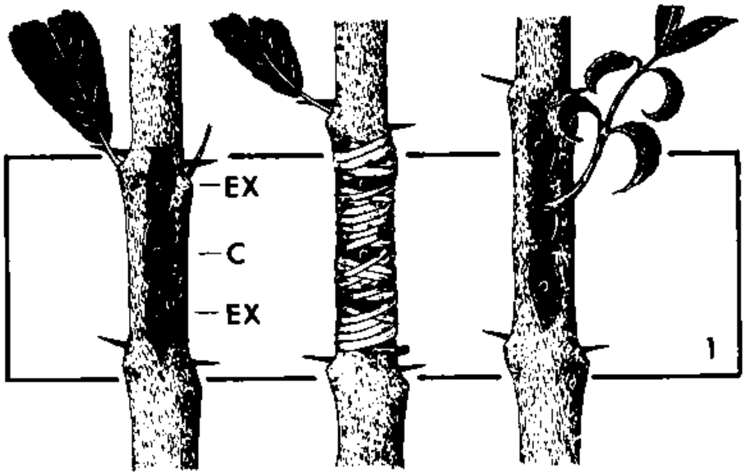
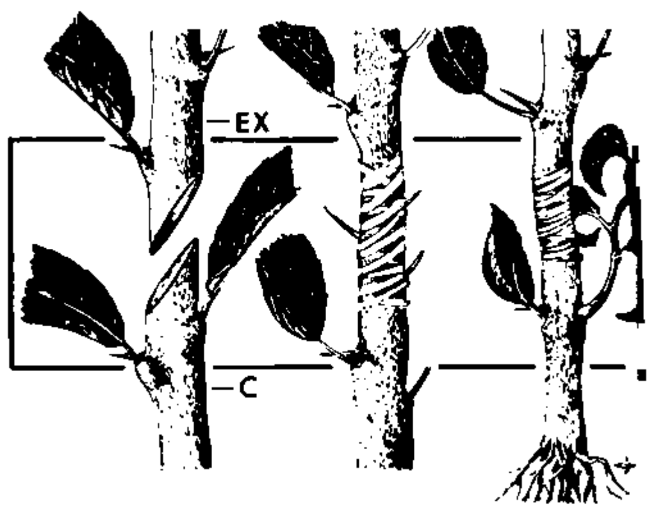
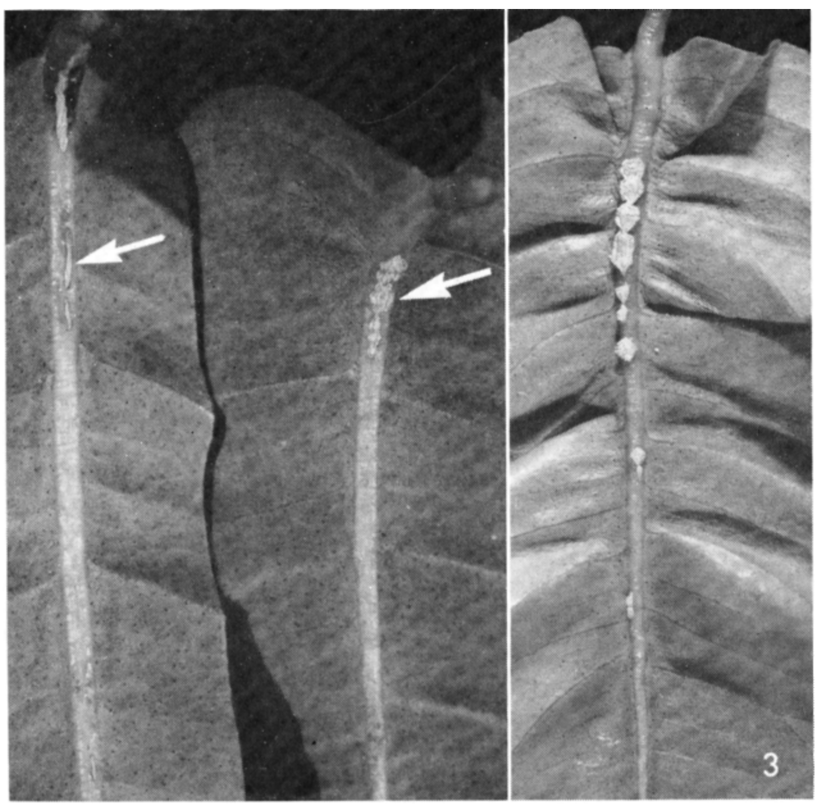
Rapid Detection of





Exocortis in citrus—an increasing problem for California growers—has emphasized the need for a rapid-indexing method for periodic testing of trees used as sources of budwood. Detection of this disease in symptomless citrus trees by field-indexing on sensitive indicator rootstocks has previously required from one and one half to more than five years. The practical method of indexing exocortis in glasshouse plants reported here caused symptoms to develop within one to five months.



