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Relationship Between Exocortis and Stunting of Citrus Varieties on Poncirus Trifoliata Rootstock

FRASER AND LEVITT (2) reported that stunting of trees on *P. trifoliata* stock can occur without scaling, with results almost as unsatisfactory as when exocortis is present. They suggested that stunting and exocortis may possibly be related. This paper reports the details of experiments by means of which the hypothesis is being tested, and discusses the results so far obtained.

Symptoms of Stunting

The degree of stunting varies from severe, where affected trees are comparable in size with those affected by exocortis, to moderate or slight. In extreme cases, cropping is poor and the foliage sparse.

Stunting is common in Washington Navel orange and Marsh grapefruit, relatively uncommon in Valencia orange. In Emperor mandarins, some variation in tree size and in the nature of the bud union is found in trees on *P. trifoliata* but it is not certain that true stunting of the type seen in Washington Navel oranges and Marsh grapefruit occurs.

Field observations suggest that, in trees affected by stunting, the slight depression in growth rate that occurs at the age of 3 or 4 years is hard to distinguish from normal variability. By the time trees are 8 to 10 years old, there are detectable differences in size between those which will be permanently stunted and nonstunted trees, and these size differences become increasingly pronounced with age. In stunted trees, the stock is broader than the scion trunk and often prominently shouldered or benched at the bud union, in contrast with the butt of nonstunted trees,

in which the stock is fluted and fairly evenly expanding from the bud union to the crown roots. All nucellar scions on *P. trifoliata* rootstocks which have been examined show the smoothly expanding type of bud union.

The presence of an indented ring in the surface of the wood at the bud union, with a corresponding projecting ridge and brown deposits in the bark, is relatively common in stunted trees, but is not constantly associated. It has also been seen fairly frequently in nonstunted trees.

The colour test found by Childs *et al.* (1) to be a reliable means of forecasting the appearance of exocortis has been used in the examination of very many stunted trees, but no positive reaction has been seen.

The development of yellow blotches, which is a constant feature of exocortis-affected wood of *P. trifoliata* older than 2 years (Frolich, personal communication), has not been seen in material propagated from stock suckers from a number of stunted trees.

Experimental Work

During the period 1950-1960, experimental propagations were made to obtain information on the hypothesis that stunting and exocortis may be related. The problem has been attacked from a number of aspects.

PERPETUATION.—To determine whether the stunting factor is carried in budwood, trees have been propagated from stunted, exocortis-free trees of Washington Navel orange, Valencia orange, and Marsh grapefruit; and these are under observation in Experiment Station orchards at Yanco and Somersby. The Valencia orange parent was an extremely stunted mature tree. Twenty progeny trees 9 years old are not noticeably smaller than trees of the same age of vigorous budlines. The Washington Navel orange parent was an extremely stunted tree 38 years old. Twenty progeny trees 9 years old average 2/3 the size of trees of vigorous budlines. The Marsh grapefruit parents were (a) a nonstunted vigorous tree, (b) a moderately stunted tree, and (c) a severely stunted tree, all 16 years old. Five progeny trees of each are commencing to show slight differences in size and habit.

TRANSMISSION OF A STUNTING FACTOR.—A nucellar navel-type orange, the Bellamy navel, which produces a vigorous, large tree on *P. trifoliata*, was used to obtain information on the effect of inoculation with buds from stunted exocortis-free trees. Nursery stocks were budded in 1953 and inoculating buds from stunted sources inserted in February,

1955. The trees were planted in the experimental orchard of the Gosford Citrus Experiment Station in September, 1955.

Nine bud sources were used, comprising 3 severely stunted and 3 moderately stunted Washington Navel orange trees, 1 severely stunted and 1 moderately stunted Marsh grapefruit, and 1 severely stunted Valencia orange. No effect of inoculation on size or vigour was observed in 1956, 1957, or 1958. In 1959, depression of vigour was apparent in trees inoculated from 2 sources, and in 1960 all inoculated trees with the exception of 1 series inoculated from a stunted Washington Navel orange and 1 series inoculated from the stunted Valencia orange were showing marked effects. The degree of stunting induced varied according to the source of inoculum. The most severe reaction was shown by trees inoculated with buds from a Marsh grapefruit source. These were little more than half the size of noninoculated trees, and their foliage was paler and less dense. Other selections have so far caused somewhat less stunting.

The effect of inoculation on butt circumference of 4 of the selections is shown in Table 1.

TABLE 1. EFFECT OF INSERTION OF INOCULATING BUD FROM STUNTED SOURCE ON GROWTH OF BELLAMY NUCELLAR NAVEL ORANGE

Source of inoculum	Number of trees	Mean butt circumference in cm, taken at 6 inches above bud union, 19.1.60
Noninoculated	11	15.8
Severely stunted Marsh grapefruit	5	12.5
Moderately stunted Marsh grapefruit	5	11.7
Moderately stunted Washington Navel orange	5	13.4
Severely stunted Valencia orange	5	14.4

INTERACTION OF STUNTING AND EXOCORTIS.—Budwood from severely stunted, moderately stunted, and very vigorous nonstunted trees of Marsh grapefruit on *P. trifoliata* stock was used for the production of trees on *P. trifoliata* stock in 1953. Ten trees of each were inoculated with a severe type of exocortis by bud insertion in February, 1955. These and 5 noninoculated trees of each budline were planted in the experimental orchard at Somersby in September, 1955.

