Gummy Pitting of *Poncirus trifoliata:* Its Association with Dwarfing of Citrus in New South Wales

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A method of dwarfing orange trees on trifoliate orange rootstocks by inoculation with a bud-transmissible dwarfing factor has been under trial in New South Wales (N.S.W.) since 1961 as a possible means of producing high-density plantings of small trees on a commercial scale (Long *et al.,* 1971). Some dwarfing sources were chosen on the basis of growth type, vigor and production record from trees in early experimental plantings and others were selected from commercial blocks of mature trees after examination of growth and cropping over several years. Trials since 1955 have explored the relationships of nonscaling dwarfing and typical exocortis. These trials, now maturing, and further observations on ageing trees in commercial blocks have given information on the range of symptoms associated with dwarfing and the possible relationships between the dwarfing factor and exocortis, additional to that previously reported (Fraser *et al.,* 1961).

In old plantings of citrus on *Poncirus trifoliata* rootstock, originating from unselected sources, variation occurs independently: (1) in size of trees, from small to large; (2) in stock external appearance, from typical exocortis scaling to smooth unblemished bark, with a percentage showing thin, flaky scales on a portion of the butt, or bark pustules with laminated structure, singly or grouped in horizontal ridges; (3) in degree and type of stock overgrowth, whether smooth, benched or shouldered, or inverted above the bud union; (4) in the presence of an indented ring in the wood at the bud union, with a corresponding ridge with brown gum deposits on the inner bark surface, varying from continuous to patchy or absent; and (5) in the numbers and size of gum-impregnated pits in the wood of the stock.

Flaky scaling is nonpersistent, though recurrent, but pustules are permanent, increasing in height and numbers with age. Flaky scaling and pustules may occur on the same rootstock in different areas.

Development of gum-impregnated pits in the surface of the wood of the stock, associated with gumming in xylem and phloem, has been found in all butt types of mature and aged dwarfed trees, except exocortis scaling. The pitting varies in degree, from very few small pits with little gum to large heavily gummed pits occurring singly or in groups, with gum impregnation of adjacent xylem and phloem. The presence of severe advanced pitting can be detected externally by uneven, flattened, or depressed areas of bark below the bud union. In the early stages of symptom development gumming and pitting appear to be intermittent, and layers of unaffected xylem cover over earlier formed gum pockets.

The most severe form of gummy pitting appears to be the same as that described by Pujol (1965), Foguet and Oste (1968) and earlier by DuCharme and Knorr (1954) and others in Argentina and by Schwarz and McClean (1969) and Schwarz (1971) in South Africa. The disease in N.S.W. is generally much less severe and shows a wide range of severity.

Gummy pitting varies in age of the tree at onset and in severity with locality, scion variety, and dwarfing strain. In the early stages, particularly in mild variants where few pits are developed it would be impossible, without destroying the tree, to determine total absence of pits or to be sure within several years of the precise time of onset.

RESULTS OF TRIALS

Direct propagations of Allen Valencia orange. Direct propagations of Allen Valencia on *P. trifoliata* rootstock are planted at Research Stations at Somersby, Yanco, and Dareton. Three budlines, taken originally from trees in a plantation over 45 years old, were used. These trees were selected as exocortis free and of good performance and subsequently indexed free of known citrus viruses, except tristeza. The behavior of progeny trees in trials has demonstrated that all three budlines carry a dwarfing factor. Each budline has produced trees showing a range of sizes. Variation occurs between budlines in percentage of small, medium, and large trees, in percentage showing gummy pitting and in severity of pitting. Size differences began to develop by the fifth year. Age, location of trial, tree size, and incidence of gummy pitting are shown in table 1.

Direct Propagations of Marsh grapefruit. Direct propagations on *P. trifoliata* rootstock of Marsh grapefruit classed as "normal," medium, and small, five trees of each, were planted in 1955 at Somersby. At the age of 20 years, two normal and one each of the medium and small budline trees show very mild symptoms of gummy pitting, indicating the presence of mild forms of this disease in normal, as well as in dwarfed budlines. The normal trees are larger, but there is little difference between medium and small propagations. Some variation in tree size within budlines has occurred.