Methods of indexing and exocortis symptoms on citron: (1) propagation of citron (C) on a citrus seedling simultaneously inoculated with exocortis-infected buds (EX); (2) splice grafting of exocortis-infected shoot (EX) onto citron cutting (C) which is then rooted and forced to develop a shoot; (3) early (arrows) and advanced stages of cracking and scarring of underside of midvein; (4) control (left) and exocortis-infected shoots of citron seedling 60-13; (5) corky lesions (left) and cracking in stems of citron seedling 60-13; (6) severe epinasty and leaf curling on shoot (left) of seedling 60-13 from Etrog grafted on symptomless exocortis-infected shoot of seedling 60-7 from Etrog.

Exocortis in Citrus

E. C. CALAVAN · E. F. FROLICH · J. B. CARPENTER
C. N. ROISTACHER · D. W. CHRISTIANSEN

FIELD INDEXING of exocortis in citrus plantings on sensitive indicator rootstocks — principally trifoliate orange (*Poncirus trifoliata* (L.) Raf.), trifoliate orange hybrids, and Rangpur or Kusaie lime (*Citrus limonia* Osbeck)—has previously required from one and one half to more than five years. Although studies in 1961 indicated that inoculated shoots and seedlings of Rangpur lime usually developed exocortis symptoms within four to twelve months, neither rootstocks nor inoculated seedlings were sufficiently reliable indicators in California. A clue to more rapid indexing was also reported in 1961, when certain varieties of citron (*C. medica* L.) reacted severely to exocortis infection within 200 days.

The present study showed that detection of exocortis by inoculation of two selected citron plants in the glasshouse was possible within one to five months. Infection caused cracking of the midvein and epinasty (a bending-down with deformity of leaves).

Experiments

Propagations of Etrog citron, PI 109620, from a tree in the University of California orchard at Los Angeles, and seedling 60-13 from Etrog, from the collection at the U. S. Date and Citrus Station, Indio, were graft inoculated by several methods with exocortis-infected citrus tissues. The old-clone tree carried vein enation virus (which causes outgrowths), but the seedling had no known infection.

Exocortis-infected buds and shoots of old-clone trees of Citron of Commerce and Diamante citrons, Eureka lemon (*C. limon* (L.) Burm. f.), and Washington Navel orange (*C. sinensis* (L.) Osbeck) were used as inocula for the first experiment at Los Angeles. All were infected with vein enation and possibly other viruses. Some later experiments at Riverside made use of inocula from two Eureka

lemon trees apparently infected only with exocortis. Indexing for exocortis has been completed for 244 exocortis-free and 125 exocortis-infected trees, including many trees with symptoms on their rootstocks. Inocula from all trees with exocortis symptoms caused a reaction on the citron indicator plants.

Three effective and practicable methods of indexing were:

Citron on budded seedling—A citron bud was grown into a shoot on an exocortis-inoculated seedling of a suitable variety such as rough lemon (*C. jambhiri* Lush.), Mexican lime (*C. aurantifolia* (Christm.) Swingle), or *C. excelsa* Wester and observed for five months. The citron bud and one or more buds from the infected tree were set close together or in contact with each other, photo 1. Preinoculation or simultaneous inoculation and propagation favored early reaction, which sometimes occurred within one month in the developing citron shoot. This method made efficient use of citron budwood and was successfully used on plants already budded for psorosis, tristeza, and tatter-leaf indexing.

Splice graft on citron cutting—A diagonal splice was used to graft a two- to three-inch section of an exocortis-infected shoot onto a citron cutting, photo 2. The citron cutting was rooted and allowed to grow, but shoots on the inoculum piece were pinched back.

Budding on citron—Two or more buds of an exocortis-infected tree were grafted to a citron budling or cutting, which was then cut back to force new growth.