No effect of source of budwood was discernible in 1956, 1957, 1958,

or 1959, but in 1960 slight differences in size had begun to show between noninoculated trees of stunted and nonstunted origin. During 1959-60, symptoms of scaling were observed on exocortis-inoculated trees of the severely stunted and nonstunted budlines, but not on trees of the moderately stunted budline. The strain of exocortis virus used has in other transmission work produced scaling symptoms in 4 to 5 years from inoculation. There are indications of a slight retardation in time of the onset of the scaling symptom in trees of stunted parentage compared with trees of nonstunted parentage. There are also slight differences in the effect of exocortis on tree size, between trees of stunted and nonstunted budlines. The effect of inoculation with exocortis on growth rate was first apparent in 1957, 2 years after inoculation, and has become progressively more marked. The trees of nonstunted origin inoculated with exocortis are smaller than similarly infected trees of severely stunted and moderately stunted origin (see Table 2) and have somewhat sparser foliage.

TABLE 2. THE EFFECT OF INOCULATION WITH EXOCORTIS ON SIZE OF GRAPEFRUIT TREES OF VERY STUNTED, MODERATELY STUNTED, AND NONSTUNTED ORIGIN

Budwood source	Girth of trunk in cm, at height of 6 inches above bud union, 19.1.60		Number of trees showing scaling symptoms, 22.9.60
	noninoculated	inoculated with exocortis	
Nonstunted	18.2	12.3	7
Moderately stunted	17	12.7	0
Severely stunted	16.7	12.9	5

THE EFFECT OF STOCK SELECTION.—*Strains of P. trifoliata.*—Variation within the species of *P. trifoliata* is not great in the material available in New South Wales, suggesting that original imports of this stock were few in number and of uniform type. However, the possibility that strains of *P. trifoliata* may perform differently as stocks and that some could produce stunted trees is being investigated. A total of 33 stock strains are under trial for Washington Navel and Valencia orange, Marsh grapefruit, and Ellendale mandarin in experiment orchards at Griffith, Yanco, and Somersby. These trees are from 6 to 14 years old and differences in size of trees of the same age on these various stocks are very slight as yet. None of the trees is stunted. In all these trials, the stocks were selected in the nursery for uniformity before budding.

Selection within a strain of P. trifoliata.—It is possible to distinguish categories of seedlings in the seedbed, based on size and on degree of deciduousness. A percentage of seedlings, which varies somewhat with the seed source, will become completely leafless during their first winter, others will retain their leaves until the spring. In 1952, seedlings of a single tree source were graded into 5 classes based on size and presence or absence of the deciduous habit as follows: (a) deciduous, over 18 inches; (b) deciduous, 12-18 inches; (c) leafy, 12-18 inches; (d) leafy, 6-12 inches; (e) leafy, under 6 inches.

These were budded with a vigorous Valencia orange selection and the trees planted in the experimental orchard at the Gosford Citrus Experiment Station. Slight differences in tree size are becoming apparent between the different classes. The smallest trees are those on the smallest deciduous stocks, the largest those on the leafy stocks. There is no difference between the trees on the different grades of leafy stock. None of the trees, however, can be classed as stunted.

Discussion

Experiments on the stunting of citrus trees on *P. trifoliata* rootstock have not yet reached the stage where the cause of the condition can be assigned. It is thought, however, that stunting may be due to several different causes. Variations in the vigour of both stock and scion almost certainly are responsible for some of the size differences seen in commercial orchards. Severe stunting in occasional cases is probably due to accidental use of nonnucellar stocks, as has been demonstrated by Webber (3) to occur with sour orange stocks. It is possible that the few cases of stunting known in Valencia orange are due to this cause, since the progeny of a severely stunted Valencia have grown well on *P. trifoliata* stock, and inoculation from a stunted Valencia to nucellar navel orange has produced no marked stunting effect in the inoculated tree.

Transmission to vigorous nucellar navel orange of a factor causing stunting has been obtained with budwood of Marsh grapefruit and Washington Navel orange and it is probable, therefore, that a virus is involved in these cases. The prompt development of exocortis in a proportion of stunted Marsh grapefruit trees inoculated with exocortis virus may be taken to indicate a lack of relationship between the two conditions, though this is not supported by the relatively greater stunting produced by exocortis when inoculated into vigorous Marsh grapefruit than when inoculated into trees of a stunted budline. This seemed to show

that the presence of the stunting factor reduced somewhat the stunting effect of exocortis, but at this stage it cannot be taken as proof of relationship.

The psorosis virus is not involved in the stunting problem, for none of the experimental material used carried psorosis. The possible association of xyloporosis has not yet been fully investigated.

From the practical aspect of providing clean budwood for use with *P. trifoliata,* quick tests for exocortis alone are insufficient because it is not possible by this means to eliminate all unsatisfactory scions.

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