vented them from declining. In one instance, a soil treatment with a mixture of parathion and benzene hexachloride in water gave a significant reduction of 50 percent in the total nematode population of the roots. However, the trees have not yet shown any beneficial effect. In another case it appeared that trees treated with 5 or 3 pounds per tree of benzene hexachloride (6 percent gamma isomer) on the soil and disced in, did not show as much decline as adjacent non-treated trees. However, there has been no satisfactory recovery from any of the treatments to date.

Summary

A survey of 387 groves during the past five years showed that the four major causes of decline were spreading decline, root rot, foot rot and water damage and that these caused decline in 81 percent of the groves examined.

There are seven factors that influence the occurrence of root rot: water relations, age of tree, rootstock pH of soil, type of soil, storm damage to roots, and lightning injury to roots.

A total of 93 groves have been observed in which spreading decline is present. The yearly rate of spread is accelerated by a reduction in rainfall between October 1st and June 1st. Among those groves previously classified as spreading decline, a total of 23 groves can now be classed as slow decline and are definitely associated with the citrus nematode Tylenchulus semipenetrans Cobb. The exact cause of the condition in typical spreading decline groves is not known.

Experiments on the control of spreading decline involving 1198 trees and an additional 18 acres of grove where the trees were removed have not shown any beneficial results to date. However, in some instances it is too early for a final answer.

LITERATURE CITED


ARSENIC SPRAYS ON GRAPEFRUIT IN RELATION TO THE NEW CITRUS CODE

Herman J. Reitz
Citrus Experiment Station
Lake Alfred

The grapefruit maturity regulations which were in effect from 1939 through the 1948-49 season set certain minimum for soluble solids, ratio of soluble solids to titratable acid, and juice content. In actual practice it was found that the minimum soluble solids requirement was so low that nearly all grapefruit easily met this requirement, and juice content was a factor infrequently. In the majority of cases the ratio requirement determined the time of legal maturity of grapefruit.

Under this combination of legal restriction and fruit characteristics, the use of arsenic to produce early legal maturity of grapefruit was extensive. Since ratio was commonly limiting and since arsenic raises the ratio by decreasing the acidity of the juice, high concentrations of arsenic were used in order to obtain the legal minimum ratio by the time the minimum juice content was obtained.

The place which arsenic has held in the grapefruit production picture was thus created for it by the passage of grapefruit maturity laws in which low ratio commonly restricted shipments of fruit in the early part of the season. Whenever similar legislation exists, there will be a place in the production program for the use of arsenic to extend the early part of the grapefruit shipping season. When new maturity legislation is enacted, the regulations must be examined to determine how they modify arsenic use.

The Florida Legislature in 1949 combined all citrus legislation into one bill, and incorporated many changes into the maturity regulations. In relation to grapefruit there were two general features which deserve
Table 1.*

Time of Maturity and Quality of Grapefruit from Citrus Experiment Station, Block IX, Over A Seven Year Period.

<table>
<thead>
<tr>
<th>Year</th>
<th>Last Sample Date</th>
<th>Variety</th>
<th>% Soluble Solids</th>
<th>Data Last Analysis</th>
<th>Juice Ratio</th>
<th>Content</th>
<th>Size</th>
<th>Calculated Passing Date</th>
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<tr>
<td>1948-49</td>
<td></td>
<td>Duncan</td>
<td></td>
<td>Passed Nov. 16</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>1947-48</td>
<td>Jan. 29</td>
<td>Duncan</td>
<td>9.10</td>
<td>6.59</td>
<td>259</td>
<td>64</td>
<td></td>
<td>March 15</td>
</tr>
<tr>
<td>1946-47</td>
<td></td>
<td>Duncan</td>
<td></td>
<td>Passed Nov. 16</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1945-46</td>
<td></td>
<td>Duncan</td>
<td></td>
<td>Passed Dec. 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1944-45</td>
<td>Oct. 27</td>
<td>Duncan</td>
<td>8.79</td>
<td>6.01</td>
<td>217</td>
<td>64</td>
<td></td>
<td>Feb. 15</td>
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<tr>
<td>1943-44</td>
<td>Jan. 18</td>
<td>Duncan</td>
<td>10.05</td>
<td>6.08</td>
<td>217</td>
<td>64</td>
<td></td>
<td>Feb. 23</td>
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<tr>
<td>1942-43</td>
<td></td>
<td>Duncan</td>
<td></td>
<td>Passed Dec. 1</td>
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<td></td>
</tr>
<tr>
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<td></td>
<td>Marsh</td>
<td></td>
<td>Passed Dec. 23</td>
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</tr>
<tr>
<td>1947-48</td>
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<td>Marsh</td>
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</table>

