New Satsuma Mandarin Strains

fruit of nucellar lines of mandarin-orange color earlier and have higher per cent of soluble solids than the parent line

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Long-time studies of Satsuma mandarin nucellar-seedling lines—derived mainly from a single seed-parent tree—indicate that both genetic change and nucellar embryony may be responsible for earlier fruit coloring, especially in heavy-crop years, and for a consistently higher per cent of soluble solids than in the old parent line.

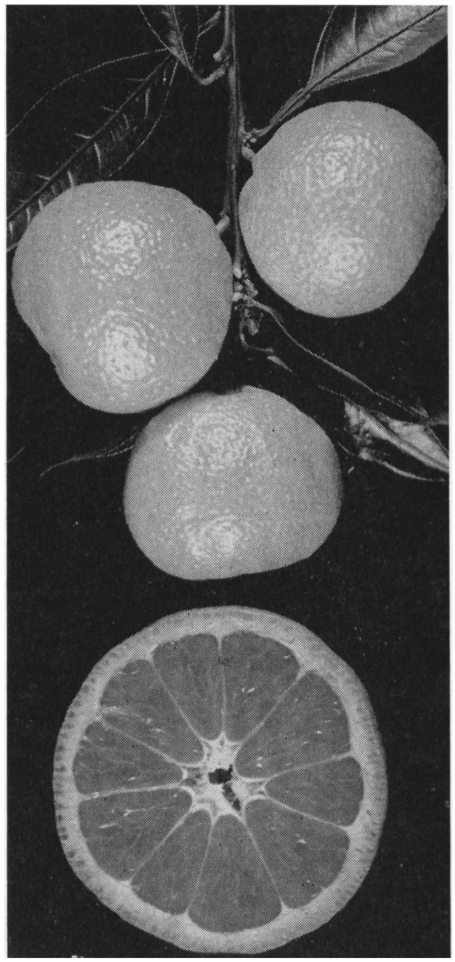
Because of its adaptability to a relatively cool climate, Satsuma—the principal citrus fruit of Japan—has had some commercial importance in several Gulf States of the United States, principally Alabama, but freezes have largely eliminated it.

In California the Satsuma has been grown in the Oroville area and in small plantings in the navel orange districts. It does not succeed under hot desert conditions. However, among the Satsuma seedling lines included in a series of long-term studies at Riverside, a nucellar strain—strain A—has been superior in over-all horticultural promise and should be useful in extension of the presently small acreage of Satsumas in California.

The parent tree—from which the nucellar Satsuma lines included in the study were derived—was obtained in about 1907. In 1920, trees of the first budded generation of several of the nucellar lines on trifoliate rootstock were planted in the experimental orchard at Riverside. In 1932 a second budded generation of two of the nucellar lines—called young-line *1* and young-line *2*—and budded trees of the old seed-parent line were planted in the orchard in two adjacent rows. These trees were on Cunningham citrange rootstock. Budded trees of two other nucellar Satsumas—young-line *3* and young-line *4*—were planted nearby during this same period.

The trees of young-lines *1* and *2* and those of the budded seed-parent line bore their first fruits in 1936. At that time, leaf-blade length and width were significantly greater in both young lines. In addition, leaf size averaged slightly larger in young-line *1* than in young-line *2* in 1936 and again in 1956. The difference in leaf length was just short of significance in both years, but the difference in width was highly significant in 1956.

Trees of young-line *1* are more open and spreading than those of young-line *2*, and the leaves are slightly darker green. Trees of both of the young lines are conspicuously larger in top volume than those of the old line.



Fruits of the Satsuma mandarin, as grown at Riverside. Actual diameter of these fruits was about two inches.

Records for the six years between 1939 and 1946 show that young-line *1* exceeded the old line in yield by 84%, and young-line *2* exceeded the old line by 72%. During the period of 1947–1955, yields were significantly different among all three lines: highest in young-line *1*; intermediate in young-line *2*; and lowest in the old line, as shown in the table on page 15.

