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Studies on Bud-Union Crease of Citrus Trees

A SERIES of tests was carried out at the Limeira Citrus Experiment Station with the purpose of enlarging our knowledge about the bud-union crease exhibited by some scion-rootstock combinations; typical examples of which are Eureka lemon [*Citrus limon* (L.) Burm. f.] on Troyer citrange [*C. sinensis* Osbeck x *Poncirus trifoliata* (L.) Raf.] or on trifoliate orange (*P. trifoliata*), and Shamouti and Pera orange (*C. sinensis*) on Florida rough lemon (*C. jambhiri* Lushington) (2, 5).

Bud-union crease is characterized by a dotted or continuous line of orange yellow discoloration associated with projections or bark pegs on the inner bark surface and corresponding pits in the wood at the bud-union (2, 3). Frequently the affected trees decline and die or remain stunted.

The list of scion-rootstock combinations exhibiting bud-union crease includes many sweet orange varieties on Florida rough lemon (1, 2, 3, 5); some sweet orange and lemon varieties on trifoliate orange and trifoliate orange hybrids (1, 5, 7, 10, 11, 12, 13); and some combinations where calamondin (*C. madurensis* Loureiro) is used as scion or as rootstock (8, 9, 10, 14). Other cases of bud-union crease were shown to the author during some field trips when the scion-rootstock combinations were Red Blush grapefruit (*C. paradisi* Macf.) on sweet lemon (*C. limetta* Risso) (Florida, 1959), Tarocco orange on *C. volkameriana* (Italy, 1963), and Marsh seedless grapefruit on sour orange (*C. aurantium* L.) rootstock (Israel, 1963).

Transmission Test

Buds taken from a Pera orange tree on Florida rough lemon rootstock exhibiting severe bud-union crease were used to inoculate very young nucellar Baianinha orange trees on Florida and Mazoe rough lemon rootstocks. Inoculations were made in January, 1958. Many buds were used to inoculate each Baianinha tree. At that time, buds from the same Pera orange tree and from a nucellar line of this variety were budded onto seedlings of the two kinds of rough lemon. Five years later, normal bud-unions were present in all Baianinha orange trees as revealed by taking out a strip of bark at the bud-union. Bud-union crease was found in all Pera orange trees, nucellar as well as old-lines.

Attempt to Inactivate the Factor

Seeds of Eureka lemon were submitted to heat in one attempt to inactivate a possible factor responsible for the bud-union crease. Germination was obtained when the temperature did not exceed 60°C. for a period of 20 minutes or 80°C. for 15 minutes. Forty seedlings were selected from those of more probable nucellar origin, obtained from seeds submitted to these limiting temperature-time combinations. Buds from these seedlings (6 months old) were budded on Troyer citrange and trifoliate orange seedlings, one year old in the nursery. Three seedlings of each one of these rootstocks were used for buds from each Eureka lemon seedling.

The budding was done in March, 1960. About one year later, all trees showed bud-union crease. At this time most of the trees on trifoliate orange exhibited yellowing of the leaves and some dieback in addition to the crease.

Trifoliate Orange on Eureka Lemon Rootstock

Trees of Eureka lemon on trifoliate orange rootstock are known to develop bud-union crease. This abnormality could have its cause in some substance toxic to the trifoliate rootstock that is produced by the Eureka lemon scion. To investigate this hypothesis the inverse stionic combination was made. Buds taken from several very young trifoliate seedlings were budded on 120 Eureka lemon seedlings in the nursery. Budding was done in October, 1960, and one year later the young trees started to die, exhibiting severe bud-union crease. Two years after bud-

ding, all remaining 43 trees were showing some bud-union abnormality. In September, 1963, only 11 of the 120 plants remained alive; and they all exhibited gummy-pegs at the bud-union.

Topworking Trifoliate Orange on Lemon Trees

In connection with an indexing program, nursery trees of 60 citrus types, including lemon, citron (*C. medica* L.), acid lime (*C. latifolia* Tanaka), and sweet lime varieties were topworked with trifoliate orange buds from nucellar origin. Buddings were made in October, 1960; and two years later abnormal bud-unions occurred when the varieties were: Armstrong seedless, Deodoro, Eureka, Genova, Harris, Siciliano and Vicosa lemon, Seda and Selvagem lime, Umbigo sweet lemon, and Doce, Etrog, and Comprida citron.

The trees of some varieties such as Seda and Selvagem lime and trees of the citron varieties were found to be severely pitted. Some of the types topworked were known to be infected with exocortis and xyloporosis viruses. No correlation was found between the occurrence of bud-union crease and the presence of any of these viruses.

Stionic Combinations Showing Crease

Examinations carried out in a planting for studies on tristeza revealed that some stionic combinations were exhibiting typical bud-union crease. The trees at that time were three years old from budding. The stionic combinations showing bud-union crease were an old-line Eureka lemon (free from exocortis, psorosis, and xyloporosis viruses) on trifoliate orange, on Carrizo citrange, on calamondin (*C. madurensis* Loureiro), and on *Citrus taiwanica* rootstocks; nucellar line calamondin on Natsu mikan, on Caipira sweet orange, on *Coachella eremocitrus*, and on Brazilian rough lemon rootstocks; old-line Seleta de Itaboray orange (exocortis-infected) on Doce (sweet) citron, on trifoliate orange, on Carrizo citrange, on calamondin, on *Coachella eremocitrus*, and on Florida rough lemon rootstocks; and *Atalantia ceilanica* on Pera sweet orange rootstock.

Discussion and Conclusions

The real nature of the bud-union crease shown by several scion-rootstock combinations has not yet been established. Many authors (3, 4, 10, 13) have suggested that this abnormality is caused by a virus,

probably xyloporosis or by a form of scion-rootstock incompatibility.

The experiments reported in this paper indicate that bud-union crease is due to a non-infective, seed-transmitted factor, very probably the result of a physiological incompatibility. Weathers *et al.* (13) have considered that if a virus is responsible for the bud-union crease it must be either seed-transmitted or very readily transmissible by mechanical means or by a vector. Transmission tests failed to induce bud-union crease and only the tristeza virus is known to have an efficient vector in Brazil. Tristeza virus cannot be responsible for bud-union crease.

Moreira (6) has shown that bud-union crease (ring) is not related to xyloporosis (cachexia) virus. On the other hand, he was able to produce a crease-like abnormality at the bud-union of trees of Orlando tangelo on sweet lime rootstock by inoculation with some sources of severe xyloporosis virus.

Trees of trifoliate orange on Eureka lemon rootstock, the inverse of the stionic combination commonly used, developed bud-union crease. This fact emphasizes the suggestion that bud-union crease is a result of an incompatibility between cells of these two varieties.

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