Dwarfing transmission trials with Lambert nucellar Eureka lemon. Nursery trees on *P. trifoliata* rootstock were inoculated by budding into the stock, using two sources of dwarfing, classed as dwarfing-nonscaling, ground-level scaling (the flaky scaling type), and exocortis.

TABLE 1
VARIATION OF PROGENY TREES IN THREE CLONES OF ALLEN VALENCIA ORANGE ON *PONCIRUS TRIFOLIATA* ROOTSTOCK

Budline, location, and date of planting	Tree size and pitting						Percent gummy pitting
	Large		Medium		Small		
	NP*	P	NP	P	NP	P	
2045, Yanco, 1953	0	2	3	6	0	3	78
2045, Yanco, 1951	0	2	2	4	0	1	71
2048, Yanco, 1953	10	3	2	0	0	0	20
2048, Yanco, 1951	10	4	1	0	0	0	26
3018, Somersby, 1955	7	7	57	26	6	2	33
3018, Yanco, 1959	1	2	6	2	4	3	38
3018, Dareton, 1955	9†		24†		11†		Estimated over 90

*NP, no gummy pitting; P, gummy pitting present.
†Trees not individually rated; about 75 per cent were examined.

Five trees of each propagation were planted in 1958 at Narara. All trees inoculated with exocortis developed scaling in three to five years. When removed at the age of 16 years all trees inoculated with dwarfing-nonscaling and with ground-level scaling showed strong development of gummy pitting, with deep pockets of gum in wood and bark and bands of gum extended from the wood surface towards the center of the butt (fig. 1). The extent of the gumming suggests the onset to have been five to six years earlier when trees were aged 10 to 11 years. Slight bark scaling occurred in one tree of the ground-level scaling selection in 1966 but did not persist. The indented gummed ring at the bud union characteristic of nucellar Eureka lemon on *P. trifoliata* varied from moderately severe to slight and incomplete.

Dwarfing transmission trials with Bellamy nucellar navel orange. Propagations on *P. trifoliata* stock, inoculated as nursery trees with nine dwarfing budlines, four trees of each, were planted in 1955 at Somersby. Dwarfing was evident by 1960 in six of the propagations and continued to develop in subsequent years. Inoculum from the selections with the best crop/tree-size ratios was used in statistically designed dwarfing trials planted at Yanco in 1961, 1963, and 1964. The propagations differ from one to another in tree size, cropping and vigor. To date gummy pitting has not developed in any of these trees nor in the trees in the dwarfing trials at Yanco.

Interaction trials with Marsh grapefruit. Trees of Marsh grapefruit propagated from normal, medium, and dwarf source trees (see above) were challenge budded as nursery trees with a rapid-developing exocortis isolate used in many previous trials. Ten trees per scion selection were planted at Somersby in 1955. Exocortis scaling was recorded first in 1960 at the age of five years and by 1962, 6/10 of the normal inoculated, 2/10 of the medium inoculated and 5/10 of the small inoculated trees showed symptoms, compared with an expected rate of over 90 per cent. Inoculation caused size depression in all selections, the depression in the normal budline being comparatively greater, so most of the exocortis-inoculated trees are now similar in size. The effect on tree size was apparent at the age of five years. No further development of exocortis symptoms has occurred and there has been some regression of scaling. Of those recorded as positive in 1962, four no longer show any scaling; trees showing exocortis scaling in 1975 are 4/10 normal, 0/10 medium, and 5/10 small. It appears, therefore, that the presence of a dwarfing factor has interfered with symptom expression of the scaling symptoms of exocortis, and that the addition of a severe exocortis virus strain has caused size reduction in trees already carrying a dwarfing factor.

Fig. 1. Radial longitudinal section of stock of *Poncirus trifoliata* under Eureka lemon, showing evidence of intermittent and persistent gumming in wood and bark.

Interaction trials with Allen Valencia orange 3018. Trees of Allen Valencia orange, now known to carry a dwarfing factor, were challenge budded with two exocortis sources and two of each were planted at Somersby in 1955. Scaling of all inoculated trees developed within five years of inoculation. No interference with symptom expression of exocortis has occurred.