In two years out of nine, low yields occurred in all three lines. Average fruit size—calculated by weight—was nearly identical in the old line and young-line *1*, but a little smaller in young-line *2*. Although there was a greater variation in fruit size in the young lines, the larger yields produced more marketable fruit than the old line.

Fruit Coloring

Time of coloring of the fruit has usually been earlier in the young lines than in the old line. For all years—averaged—the percentage of well-colored fruit at date of harvest was 60 for the old line, 93 for young-line *1* and 83 for young-line *2*. There is considerable relationship between high yields per tree and per cent of fruits well colored at time of picking. In years of heavy crop—such as 1948—the fruit of young-line *1*, in particular, approached 100% well colored when the old-line fruit was still poorly colored. However, in 1949, when young-line *1* had an unusually light crop, coloring was late and little different from that in the parent line. Young-line *2* has been less consistent; it was slow to color in years of light crop, but often colored less well than young-line *1* in years of heavy crop. Its heavy crops were not as great in pounds per tree as those of young-line *1* in the same years.

Tree size in both young lines is much greater than in the old line, which means that yield per unit volume of top is often no greater in the young lines than in the parent line. The earlier rind coloring occurs despite similar yields per unit volume. Only when yield per unit volume was much less in the young lines than in the old line, as in 1949, was the time of coloring about equal.

Fruit Shape

Differences in fruit shape between young-lines *1* and *2* were found in the first budded generation of the seedlings. The fruit of a tree of young-line *1* averaged somewhat flatter than that of young-line *2* in each of nine years. This difference has persisted although both young lines seem to be producing fruit that is less flat than the earlier fruit. The decrease in flatness is suggestive of a change in a juvenile condition, which originally favored flatter fruit. Fruit shape was also studied in one budded

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MANDARIN

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tree from each of 20 other nucellar Satsuma seedlings. Results indicated that at least three degrees of flatness are probably characteristic of the seedling lines involved.

Soluble Solids

The percentages of soluble solids were substantially higher in young-lines *1* and *2* than in the old line, in each of the eight years of measurement. The average for the old line for all years was 12.1%; and for the two young lines, 13.4% and 13.2%. The difference between the old line and either of the young lines is highly significant. Percentages of acid were rather similar among the three lines within any one year. As a result, the solids-to-acid ratios reflect the behavior of the solids and are higher in most years in the two young lines. The only notable exceptions were in 1949 and 1954, which were years of very light crops.

Such differences for soluble solids are usually not found between old and young lines of the same strain of citrus. To determine whether these young lines maintain higher solids throughout the season, samples were measured at four dates in the season of 1953 and again in 1954. Solids were higher in the young lines in December of both years, and remained so throughout the seasons. There was no tendency for the solids content of old-line fruit to become equal to that of the young lines as the fruit became more mature.

Further evidence of higher solids in the nucellar Satsuma lines is available from an orchard planting made in 1949 on trifoliate orange rootstock. This planting includes trees from the old parent line, from young-line *1*, and from an additional line—young-line *4*. Fruit samples were obtained in 1954 and 1955. In both seasons the relative levels of soluble solids behaved as before, with the old line lower than the young lines.

Young-lines *1* and *2* show certain characteristics typical of nucellar lines derived from old varieties—larger tree size, greater yields—and, in addition, they seem to differ genetically from one another in tree habit, fruit shape, and probably in leaf size. Therefore, young-line *1* has been designated as genetic strain *A* and young-line *2* as genetic strain *B*. Strain *A* shows the better over-all horticultural promise. A third clearly distinct type—strain *C*—has also been identified. It was produced by only one seedling. It has fruit that ripens about a month later than that of strains *A* and *B*, with thicker rind and a more solid center. The causes of earlier coloring and higher soluble solids, which occur in strains *A* and *B*, are not certain. It is possible, but unproven, that elimination of unidentified virus infection is related to these two differences.

