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Nucellar Clones of Commercial Citrus Varieties in Italy—Present Status of Production and Use

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PRODUCTION of nucellar clones of citrus was started at the Stazione Sperimentale di Agrumicoltura di Acireale, Italy, in 1949 (4) as part of a general program of citrus improvement including breeding. Since 1949, production of nucellar clones has continued and increased.

In 1957, J. W. Cameron *et al.* (1) reported further research on the nucellar embryony of citrus, which was discovered by Strasburger in 1878. The fruit production and fruit quality of nucellar clones and old-line clones have been compared by several workers (3, 4, 5, 6).

The value of nucellar embryony as a means of freeing citrus clones from viruses was discussed by Weathers and Calavan (7). Recently, Childs and Knorr (2) in Florida reviewed the ten years of indexing rigorously selected and apparently healthy old-line citrus trees and showed that less than 0.5 per cent of the old-line trees survived the test for four viruses. They concluded, "that budwood from nucellar seedling trees is superior to old-line budwood because (i) it is far more certain to be virus free, (ii) it requires little, if any, additional time to produce compared with complete indexing of old-line sources for all known viruses, and (iii) it is cheaper to produce."

This paper describes the research on nucellar citrus conducted at the Stazione Sperimentale di Agrumicoltura di Acireale.

Methods and Results

BREEDING AND SELECTION.—For production of nucellar clones we pollinated citrus flowers with trifoliolate orange [*Poncirus trifoliata* (L.) Raf.]. This method facilitates selection of the seedlings of nucellar origin soon after germination of the seed. The seedlings were grown in pots in the greenhouse, and after 1 year a budwood stick was removed and grafted on sour orange or other rootstock in the field. Later the nucellar seedlings were transplanted to the field. Thus, the seedling and 1 or 2 budded trees were grown from each seed.

Nucellar mandarins (*Citrus reticulata* Blanco) and lemons [*C. limon* (L.) Burm. f.] were similarly propagated. In order to obtain a large number of seedlings of normally seedless varieties such as Tarocco, Moro, and other sweet orange [*C. sinensis* (L.) Osb.] varieties, seeds from "open-pollinated" fruits were also used. Up to 1965, 90 nucellar

clones of our commercial oranges, mandarins, and grapefruits (*C. paradisi* Macf.), and 30 clones of lemons [*C. limon* (L.) Burm f.] were produced through pollination with *P. trifoliata*.

PRODUCTION BEHAVIOR OF NUCELLAR LINES.—The nucellar lines of different species of citrus, budded directly from the seedlings onto sour orange (*C. aurantium* L.), behaved differently. Mandarins and grapefruit bore fruit earlier than did lemons and oranges. However, the differences among different varieties of mandarin, Avana, Avana tardivo, et cetera are small; most commence bearing in 4-5 years. Differences are greater among the lemon varieties. Femminello and Arancino seedling lines produce fruit earlier (5-6 years) than do Monachello clones (7-8 years). Sweet orange seedling lines were even later in coming into production (7-8 years).

TABLE 1. RELATIVE SIZE OF YOUNG AND OLD CLONES BUDDED MAY, 1958, AND PLANTED MAY, 1960, AT PALAZZELLI. DATA RECORDED SEPTEMBER, 1964

Clones	Number of trees	Average trunk size, ^a cm ²	Average height, m
Sanguinello moscato orange			
Young clone 1949-5-1	2	63.6	3.3
1949-5-2	2	51.8	2.4
1949-5-3	2	69.6	3.3
1949-5-4	2	89.3	3.8
1949-5-5	2	65.9	3.3
1951-5C-1	2	53.9	3.7
Old clone	6	34.3	1.9
Marsh grapefruit			
Young clone 1950-27C-1	2	106.6	2.9
Old clone	1	58.0	1.8

a. Comparative tree sizes as indicated by cross sectional area of trunk 15 cm above the soil.

COMPARISON OF OLD AND YOUNG CLONES FROM THE SAME MOTHER TREE.—In 1958, buds were selected from high thornless twigs of 6 clones of Sanguinello moscato orange, 1 clone of Marsh seedless grapefruit, and 4 of Avana mandarin, and budded on Troyer citrange (*C. sinensis* x *P. trifoliata*). Buds of the mother trees of the above nucellar clones were also budded on Troyer citrange. In 1960, the budded trees were planted in one plot for comparison of old and young clones. Each selection is represented by 2 trees of the young clone and 1 of the old clone (Table 1).