Results of indexing. Six dwarfing budlines, five of Washington navel and one of Valencia orange, showed positive exocortis reactions in Etrog citron (Broadbent *et al.*, 1971). No dwarfed tree tested has shown a positive reaction by the phloroglucinol/HCl test (Childs *et al.*, 1958). One dwarfing budline only (grapefruit) was positive for xyloporosis. All are negative for psorosis. All carry the strains of tristeza virus normal for the variety.

Scion varieties known to carry gummy pitting. Gummy pitting symptoms have been seen in the *P. trifoliata* rootstocks of the following scions in varietal collections on research stations and on growers' properties: Valencia and Washington navel orange; Marsh and Thompson grapefruit; Dancy, Imperial, and Emperor mandarin; Ellendale tangor; and Knight citron.

DISCUSSION

Though gummy pitting may not be apparent until trees are 15 to 20 years old, or older depending on strain and locality, onset of dwarfing is usually at about four to five years, varying in degree with strains.

The earliest onset and most severe symptoms of gumming and pitting occurred in *P. trifoliata* under Eureka lemon scions. There is an indication that time of onset is later and that severity is less under Marsh grapefruit than under Valencia orange. The differences in percentages of gummy pitting shown by trees of the same budline at three different sites is an indication that symptom development is favored by high temperatures. Size differences in the progeny of single trees and differences in numbers in each size class shown in trials of the Allen Valencia point to the prevalence in dwarfed trees of strain mixtures, the components of which are not transmitted evenly to progeny trees, indicating uneven distribution within the tree itself. Variations in symptom intensity suggest that strains may exist which may not cause detectable pitting until the trees reach an advanced age, and that the disease could be present, but unrecognizable, in trees of reasonable size and good appearance.

The correlation between degree of dwarfing and intensity of gumming and pitting is not close. Some large progeny trees of Allen Valencia 3018 show pitting as severe as medium and small trees and there is some suggestion that scion vigor may induce earlier onset of pitting in this budline.

Exocortis has been shown to exist as a number of strains (Calavan and Weathers, 1961; Salibe and Moreira, 1965) and variable rates of transmission have been reported (Norman, 1965; Salibe and Moreira, 1965). Similar results have been obtained with exocortis transmission trials in N.S.W.

The modification of exocortis expression by the presence of gummy pitting in some but not all trees carrying both conditions, shown in the trial with grapefruit, prompts the suggestion that mixtures of strains of gummy pitting and exocortis may occur commonly. Not all gummy-pitting strains, however, have a modifying effect on exocortis expression, as shown by the reaction of Allen Valencia 3018 challenge inoculated with severe exocortis. Foguet (1973) reported more rapid wood-pitting symptom development in the presence of exocortis virus. The intermittent nature of flaky scaling, both in experimental trials and old commercial plantings, is interpreted as an effect of interference with exocortis expression by a severe strain of gummy pitting.

If strains of the pathogens of both diseases are distributed unevenly and independently in the tree and are transmitted unevenly to progeny trees, this could explain the great range of conditions encountered in old plantings. The somewhat variable reactions on indicators reported from different countries could possibly be explained by differences of strains and mixtures of exocortis virus and the gummy-pitting pathogen and to interference between these. For example, Rangpur lime, though a good indicator for exocortis elsewhere, has proved unsatisfactory as an indicator in N.S.W. A positive Etrog reation has been obtained from some dwarfing selections in N.S.W., but not by Schwarz (1971) from selections with a very severe manifestation of the disease in South Africa. Variation in the intensity of the Etrog reaction among bud sources and among the test plants inoculated from the same bud source in the N.S.W. indexing program has been attributed to a masking effect by severe tristeza at temperatures below optimum for exocortis. Interference by gummy pitting could be an additional cause of variation here.

Because of its variability and the impossibility of determining precisely the time of onset of symptoms, the dwarfing-gummy-pitting complex has proved unsatisfactory for field experimentation and evaluation, and clarification of relationships between it and exocortis "will only come when the stunting virus is purified" (Broadbent *et al.*, 1971).

The variability in size of progeny trees from single-tree sources makes the production of uniform blocks of dwarfed trees by inoculation of virus-free young trees, or by direct propagation, more uncertain than originally thought.

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