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LOSS OF PRODUCTIVITY IN CLONAL APPLE ROOTSTOCKS

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Abstract. The paper outlines the apparent loss of rootability and juvenility in the Ottawa series of apple rootstocks in Canada. The lack of a suitable quick chemical test, as well as the uncertainty of using morphological characteristics associated with juvenility for assessing rootability is briefly discussed. Based on published work, as well as anatomical differences between the easy-to-root and difficult-to-root sources of the Ottawa rootstocks, a quick, easy test using the mid-nodal region of the basal internode of one-year old apple wood and staining cross-sections with phloroglucinol-HCl is suggested. Not only the lesser amount of phloem fibre in the easy-to-root type, but also the existence of large gaps in the ring is important. Suggestions are made for retaining rootability in clonal apple rootstocks and for their distribution.

There is a need to safeguard the existing levels of rooting in clonal apple rootstocks but more important, new clonal or vegetative lines must be kept in the juvenile condition especially for their successful propagation by softwood cuttings. According to Beakbane (2), Gardner first reported the loss of rooting ability over the period of change from juvenility to maturity in 1929, but even for tissue culture, Abbott (1) specified juvenile material. This paper is not intended to review the vast amount that has been published on juvenility, but rather it is an

attempt to bring to the propagator's attention a situation where juvenility and rootability has been inadvertently lost in a series of apple rootstocks and to suggest a rather simple test to ascertain rootability in apple tissue.

In the 1950's the author was involved in an apple rootstock breeding program with Agriculture Canada, but the final selection, as well as the introduction of a series of rootstocks, known as the Ottawa series, was carried out by other researchers when he left that service. Early in the selection program, random samplings of the selection showed high rootability by softwood cuttings under intermittent mist outdoors. Much later nuclei of the rootstock series were received at Saskatoon, Saskatchewan directly from Ottawa and were established in stoolbeds. These stools were cut to ground level annually and no difficulty was experienced in rooting softwood cuttings from them (10). With Ottawa 3, which was of particular interest because of its dwarfing ability, he also cited other researchers, however, who had reported extremely poor rooting or complete failure with this rootstock; at Saskatoon, however, there was 89 to 100 percent rooting with an average root score of 4.8 to 5.0 in a 0 to 5 range (5 best) after seven weeks in an intermittent mist bed outdoors with no bottom heat. The above values were from treatments receiving either 0.1, 0.3 or 0.8 per cent IBA in talc, but there was no rooting trend from hormone concentration. Cuttings not treated with hormone rooted in the same percentage range, but the average root score was less (3.1). Since propagation technique was not in question, it seemed an obvious case of loss of juvenility and rootability.

Hess (6,7,8), reporting to the International Plant Propagators' Society, explained the difference in rooting of easy- and difficult-to-root plants on the basis of rooting cofactors. Applying this theory to apple, Challenger et al (5), Quamme and Nelson (12), and Nelson and Pepper (11) all presented evidence of what appeared to be three separate cofactor type responses in apple. The partial transfer of this rooting response to adult softwood cuttings by grafting juvenile tissue into the adult tissue above the rooting medium level was also demonstrated by Nelson (9). On the other hand, Zimmerman (13), working with *Pinus*, was unable to demonstrate a difference in the two growth phases and Nelson and Pepper (11) cited results obtained by a graduate student, Miss Hivang, where the use of toluene to remove fats and pigments from the extracts allowed the extracts from adult tissue to express a root promoting effect similar to the juvenile extracts. Unfortunately, this work was not continued and some of the emphasis on rooting cofactors seems to have been dropped. Regardless, to the author's knowledge, no suitable chemical extraction method that will easily

ascertain the degree of rootability in relation to juvenility is available to the plant propagator.

Morphological characteristics have been used to describe the juvenile and adult growth phases and Blair, MacArthur and Nelson (4) cited European literature, mostly German, that became available after World War II to describe the two growth phases in apple. Blair, *et al* (1956) worked with *Malus* × *robusta* 5 apple rootstock which existed in the two growth phases and matched the morphological descriptions. The rooting ability was vastly different, with the juvenile phase being superior. Nelson (10), citing earlier unpublished data, reported that the juvenile crowns showed a marked reduction in rootability of softwood cuttings when the crowns attained a height of only six inches above ground. These crowns had never been allowed to reach the fruiting stage and had not changed in morphological characteristics from that of the juvenile stage. Accordingly, morphological characteristics as described for juvenility could hardly be used as a practical test.

Although not included in the published report (4), MacArthur had observed differences in the fibre content of the phloem in the cross-sections of the two growth phases of *Malus* × *robusta* 5, but a later search of her stored laboratory notes failed to uncover details. Beakbane (2) showed that the formation of fibres and sclereids in the primary phloem acted as a barrier to root formation and that rooting was inversely proportional to the amount of fibre, as well as the continuity of the fibrous ring. She also suggested that this explained the difference in rooting between the juvenile and adult growth phases. This was later confirmed (3) and she elaborated further on the nature of the barrier which was not only mechanical, but also showed that some of the lack of rooting was due to the fact that phloem ray cells abutted fibre tissue and were not connected by living cytoplasmic strands in the shy-rooting types.