From the first year, the young clone trees were more vigorous, and

more thorny, although thorniness later decreased and is now almost absent in the highest branches. Four of the young clones of Sanguinello moscato orange are tall and upright. However, 1 differs from the others in being almost the same size as the old clone. In 1965, 2 trees of the old clone showed symptoms of exocortis. The habit of growth of the young clones of Avana mandarin and Marsh seedless grapefruit is similar to that of the old clones.

The young clones of mandarin and grapefruit produced a few fruits in 1963, only 1 year later than old clones. The old clones of Sanguinello moscato produced the first few fruits in 1962, and in 1963 one young (stunted) clone produced a few fruits. The others produced a few fruits in 1964. Yields since 1964 are shown in Table 2.

In the last 2 years, the average yield of the young clones of mandarin

TABLE 2. THE AVERAGE YIELD OF YOUNG AND OLD CLONES ON TROYER CITRANGE ROOTSTOCK

Variety and date harvested	Number of trees and yield per tree in kg			
	Young clones	No. trees	Old clones	No. trees
Avana mandarin, 1964	12.0	(8)	7.5	(4)
" " , 1965	16.4	"	10.5	"
Marsh grapefruit, 1964	20.9	(2)	18.1	(1)
" " , 1965	45.5	"	26.9	"
Sanguinello moscato, 1964	2.1	(12)	4.6	(6)
" " , 1965	3.5	"	8.8	"

and grapefruit was greater than that of the old clones, whereas the young clones of Sanguinello moscato produced less than the old clones. However, the estimated production of Sanguinello moscato for 1966 is considered greater than that of the old clones.

FRUIT CHARACTERISTICS.—Almost all nucellar clones produced larger fruit than did the old clones, but the surface of the fruit of the young clones of mandarin and orange is rougher than that of the old clones. There was no difference in the grapefruit.

In all the fruits of the young clones the diameter of the core (columnella) was larger and the rind slightly thicker. In other fruit characteristics there were no differences.

PERFORMANCE OF NUCELLAR CLONES ON SEVERAL ROOTSTOCKS.—To test the behavior of the nucellar clones on several rootstocks, an experimental plot using the following rootstocks was established in 1958: Sour orange, Troyer citrange, Cleopatra mandarin, and *C. volkameriana*.

These rootstocks were budded in 1961 with 2 nucellar clones of Sanguinello moscato orange and 1 of Avana mandarin. Each rootstock-nucellar clone combination was replicated 12 times.

In 1964, another plot was established in the same field using nucellar clones of Moro and of Tarocco sweet orange budded in 1963 on the following rootstocks: sour orange, Troyer citrange, Carrizo citrange, Cleopatra mandarin, and *P. trifoliata*. Each combination of rootstock and nucellar clone was replicated 6 times. A plot with 2 nucellar clones of lemon on 2 rootstocks, *C. macrophylla* Wester and *C. volkameriana* Pasq., was established in 1964.

Budwood of the following clones was introduced from California in 1955 (5): Valencia Campbell S2-G 18/9, Valencia Olinda C.E.S. 2750, Washington navel C.E.S. 3033; Washington navel S1 C-6-15; and Washington navel S1 D-15-10. Before introduction, the trees were indexed for tristeza, psorosis, and vein-enation viruses. In 1957, 10 trees of each clone on sour orange were planted in the same field as the previous plantings. For comparison, old-clone trees of the following varieties, also from California, were propagated on sour orange and planted at the same time: 10 of Valencia, old clone C.E.S. 2794; and 10 of Washington navel, old-clone C.E.S. 3039. The old clones were also indexed for the above-mentioned viruses.

The nucellar trees are now larger than the old-line trees, and in the last 5 years the fruit production of the young clones was greater. The fruit characteristics of old and young clones do not differ appreciably.

DISTRIBUTION OF BUDWOOD OF NUCELLAR CLONES.—In 1965 and 1966, 77,480 buds of nucellar clones of Valencia Olinda C.E.S. 2750, Washington navel C.E.S. 3033, Sanguinello moscato 49-5-3 and 49-5-5, Avana mandarin, Marsh seedless grapefruit, Femminello comune, Femminello S. Teresa, and Femminello Continella lemons were distributed to citrus growers and nurserymen.

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