WALTER REUTHER

The California Citrus Variety Improvement Program

In a previous report (3), the historical background, objectives, facilities and program for establishing and maintaining virus-free citrus stocks in California were outlined. The program is a coordinated undertaking of the University of California Citrus Experiment Station, the California State Department of Agriculture, and the U.S. Department of Agriculture. The University is developing and will maintain primary sources ("foundation blocks") of healthy, true-to-name propagating material of improved citrus scion varieties and rootstocks. The University's phase is administered by the Citrus Variety Improvement Committee. The State Department of Agriculture will handle the regulatory and certification phase, the details of which have been outlined by Hiltabrand (1). The role of the U.S. Department of Agriculture in the importation of foreign varieties is outlined in a previous report (4).

This paper presents some data on the incidence of certain virus diseases in citrus selections of both domestic and foreign origin which have been indexed in connection with this program.

Domestic Indexing Program

Details of the indexing procedures used are essentially those described by Wallace and Drake (4). Individual trees of varieties or strains of domestic (California) origin to be indexed are called "candidate" trees, and are selected by the Citrus Variety Improvement Committee. Normally, such candidate trees are mature, bearing trees which are known to be true to name or type, free of bud mutations, and apparently vigorous

and healthy. Budwood cut from a candidate tree is used not only to inoculate indicator plants for short-term indexing procedures for certain viruses, but also to propagate budwood source trees. Both the indicator plants and the budwood source trees are grown together in a special domestic quarantine greenhouse providing maximum security against possible insect vectors. Before budwood or plants from the domestic quarantine greenhouse may be moved to the foundation blocks, short-term indexing procedures must show them to be free of psorosis, tristeza, and vein enation. Long-term (4 to 6 years) indexings for exocortis, xyloporosis, cachexia, and stubborn viruses are continued in a special nursery-type planting after budwood or nursery trees have been moved provisionally to the foundation block. Foundation trees are propagated (from material moved from the domestic quarantine greenhouse) on several rootstocks and established in a separate orchard-type planting. Trees found to be free of known bud-transmissible diseases and true-to-name will be retained in the foundation blocks and become "registered." The first long-term indexings probably will be completed in about 6 years. At least 2 appreciable crops on foundation trees will be required to detect mutations and assess trueness to name. Hence the first foundation trees probably will be registered about 1966.

Short-term indexing has been completed on 75 candidate trees of domestic origin. Some 40 more are currently being indexed. The incidence of psorosis, tristeza, and vein enation in various types of citrus is summarized in Table 1. Fifteen out of 75 candidate trees tested, or 20 per cent, contained one or more viruses. This incidence is higher than expected because most candidate trees were judged likely to be virus-free because they were either of nucellar or hybrid origin, because they had been indexed previously, or for other reasons. One orange and 2 lemon candidate trees of nucellar origin had psorosis. These infections appeared to result from root grafting with adjacent trees known to be infected with psorosis. The cases of vein enation and tristeza were probably due to infections of the candidate trees by insect vectors.

This experience emphasizes the importance, under California conditions at least, of propagating source trees *from the same budwood sticks used for inoculation of test seedlings,* and of holding these source trees within insect-secure quarantine houses during the period of the indexing. Such a procedure provides propagative material for foundation-block trees that runs far less hazard of becoming infested during the course of indexing than the original candidate trees located in the orchard.

Of the 60 candidates free of virus detectable by short-term indexing,

TABLE 1. INCIDENCE OF CERTAIN VIRUS DISEASES IN CITRUS CANDIDATE TREES INDEXED IN THE CALIFORNIA CITRUS VARIETY IMPROVEMENT PROGRAM

Group or species	Accessions positive for				accessions negative
	tristeza	seedling yellows	psorosis	vein enation	
	Domestic accessions				
Orange - Navel	3	–	1	2	11
Orange - Valencia	1	–	0	0	5
Orange - misc.	1	–	0	1	0
Eureka lemon	0	–	0	1	5
Lisbon lemon	0	–	0	2	7
Other lemon	0	–	2	0	2
Grapefruit	0	–	0	0	4
Mandarin	0	–	0	1	15
Lime	0	–	0	0	1
Tangelo	0	–	0	0	2
Hybrid - misc.	0	–	0	0	8
Totals, Domestic	5		3	7	60
	Foreign accessions				
C. aurantifolia	0	0	0	1	3
C. bergamia	1	0	0	0	1
C. grandis	1	0	0	0	6
C. jambheri	2	0	0	0	1
C. limon[a]	3	1	6	0	9
C. medica	2	1	2	0	1
C. natsudaidai[a]	1	0	1	0	0
C. nobilis, unshiu	0	0	0	0	3
C. paradisi	0	0	0	0	1
C. reticulata[a]	1	0	2	0	7
C. sinensis[a]	0	1	18	0	12
C. spp.	6	2[b]	0	1[b]	10
Fortunella japonica	1[b]	0	1[b]	0	0
Paramignya monophylla	0	0	0	0	1
Micromelum spp.[c]	0	0	0	0	1
Poncirus, spp.	0	0	0	0	1
Totals, Foreign	18	5	30	2	57

[a]In a few of the earliest accessions, no further indexing was performed if clear-cut psorosis symptoms were present on the plant when received at Riverside. Falling in this category were 8 *C. sinensis,* 1 each of *C. limon, C. reticulata,* and *C. natsudaidai.* Had the regular indexing program been followed on these plants also, a few more accessions with more than 1 virus might have been recorded.

[b]One plant contained 2 viruses.

