom.

The yield data in these studies were treated in the same statistical manner as the size data, but no significant statistical relationship—between mean monthly temperatures and orange yield—was found.

**The Relationship Between Orange Fruit Size and Temperatures Above and Below Average During Certain Periods of the Year in the Redlands Area.**

| | Valencia oranges | | | Navel oranges | |
|---|---|---|---|---|---|
| | Temperature departures | | | Temperature departures | |
| | Year | Sept.–Aug. | Oct.–Jan. | Year | June–Jan. |
| Years of largest size | 1951 | +0.36 | +3.11 | 1923 | +0.97 |
| | 1942 | −0.20 | −0.07 | 1930 | +2.60 |
| | 1934 | −1.79 | +2.58 | 1951 | +1.05 |
| | 1923 | −0.89 | −0.35 | 1935 | +0.10 |
| | 1938 | −0.78 | +1.78 | 1940 | +0.95 |
| | 1940 | −0.44 | +1.91 | 1928 | +1.10 |
| | 1930 | +0.46 | +3.26 | | |
| | 1943 | −0.34 | +1.13 | | |
| | 1941 | +1.09 | +0.66 | | |
| | 1933 | −2.07 | | | |
| Years of smallest size | 1929 | +1.14 | −0.90 | 1929 | −0.06 |
| | 1927 | +1.43 | +1.56 | 1939 | −0.36 |
| | 1948 | +0.67 | −0.52 | 1925 | −0.41 |
| | 1931 | +1.80 | −0.37 | 1921 | −1.85 |
| | 1947 | +0.37 | −0.92 | 1924 | −0.60 |
| | 1950 | −1.72 | −0.23 | 1936 | −0.02 |
| | 1953 | −0.85 | −0.45 | 1922 | −0.15 |
| | 1932 | +1.15 | −3.77 | 1931 | −0.58 |
| | 1928 | +0.94 | | 1933 | −1.82 |
| | 1935 | +1.90 | | | |
| | 1952 | +0.64 | | | |

## Apparent Differences

This study suggests that during the spring and summer months following bloom, warmer than normal temperatures are favorable for sizing of the navel but unfavorable for sizing of the Valencia. It is difficult to resolve this apparent difference in the temperature requirements of navel and Valencia oranges for this period.

The harvest period for navel oranges in the East Highlands orchard studied is during January through April; therefore, most of the crop is harvested before the next crop is set. With Valencia oranges, however, harvest begins in June and continues until September, occasionally extending into October. Under these conditions, the tree is supporting two crops of fruit from April through September. Some physiological mechanism may be operative in such a situation to make cooler than average temperatures more favorable for larger sizes in the new crop. With one crop only on the tree, the photosynthetic-respiratory ratio may increase with rising temperatures in the spring and summer period, whereas when two crops are on the tree during this period, this ratio may decrease with rising temperatures. In the latter case, warmer than average temperatures would put the new crop at a disadvantage, because less food would be available for fruit growth.

The overlap of crops in Valencia is characteristic of many of the California citrus districts, but does not occur to any great extent in Tulare County, or in the hot desert regions of California, or in the other principal citrus areas of the world.

The present study indicates that warmer than average temperatures in the Redlands district would result in larger fruit for the navel orange. It also suggests that—for Valencia oranges—warmer than average temperatures for the fall and winter period should result in larger fruit.

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