* The author is indebted to J. W. Sites, Horticulturist, Citrus Experiment Station, for the use of the information contained in this table.

mention here. In the first place is the fact that the Florida Citrus Code of 1949 contains the old 1927 and 1929 Arsenic Spray Laws with the modification that the use of arsenic is not prohibited on grapefruit (1, Sec. 92-97). This removes the effect of the injunction of 1933 under which arsenic has been used on grapefruit for many years. In the second place are numerous changes in the maturity requirements. The revisions include the requirement of a color break and an increase in the soluble solids minimum requirements, but since color characteristics are not changed by application of arsenic and the soluble solids requirement is not so high as to restrict much grapefruit movement, they will not be of concern here. However, in other respects the 1949 Citrus Code contains maturity provisions which involve the use of arsenic. These are the continuous inspection of fruit throughout the year, and the changes in relative importance of juice content and ratio.

An entirely new feature of the 1949 Citrus Code is the provision for continuous inspection of grapefruit throughout the entire season. In the past, the inspection for maturity of
grapefruit was discontinued in December and from that time on grapefruit did not have to meet any maturity standards for any purpose. Now throughout the entire season all grapefruit must have a passing ratio before it can be shipped or used in processing.

There is not a great deal of information available on the composition of grapefruit in the extremely late part of the season, but there is ample information available to indicate that much grapefruit will fail to pass the ratio requirements in midseason, and some at least will fail in some years to meet the requirement until very late in the season. An example of this situation is afforded by the data in Table 1. These data are for a group of plots at the Citrus Experiment Station on which maturity records are available for several years. In most years the fruit was tested into late midseason, and in many cases the fruit failed to pass the ratio test as late as the sampling was continued. Low ratios were more common with Marsh than with Duncan grapefruit, although this is not known to be the general rule. Many similar examples from Station records could be cited in which fruit failed to pass the ratio test in midseason and the trend indicated that the ratio would continue to be low throughout the remainder of the season.

The survey of Harding and Fisher, also points out the seasonal nature of this situation. In the 1940-41 season, only half of the 16 groves in which they took samples had passing ratios in December, and only 75 percent had passing ratios in February according to the 1949 standards. One grove did not pass until May. In the 1941-42 season, however, all of the 20 groves tested passed the 1949 ratio test not later than the December sample. This season was in all probability similar to the 1948-49 season which was exceptionally early in maturity. However, in every year all of the groves sampled by Harding and Fisher did pass the 1949 minimum ratio test before their sampling season ended.

It is impossible to say whether the fruit from the grove at the Citrus Experiment Station used as an example (Table 1) would or would not have passed the ratio test if sampling had continued later into the season. The calculated probable passing date given in Table 1 are extrapolated values, but do indicate eventual passing of the ratio requirement. It may at least be concluded that in some years many crops will not pass the ratio test until very late in the season. This will restrict the time during which crops of fruit may be harvested, and may prove a handicap in marketing.

Production methods for ensuring passing ratios for grapefruit in midseason are thus desirable. The simplest and most readily available method for accomplishing this is the use of arsenic. Use of arsenic for this purpose is not to be confused with the use of arsenic to produce early fall maturity of fruit. To obtain early fall maturity it is necessary to use moderately high concentrations of lead arsenate in order to raise the ratio sufficiently in September or October to pass the test. For obtaining passing ratios in midseason it is not necessary to use high concentrations, for with the passage of time the effect of a given application of arsenic becomes greater. A low concentration will have as much effect on the ratio in February as a high concentration will have in September.
The data shown in Fig. 1 will make this clear. On October 15, 1947, fruit from a Marsh block at Lake Alfred showed a ratio of 5.14 where no arsenic had been used. Comparable plots sprayed with arsenic at 1.25 lb. per 100 gallons of spray mixture had a ratio of 6.18, or an increase of 1.04 ratio units. The increase produced by 0.31 lb. per 100 gallons was quite noticeable but smaller in extent. However, on February 2 the 0.31 lb. per 100 gallons rate had increased the ratio from 5.81 to 7.06, an increase of 1.25 ratio units. This is an example of the cumulative effects of an arsenical application, in which the margin between treated and untreated fruit increases as the season progresses.

Numerous other examples could be cited to show the relative effectiveness of small applications of arsenic in raising the ratio of soluble solids to acid during the middle part of the shipping season. In general, application of 0.3 lb. of lead arsenate per 100 gallons appears to be sufficiently high to ensure a passing ratio in nearly all groves by February. This application can be made at nearly any part of the growing season between bloom and the end of the oil spray season with satisfactory results.