[c]Identity questionable.

28 have been moved to the foundation block at the University of California experimental citrus orchard at Lindcove in Tulare County. This is in an important citrus-growing area in the San Joaquin Valley located about 250 miles from Riverside, and is well isolated from other citrus-growing areas by mountains and arid, non agricultural regions. Recent surveys have detected neither tristeza nor vein enation in the area.

Because tristeza is not present in all citrus areas in California, quarantine regulations established by the California State Department of Agriculture prohibit the movement of citrus budwood or nursery trees from infested areas to noninfested areas. However, by special permit and under rigorous inspection by California State Department of Agriculture personnel, tristeza-free source trees produced and held in the University of California quarantine houses at Riverside, a tristeza-infested area, are permitted to move to the Lindcove site, a tristeza-free area. Many valuable citrus clones, including a number of nucellar origin, are represented in the Citrus Experiment Station variety collection at Riverside. The threat of infestation with tristeza and other insect-transmitted viruses present in the area lends urgency to moving virus-free propagative material of such clones to a tristeza-free location, such as the Lindcove foundation plot.

Foreign Indexing Program

The introduction of fungus or bacterial diseases and insect or nematode pests on foreign citrus introductions is avoided by first propagating them in the greenhouses of the U.S. Department of Agriculture at Glenn Dale, Maryland. After about 2 years of careful inspection, clean material is sent to California for rigorous virus disease indexing, which involves separate greenhouse and screenhouse facilities isolated from those used for the indexing of domestic selections. The short-term indexing procedures are essentially the same as for the domestic selections, but the long-term indexing procedures are more rigorous and exacting (4).

In the 7 years since the foreign citrus budwood importation program (4) was started, 143 accessions have been received at Riverside. Of these, 13 were discarded because the variety or species was already established at Riverside, or because of insufficient descriptive information. Currently 20 accessions are being indexed for psorosis, tristeza, seedling yellows, and vein enation. Indexing for these viruses has been completed on 110 foreign citrus accessions. A summary is presented in Table 1.

In contrast with the domestic indexing results, 53 out of 110, or 48

per cent, of the foreign clones contained 1 or more of the 4 viruses listed above. Of the 30 that were positive for psorosis, 13 were discarded but 17 are being held for observation of fruit characters, and possible production of nucellar clones from any that are particularly desirable. It is evident that these viruses have a wide geographic distribution, since these accessions came from 25 different countries. The discovery of tristeza virus in introductions from 3 countries was the first evidence of the presence of tristeza in those countries. The data in Table 1 also indicate that these viruses are common in a wide range of species and varieties in the genus *Citrus* and that they may occur in certain citrus relatives.

Of the 57 accessions surviving the short-term indexing, 17 have completed the 3-year scion-stock indexing (4) carried on in the quarantine screenhouse. Of the 17, 5 lemon varieties, Berna, Ricote, La Porto, Mesero Jhamberi, 2 mandarin varieties, Clementine de Alcazar and China orange, and 1 orange, Sanguinello Moscato Cuscuna, have been moved to the Lindcove foundation block; others will be moved next spring.

The incidence of virus diseases in foreign accessions so far disclosed by short-term indexing is rather high. If the incidence of xyloporosis and exocortis turned up by the long-term indexing procedures to be carried out at Lindcove is as high as found by Norman (2) in Florida, perhaps fewer than 20 of the 57 introductions will prove to be free of detectable virus diseases. This rate of loss is extremely high for the time, effort, and expense involved and emphasizes the critical need for faster indexing procedures and dependable, simple ways of eliminating specific virus diseases from citrus tissues. A reasonably rapid means of exchanging new or untried citrus varieties and breeding material among workers in the United States and other citrus-growing areas of the world without exchanging diseases or pests, especially viruses, is essential if reasonable progress is to be made in improving citrus varieties through breeding and selection.

Literature Cited

1. Hiltabrand, W. F. 1959. Certification program for maintenance of virus-free propagation sources of citrus in California, p. 229-231. *In* J. M. Wallace [ed.], Citrus Virus Diseases. Univ. Calif. Div. Agr. Sci., Berkeley.
2. Norman, G. G. 1959. Florida State Plant Board programs for virus-free budwood, p. 237-242. *In* J. M. Wallace [ed.], Citrus Virus Diseases. Univ. Calif. Div. Agr. Sci., Berkeley.

3. REUTHER, W. 1959. A program for establishing and maintaining virus-free citrus stock, p. 215-217. *In* J. M. Wallace [ed.], Citrus Virus Diseases. Univ. Calif. Div. Agr. Sci., Berkeley.
4. WALLACE, J. M., and R. J. DRAKE. 1959. An indexing program to avoid viruses in citrus introduced into the United States, p. 209-214. *In* J. M. Wallace [ed.], Citrus Virus Diseases. Univ. Calif. Div. Agr. Sci., Berkeley.

This is a report of the Citrus Variety Improvement Committee, which consists of three members of the Department of Horticulture: Dr. W. P. Bitters, Dr. J. W. Cameron, and Dr. Walter Reuther, Chairman; three members from the Department of Plant Pathology: Dr. E. C. Calavan, Dr. J. M. Wallace, and Dr. L. G. Weathers; and one representative of the U.S. Department of Agriculture: Dr. J. R. Furr. Special recognition is due Mr. E. M. Nauer, Assistant Specialist, and Mr. C. N. Roistacher, Laboratory Technician IV, for their very capable services in handling the actual details of the plant care, propagation, indexing, and record-keeping procedures.