A simple test based on these anatomical differences has been suggested by Nelson in a paper entitled, "A Test for Juvenility and Rootability in Clonal Apple Rootstocks", which has been submitted to the Canadian Journal of Plant Science. Essentially, the remainder of this paper is a summary of this recent submission. Using the mid-nodal region of the basal internode of one-year old wood, cross-sections were made with a sharp knife and stained by the phloroglucinol-HCl technique. The colour developed rapidly and very little magnification, if any, was needed to ascertain the difference in phloem fibres illustrated diagrammatically in Figures 1 and 2. Where comparisons could be made, the easy-to-root material at Saskatoon had much less fibre, as well as more numerous and wider gaps in the ring, than the difficult-to-root material gathered at the Ag-

riculture Canada Research Station, Sydney, British Columbia. The varying amounts of fibre in Ottawa 3 and Ottawa 12 are depicted in Figure 1 as examples, but similar differences were recorded for Ottawa 7, 8 and 11, with the amount of phloem fibre being rated very light or light in the material from Saskatoon and medium or heavy in the material from Sydney. The same differences occurred between shoots from the stool beds of juvenile *Malus* × *robusta* 5 (Figure 2A) and adult trees of the same selection (Figure 2B) grown at Saskatoon. Although the adult phase only had a medium amount of fibre, it formed a narrow ring with almost no gaps. The least fibre was found in tissue taken about 7 cm from ground level on transplanted seedlings of the cultivar, Kerr, after their first full season in the field (Figure 2C). All the fruiting trees and selections sampled (BE601, BE6027, Edith Smith, Patterson, Pioneer 60, and U10-11) had at least a medium rating as depicted for Patterson (Figure 2D).

This review of a case of loss of rootability in a series of apple rootstocks points out certain rather important facts about the maintenance of high root capacity and the distribution of rootstocks in a manner which will preserve this rootability. To maintain the high level of rooting, stools of apple rootstocks must be pruned as close to the ground level as possible which will mean periodic pruning back of the crowns themselves. Although crowns for rooting material used solely for commercial rootstock purposes can be allowed to develop slowly in height for several years and still maintain suitable root formation, any propagation of new nuclei for propagation purposes should come from very severely pruned crowns to obtain the highest rooting potential possible. Although, in the case of the Ottawa rootstock series, nuclei have been propagated to send for virus indexing at Sydney, B.C., other sources of the Ottawa or any other rootstock selections should be monitored by the phloroglucinol-HCl test to select and perpetuate those sources with the least fibre present. It is obvious that in the handling of the Ottawa and *Malus* × *robusta* 5 rootstocks currently being held at Saskatoon they have progressed considerably in fibre content, even though they still root satisfactorily, when compared to the fibre content of the Kerr seedlings.

Although the exchange of rooted material over international boundaries does present certain problems, it seems to be the only method of transmitting the high level of rootability. Quarantine and virus-indexing stations must realize that these rootstock nuclei have to be handled differently from nuclei of fruiting cultivars. These rooted plants must be isolated so that the basal tissue can be perpetuated if and when the material is cleared. Also, the practice of distributing budwood or scions, as

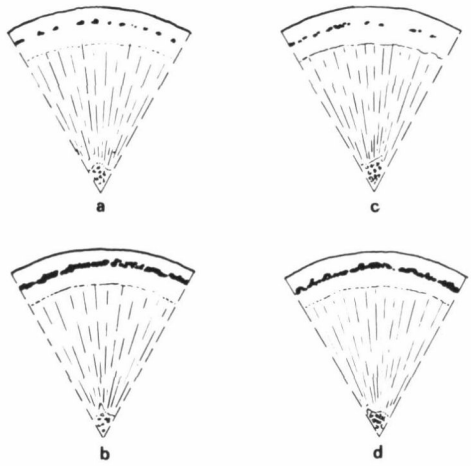

Figure 1. Diagrammatic sketch showing differences in the presence of phloem fibres and continuity of the fibrous ring in cross-sections of the mid-internodal region of the basal internode of one-year old apple wood in the dormant condition. A — 'Ottawa 3' rootstock from Saskatoon, Saskatchewan; B — 'Ottawa 3' rootstock from Sydney, B.C.; C — 'Ottawa 12' rootstock from Saskatoon; and D — 'Ottawa 12' rootstock from Sydney.

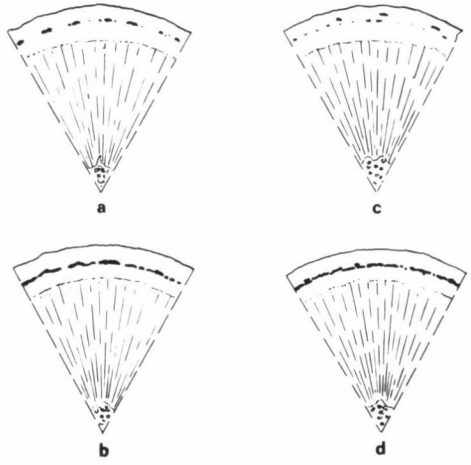

Figure 2. Diagrammatic sketch showing differences in the presence of phloem fibres and continuity of the fibrous ring in cross-sections of the mid-internodal region of the basal internode of one-year old apple wood in the dormant condition. A — '*Malus robusta* 5 rootstock (juvenile); B — '*Malus robusta* 5 rootstock (adult); C — 'Kerr' seedling after one full season in field; and D — 'Patterson' (from fruiting age trees).

practiced with fruiting cultivars, is quite unsatisfactory for transferring the high rooting capacity of the tissue.

Finally, if original clones are maintained in the future and if the amount of liquified phloem tissue is monitored, the loss of rootability as experienced in the Ottawa rootstocks should be avoided. The phloroglucino-HCl test on tissue of the mid-internodal region of the basal internode of one-year old wood in the dormant condition is suggested as a satisfactory, easy, and quick test.

ACKNOWLEDGMENT

The author would like to acknowledge the assistance of Mr. D. Bertoia of the Agriculture Canada Research Station, Sydney, B.C. who supplied the Ottawa rootstock tissue. Through his co-operation the paper and this discussion was made possible.

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