The question may be raised as to why it would not be advisable to make a heavy application of arsenic to all groves in an attempt to get a part of the early market, and if this failed, still have ratios high enough to pass the test in midseason. There are several considerations which make this inadvisable. In the first place is the fact that two entirely different types of groves are involved. Groves which bloom early and for which the season is favorable may produce early fruit if given the high arsenic treatment, but even if not given the arsenic treatment, they still may pass the ratio test satisfactorily in midseason. If a grove blooms very late however, and is not favored by satisfactory growing conditions, no amount of arsenic will overcome this handicap and result in early maturity of the fruit. However, it is in this type of grove that the use of a small application of arsenic may be advisable to prevent undue delay in the passing of the ratio test for midseason fruit. In the second place, general heavy applications on all groves are unduly expensive, and may result in unnecessary toxicity to the trees. Furthermore, heavy applications lead to very high ratios in late season, and the fruit is thus made less acceptable for processing. In order to avoid these possible handicaps the grower should carefully consider the reason for the application of arsenic, and choose the rate which is suitable.

Quite aside from any legal maturity aspects, there is some basis for the belief that the use of arsenic on grapefruit is justified entirely by its effects upon the sweetness of the fruit. There is a growing opinion in the industry that the northern consumer would prefer to have a sweeter grapefruit than they now obtain from Florida, and that Florida grapefruit suffers to some extent in competition with Texas grapefruit because the Texas grapefruit is sweeter.

Specific data on consumer preferences is difficult to obtain, and consequently there is not much data available on the consumer preference for grapefruit ratios. Most of the evidence lies in the experience of the fresh fruit trade. Only the data of Harding and Fisher, are available to show the effect of arsenic on the palatability of grapefruit. Their work showed that the taste panel they used definitely preferred the fruit from the arsenic sprayed plots to the more acid fruit from the check plots.

If it is granted that the consumer would prefer to have a sweeter fruit, it is readily demonstrated that Texas produces a naturally sweeter fruit and hence must enjoy an advantage in selling. This position is based upon comparable analyses of Texas grapefruit and Florida grapefruit. The published analyses of Texas grapefruit by Traub, Fraps, and Friend, and Wood and Reed show higher soluble solids and higher ratios for Texas fruit than are commonly found in Florida fruit. Lower ratios are quoted by Wood and Reed than by the former authors. In both these papers, with the exception of one plot near Mission where the bloom was exceptionally
late (5, Table 25), all ratio values quoted for the months of December and later are above 7.05 to 1 and generally are above 8 to 1 in January. This is in decided contrast to the information given in Table 1, and to that of Harding and Fishers, particularly for the season of 1940-41. The higher ratios obtained in Texas are obtained without the use of arsenic.

The difference in fruit quality is also reflected in the maturity laws of the two states (1, 3). In both cases, sliding scales of ratio values are used in which higher ratios are required for fruit with lower soluble solids levels. Texas grapefruit must have at least 9 percent soluble solids in contrast to a Florida minimum of 7.5 percent for seedless fruit and 8 percent for seedy grapefruit. The maximum ratio required in Texas is 7.2 to 1 while Florida requires a maximum of only 7.00 to 1. In addition, the Texas ratio scale slides to a minimum of 6.5 to 1 for fruit with 11.5 percent soluble solids, while in Florida it slides down to 6.00 to 1 for fruit with 12 percent soluble solids.

It is not to be assumed that Florida should adopt the equivalent of the Texas requirements. This would be completely impractical, since there are fundamental differences in rootstock, soil, and climate involved which make a 9 percent minimum soluble solids level for all Florida grapefruit a practical impossibility at the present time.

The thing that is indicated by these points is that the chief competitor of Florida is shipping a sweeter grapefruit than Florida does and apparently the consumers like that type of fruit very well. Wherever possible and practical then it would be advisable to compete on a stronger basis by shipping a sweeter fruit.

Continuous inspection tends to provide a sweeter fruit by eliminating the very low ratio fruit which formerly was shipped, but no doubt will lead to some difficulties with low ratio fruit as discussed above. A very effective aid to putting the sweetness of Florida grapefruit upon a competitive basis is through the simple and relatively inexpensive application of arsenic as outlined above. It is entirely possible that the application of arsenic for the purpose of sweetening the fruit and improving its palatability will become a standard practice among Florida growers.

The second aspect of arsenic use in Florida is concerned with the heavy application for the purpose of obtaining early maturity. Such applications have in the past been the sole use for arsenic, and as long as there is a high ratio requirement for grapefruit, there will probably continue to be a place in the production program for such use.

Too much reliance should not be placed upon the ability of an arsenic application alone to produce early maturity. There is substantial data available to show that the acidity and ratio of grapefruit juice are influenced markedly by some fertilizer elements, as well as by irrigation practices, time of bloom and general weather conditions during the year preceding the harvest. All of these factors are not understood but it is readily apparent that the use of arsenic will not overcome the disadvantage created by combinations of other factors such as lateness of bloom and unfavorable weather. Only where conditions are already favorable for the production of early fruit will the use of arsenic be advisable for early maturity purposes.