Tests for tristeza and for psorosis produced negative results indicating that neither disease is a complicating factor in strain *A* or in strain *B*. The numerous differences found among the seedling lines might suggest that they are hybrids, or progeny from self-pollination, rather than nucellar lines. However, this is almost certainly not the case. Self-pollination does not seem to occur in the Satsuma, and hybrids in citrus almost always show marked changes in appearance of the fruit. Except for shape, no such changes have appeared in these lines.

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Yield and Fruit Characters in Old and Young-line Satsuma Plots.[1]

Line	1947	1948	1949	1950	1951	1952	1953	1954	1955	Average for all years
Average yield in pounds per tree										
Old	57	65	69	104	82	78	86	78	101	80
Young-1	135	184	60	147	130	170	127	86	198	137**
Young-2	114	138	74	133	84	113	85	77	163	109*
Average per cent of well-colored fruit at time of harvest										
Old	76	29	78	68	56	79	...	...	32	60
Young-1	100	89	82	96	85	99	...	...	100	93**
Young-2	99	79	84	74	54	89	...	...	100	83*
Average per cent of soluble solids										
Old	12.5	11.4	12.6	11.9	11.8	11.8	11.8	12.8	...	12.1
Young-1	13.6	12.3	14.0	13.4	12.9	13.8	13.0	14.5	...	13.4**
Young-2	14.1	12.6	14.0	12.6	12.4	13.3	12.8	14.1	...	13.2**
Average solids/acid ratio										
Old	9.5	10.3	8.1	9.4	10.9	8.7	9.8	8.8	...	9.4
Young-1	10.6	11.3	8.3	10.2	11.7	9.9	10.5	9.0	...	10.2
Young-2	11.9	11.6	9.0	10.2	11.4	9.7	11.0	8.7	...	10.4

[1] Number of trees: old line, 3; young lines, 4 each. Asterisks show significance of differences of young lines from the old line in the same year: * means young-line difference is beyond the 5% point of probability; ** means beyond the 1% point. No statistical tests were made on the solids/acid ratios.

MARKETING

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All but three of the 117 marketing contracts inspected during the course of study provide for the assessment of liquidated damages against members for nonperformance, whereas only 45 contracts definitely mentioned injunction and specific performance as additional remedies. The basis of assessment, however, varies. In the majority of contracts, the damages are for a specific sum per unit—for example, 25¢ a field box for citrus fruit, $5 a ton for wine grapes, $10 a ton for fresh deciduous fruits, and 5¢ a dozen for eggs.

The contracts of many other associations provide liquidated damages at some per cent—usually 20%—of the current market value of the product.

A less common method used by a few associations is to specify that liquidated damages per unit shall be equal to the associations' per unit fixed operating costs during the current year. In such a case, if a member failed to market his product through his association, he would, nevertheless, contribute his share of fixed costs.

Although nearly all marketing cooperatives in California have marketing contracts which specify the association's right to one or all of the legal remedies for nonperformance, very few associations have found it necessary to impose such remedies. During one five-year period, only one out of ten associations collected liquidated damages from members and—in only a handful of the associations—were they collected from more than five members. In some cases of collected liquidated damages there appeared to have been a prior agreement that the members could sell part of their crop output—usually through channels not readily available to the association—provided they paid to the association the stated liquidated damages.

Only five of the associations supplying information for the study indicated that during the five-year period they resorted to injunction and specific performance remedies for breach of contract. In four of those associations such action was taken only once; in the fifth association, only twice, and none indicated use of injunction alone. However, these cases probably understate the actual situation concerning the breach or threatened breach of contract. In the event of misunderstandings between management and members over product grading, association policies and actions, or a member's dissatisfaction with prices or the services rendered, the Board of Directors of most associations would attempt to compose such misunderstandings by direct contact or negotiation.

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