Most plants of seedling 60-13 and Etrog citron PI 109620 reacted to exocortis infection within three months. The first symptoms were epinasty (bending downward) of the leaves, and cracking of the lower side of midveins, photo 3. Some severely affected leaves curled downward from the tip, while the blades twisted to varying degrees from the normal plane, photo 4. Other symptoms included dwarfing, stem epinasty, small corky lesions or vertical cracking of the stem, photo 5, and yellow blotching of the stem. Sometimes the petiole bases and the lower sides of principal veins showed abnormal darkening. Mature leaves of some plants dried up while firmly attached. Response of the indicator shoots of both citron selections was about the same with all methods of inoculation, but variations in symptoms among plants of the same clone inoculated with buds from different trees indicated that variations may exist in the exocortis virus. Many citron seedlings, such as 60-7 from Etrog, were poor indicators of exocortis, photo 6.

Plants of seedling 60-13 responded with exocortis symptoms when inoculated with buds infected with exocortis, and other viruses, such as cachexia, concave gum, psorosis-A, stubborn, tristeza, tristeza-seedling yellows complex, and vein enation. Epinasty of the leaves occurred on plants inoculated from trees infected with a virus that caused stunting without bark cracking of trifoliate orange rootstocks.

Plants of Etrog citron or seedling 60-13 were inoculated separately with cachexia, concave-gum, infectious-variegation, psorosis-A, stubborn, tatter-leaf, tristeza, tristeza-seedling yellows complex, vein enation, and yellow-vein viruses from exocortis-free buds. Although the plants reacted to certain of these viruses, the symptoms did not closely resemble those of exocortis infection. All control plants remained symptomless during the indexing period, but several in one glasshouse reacted later. Infestations of citrus red mite, *Metatetranychus citri* (McG.), a species of whitefly and citrus thrips, *Scirtothrips citri* (Moult.) were noted in this glasshouse. No natural spread of the virus into control plants was apparent in the insect-free quarantine glasshouse. The possibility of vector transmission is being investigated.

To avoid confusing or erroneous results in these tests, it was found necessary to maintain the citron budwood supply and the indexing plants in separate pest-free compartments in order to avoid accidental spread of exocortis virus; to propagate control plants from each citron tree used; to maintain good growth in the index plants; to avoid infection of seedling stocks; and to use the most sensitive citron selections.

Rapid detection of exocortis virus has already accelerated certain phases of research on citrus virus diseases and should soon permit the identification of sufficient numbers of exocortis-free trees to meet grower requirements for most varieties.

E. C. Calavan is Professor, Department of Plant Pathology, University of California, Riverside; E. F. Frolich is Laboratory Technician IV, Department of Plant Biochemistry, U. C., Los Angeles; J. B. Carpenter is Plant Pathologist, Crops Research Division, ARS, USDA, Indio; and C. N. Roistacher and D. W. Christiansen are Laboratory Technicians, Dept. of Plant Pathology, U. C., Riverside.

CALIFORNIA and WORLD

As THE WORLD's largest trading country, the United States has recognized both the advantages and responsibilities of international trade and development activities of the current decade. Since the late President Kennedy signed the Trade Expansion Act of 1962, the United States has been preparing for the "Kennedy Round" of tariff talks under the auspices of the General Agreement on Tariffs and Trade (GATT). The transition period has been characterized by: (1) a new high level for U.S. exports with merchandise shipments totaling nearly $22 billion for 1963, while merchandise imports have also risen to almost $17 billion; (2) further growth in U.S. farm exports to a total of $5.6 billion in 1963—a little over 27% of all U.S. exports; (3) increased attention from the U.S. as well as regional and international organizations to the trade and development needs of less developed countries.

U.S. and trade expansion

United States merchandise exports (excluding military sales) have increased in value from $12.3 billion in 1953 to $21.9 billion in 1963, while imports for consumption have increased from $11 billion to $16.9 billion in the same period. On the average, U.S. total exports since 1960 (exclusive of military special shipments) have been just over 3.5% of the gross national product and imports just under 2.9%—the relationship remaining almost stationary for 1962 and 1963.

While increases have been characteristic of total U.S. trade, the regional destination of shares of U.S. total exports has stayed remarkably stable. Canada, the major single-country recipient of U.S. exports, has a slightly smaller current share (about 20%), with the main growth in the "all Western Europe" share of U.S. exports and a steady decline in Latin America's share (even excluding Cuba). United States total imports have had an even greater stability of division among regions, with Canada, Europe, and Latin America as the major suppliers.

United States agricultural exports, which amounted to $5.6 billion in 1963,