Such usage needs to be modified very little to fit the provisions of the 1949 Citrus Code. The general effect of the new law is to subordinate slightly the use of arsenic for early maturity rather than to emphasize it. This is the result of increasing the juice content requirement for grapefruit without a corresponding increase in ratio. Since the ratio is the factor acted upon by arsenic, and since the juice content is either not changed or slightly decreased by arsenic application, it follows that the use of arsenic for early maturity is slightly discouraged by the 1949 Citrus Code.

An example is given in Figure 2 in which the juice content and ratio requirements according to the old law were met on October 2. Since the soluble solids level was between 7.00 and 9.00 the ratio requirement remained the same under both the new and the old law.
However, the new juice requirement of an additional 10 milliliters per fruit of size 96 delayed the attainment of legal maturity by 12 days. The point to note is that there would be no reason to have increased the rate of application of arsenic because of the 1949 law. Suppose in the example of Figure 2 that more arsenic than 1.25 lb. of lead arsenate per 100 gallons had been used. The ratio values would have been slightly higher than those shown for 1.25 lb. per 100. However, even by the 1948 standards this could not have resulted in earlier legal maturity for the treatment would not increase the juice content and this was limiting until October 2. Under the 1949 regulations the use of additional arsenic would have had the same result on ratio, but would have been less successful in advancing the date of legal maturity because of the increased juice content requirement which would delay legal maturity until October 14. Thus there is reason to decrease the rate of application of arsenic slightly, but for practical purposes the decrease indicated is so small that it is of very little importance.

Arsenic applications to grapefruit in light of the 1949 Citrus Code thus fall into two categories: those made for very early maturity and those made to sweeten the fruit and obtain passing ratios in midseason. For early fall maturity, applications of arsenic should be limited to groves which give promise of early maturity aside from arsenic application. In such groves arsenic sprays should be applied before the fruit exceeds an average diameter of 1.5 inches. A spray concentration of six pounds of lead arsenate per 500 gallon tank has usually given passing ratios by the time...
passing juice content is obtained. For the purpose of obtaining passing ratios in midseason and general improvement of fresh fruit palatability, a rate of application of not more than 2 pounds of lead arsenate per 500 gallons is needed, and this amount may well be reduced as low as 1 pound per 500 gallons with adequate results. The spray may be applied any time from melanose time through the oil season. Excessive applications of arsenic are unnecessary, expensive, dangerous to the trees, and sometimes detrimental to fruit quality, and it is highly advisable to avoid such use.

LITERATURE CITED


3. Texas Department of Agriculture. Citrus maturity requirements for 1942 season. 1942. (Mimeographed.)


NUCELLAR SEEDLING STRAINS OF CITRUS

L. D. Batchelor and J. W. Cameron

University of California Citrus Experiment Station

Riverside, California

You have asked us to prepare a paper for your program which will summarize our present thinking as to the value of nucellar seedling strains of citrus. The practical value of such strains as a means of rejuvenating some of the older varieties has been of especial interest to investigators and commercial fruit growers.

Perhaps we should first explain what nucellar seedlings are. In the reproduction of most Citrus species by seed, several seedlings may be produced from a single seed. One of these may be a gametic seedling produced by the ordinary sexual process. The others are produced from cells of the seed parent outside the actual egg cell. These cells make up the nucellus and seedlings arising from them are called “nucellar seedlings.” These extra embryos which develop into nucellar seedlings are in some degree comparable to adventitious buds which push out from twigs and branches of trees.

In reviewing the possible practical value of nucellar strains of citrus we do not feel called upon to prove or disprove the theory that there is a general senescence of horticultural crops which are propagated by budding, grafting, and other comparable means. Many papers have been written on this subject, and possibly a part of the explanation for their not being in agreement, is their consideration of a wide variety of plant material grown under diverse conditions. Nucellar seedlings, however, have one outstanding characteristic which makes them of value as a means of rejuvenating citrus varieties.

So far as we know, all nucellar seedlings make an extremely vigorous and rapid growth. In any sort of a comparison one can make with budded progeny of a parent tree, seedlings or budded trees from the seedlings usually grow much faster than the parent stock. The nucellar strains, however, are much more thorny than the parent, produce flowers at least one or two years later, and generally come into full bearing very much slower. Some of these juvenile tree characteristics are commonly observed in citrus nurseries among seedlings grown for rootstocks. Such nursery trees are largely nucellar; that is why

(1) Paper No. 628, University of California Citrus Experiment Station.

(2) Director, University of California Citrus Experiment Station.

(3) Assistant Geneticist, University of California Citrus Experiment Station.