Interrelations Between Tree Performance and Some Virus Diseases

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CITRUS GROWERS, and horticulturists in general, have come to regard virus diseases as such a hazard to crop production that the elimination of these diseases is considered necessary regardless of effort and irrespective of costs.

Elaborate indexing and bud certification schemes have been established in various countries, and the use of nucellar budwood has been widely advocated. Vigorous growth, especially of nucellars, has been acclaimed as evidence of health, and strong vegetative development of a tree has been correlated with yield.

However, during the last decade, new concepts have arisen in citriculture, especially from an economic viewpoint. The lowering of production costs has become imperative in view of the strong competition among citrus-growing countries. Labor shortages and costs have stimulated mechanization. After mechanization of cultural operations, picking

remains the most expensive item on the budget of a citrus plantation.

In all progressive citrus regions, efforts are, therefore, being directed towards the mechanization of picking, and investigations are being conducted on the shape of trees best suited for mechanical picking. In the course of these investigations, it becomes obvious that picking high trees is uneconomical in any case, even with hydraulically operated "picking towers" or "picking platforms." In many groves, therefore, topping (lowering the height of the tree by mechanical pruning) has been carried out. However, in many cases, topping results in renewed vegetative growth of the top branches, and in a few years the operation must be repeated. Control of tree size, therefore, becomes an urgent problem.

It is a well-known fact that the relative yield per unit volume of a tree decreases with size. Table 1 illustrates this relationship for a Washington navel tree in a rootstock experiment, ten years after planting (trees are grouped according to size, irrespective of rootstocks). This table clearly shows that the yield of a single tree increases with size, whereas the yield per unit volume decreases. Consequently, the ultimate size of the tree determines the spacing of trees in the grove, and there will be an optimum tree size, which allows a spacing for maximum yields per unit area. It must be kept in mind that this is true only for trees growing under optimum soil and management conditions. The maximum yield obtainable from an adult citrus grove per unit area remains fairly constant, irrespective of the size of the trees or the number of trees per unit area. This means that, with smaller and more trees per unit area, picking cost per case or container will be lower.

TABLE 1. YIELD OF WASHINGTON NAVEL TREES ON VARIOUS ROOTSTOCKS IN RELATION TO TREE SIZE (VOLUME[a])

Volume, m	Average yield per tree, kg	Average yield per unit volume, kg
5-10	55.4	7.9
10-15	91.0	7.6
15-20	123.4	7.3
20-25	150.8	7.0
25-30	170.3	6.5
30-35	194.0	6.2
35-40	207.0	5.3

a. Calculated as prolate or oblate spheroids (3).

These deliberations lead to the question of the desirability of dwarfing or semi-dwarfing rootstocks in citriculture. Until now, no really dwarf-

ing rootstock was known in citrus. Trifoliate orange [*Poncirus trifoliata* (L.) Raf.], when budded with exocortis-free or nucellar budwood, will eventually develop a large tree. In 1954, the author visited a 40-year-old grove of Washington navel orange [*Citrus sinensis* (L.) Osb.] on trifoliate orange in San Bernardino County, California. The grove was planted at an interval of 6 x 6 m, and the trees (apparently from exocortis-free budwood) had closed the spaces between them completely. The height of the trees was about 6 m.

Before the development of our knowledge of virus diseases, a number of semi-dwarfing rootstocks were mentioned in the literature. In particular, the Palestine sweet lime (1) and the Rangpur lime (2) were referred to as semi-dwarfing stocks. We now know that this effect is caused by the xyloporosis or the exocortis virus, respectively. However, groves on these rootstocks, when given proper care, are reported to produce good yields, and with the adequate number of trees per unit area the yield will be in the maximum range.

This raises the question of whether virologists and citriculturists should cooperate to use these viruses for effective tree size control in order to meet the demands of mechanical harvesting operations.

The author is aware of the welter of problems connected with this aim, and of the research, most of it basic, which must be carried out before the results can be applied in practice.

First of all, citrus viruses occur in various more or less virulent strains. Sometimes these strains are present in the same region, as is the case with virulent and mild strains of tristeza. The same situation seems to occur with the exocortis virus in Brazil, where sometimes trees on Rangpur lime develop quite normally and produce good yields, whereas in other cases trees are in decline the third year after budding. In Israel, Shamouti sweet orange trees on Palestine sweet lime [*C. aurantifolia* (Christm.) Swing.] exhibit only minor symptoms of xyloporosis and later develop into trees with good production. In other cases, severe symptoms accompanied by decline develop quite early and the trees can be saved only by early inarching with a tolerant rootstock.

Therefore, the first step towards using viruses for tree size control is the isolation of the various strains of the virus and the study of the influence of each strain on the trees. Here, two approaches are possible: If the virus is not insect- or seed-transmitted, the isolation work can be carried out in the field by collecting material from selected trees in the groves. The other approach would be the extraction and purification of the various strains by biochemical or biophysical methods. An advantage

of virus material obtained in the latter manner would be the possibility of inoculating virus-free plant material with the desired strain to evaluate exactly the influence on the tree. Considerations of cross-protection would also come into play in this respect.

The author is aware that the ideas developed in this paper constitute a very unusual approach to the virus problem in citriculture. It has been stated in the past that in many cases "we have to live with the virus." With the progress of our knowledge of the structure of viruses and virus strains, it should be possible to use mild strains of certain viruses for effective tree size control.

This paper is a contribution from The National and University Institute of Agriculture, Rehovot, Israel. 1966 Series, No. 1049-E.

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