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MODERATOR BLAIR: I am now going to call on Dr. S. H. Nelson to give you the results of his work this past season in propagating apple from leaf-bud cuttings.

Dr. Nelson is a plant propagator employed by the Canadian Department of Agriculture. I don't know of any other similar position in the entire Dominion Service. He was appointed a few years ago to work exclusively on the problems pertaining to the propagation of fruit and ornamental materials. We consider this matter of propagation to be of equal importance to other phases of our horticultural work. Dr. Nelson took his undergraduate work at Ontario Agricultural College and, as a graduate student at Michigan State University, worked with Dr. H. B. Tukey. Therefore he has quite an appreciation of propagation work and experiments which are in progress in the United States. Dr. Nelson!

DR. NELSON: I think it is needless for me to say that I am very happy to be here today. It is a pleasure and an honor to have the opportunity to describe to you my recent work with leaf-bud cuttings.

Dr. Nelson presented his paper, entitled: "Malus Understock from Leaf-bud Cuttings." (Applause).

MALUS UNDERSTOCK FROM LEAF-BUD CUTTINGS

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As Mr. Blair has pointed out in his survey, there are two or three broad types of rootstocks that can be used as understocks for apples. With due respect to seedlings and apomictics, we will leave these and concern ourselves only with clonal rootstocks, for the purpose of this paper.

Let us reiterate a little further. It has been brought out that stool bed maintenance is costly and laborious, and even with mechanical aids the production of clonal rootstocks is expensive. Furthermore, with stool beds a rather fixed amount is produced each year and the flexibility required to fit the unstable requirement for apple trees is lacking. Some more flexible method is desired, and cuttings naturally appear to fit this problem.

At Ottawa, random attempts have been made over the years to root harwood cuttings, but with little success. Climatic factors certainly play an important role since we cannot line out cuttings in the field, as is being done in Europe. Another factor, however, may have been the mature physiological condition of the wood, referred to by Mr. Blair.

Root cuttings have proven to be a successful way of propagating rootstocks, but here, again, cost and availability rather rule out this method unless it is of particular importance experimentally.

Now we come to softwood cuttings. As reported in a recent issue of the American Nurseryman, both soft tip and leaf-bud cuttings rooted in a preliminary survey. Leaf-bud cuttings were particularly promising in this survey under continuous mist and a glazed propagation box. The cuttings were taken similar to the buds used in bud grafting but the leaf was not detached. The cuttings were subjected to meticulous care, such as shading and syringing, in the glazed propagation box. Briefly, it was shown that the apple rootstock Malus #5 could be multiplied successfully by leaf-bud cuttings, and that soft tip cuttings also showed promise under mist.

Having proved that such cuttings would root fairly readily, a sizable experiment was planned this year under conditions more feasible commercially. Six propagation frames were established. These included:

(1) Intermittent mist out-of-doors, using the day-night clock and minute timer. A spray was applied intermittenely through Florida 550A nozzles from 6 a.m. to 8 p.m. daily. At first the sprav interval was twelve seconds in sixty, and later reduced to four seconds in sixty. A windbreak of burlap was placed around the frame.

(2) Intermittent mist in greenhouse. Same as previous description. except it was placed on the side bench of a greenhouse.

(3) Continuous mist out-of-doors. Same set-up as intermittent, except spray continuous from 6 a.m. to 8 p.m. daily.

(4) Plastic tent out-of-doors. A wood frame was built over the propagation frame and covered with a double layer of cheesecloth. Over this a roll of polyethylene 132 inches wide was spread, cut to length and stapled in place, leaving the sides so they could be rolled up.

(5) Plastic tent in the greenhouse. Here, again, the set-up was very similar, except the entire frame was hinged on one side and could be lifted.

(6) Glazed propagation box. Here the glass was sloped enough on both sides to allow condensation run-off. The light for reach compartment was hinged to the central ridge.

Four media were included in each propagation frame, namely, sand, sand plus peat, sphagnum moss, and vermiculite.

Over all, five types of cuttings were used—the standard soft tip cutting, and four types of leaf-bud cuttings. Since cutting the shallow shields was time consuming, it would be more expedient to cut the current growth about three-quarters of an inch above and below the bud without scoring, and this formed one of the treatments. For the second type, similar buds were made and scored on the side distal from the bud. For the first two types, the buds had not expanded or were not showing auxillary growth. With M. robusta #5, however, there is a great tendency toward spurring, and therefore the other two treatments consisted of leaf-bud cuttings with active buds that were unscored and others that were scored. For the purpose of this paper, they will hereafter be referred to as active leaf-bud cuttings, although they could well, and possibly more correctly, be called "mallet cuttings."

Cuttings were taken from mature 18-year old stock trees and the juvenile form in the stool beds. It was planned to take cuttings at three intervals during the summer, but due to heavy demands for space by ornamental material only two dates were possible.

Hormone treatments of Hormodin #1, Hormodin #2, Hormodin #3 and Chloromone were employed.

In all, 6,150 *Malus robusta* #5 cuttings were taken. Each treatment consisted of five replications of ten cuttings each. Where only two comparisons were made, the data was subjected to the Student-Fisher "t" test for significance. Where more than two comparisons were available, the data was subjected to analysis of variance and the least significant differences calculated.

Now to consider the results. First of all, the glazed propagation box out-of-doors, the plastic tent out-of-doors, and the plastic tent in the greenhouse were complete failures. With the glazed propagation box, this is rather contradictory to the preliminary findings. This past summer, however, was unusually hot and this unnatural weather was of prolonged duration. Shading was increased, but even two layers of cheesecloth and a layer of burlap failed to stop the scorching of the cuttings. This summer has clearly shown that the glazed propagation box, as well as the plastic tent, cannot be recommended universally, although they prove successful in some seasons. For the comparison of techniques, only three treatments were left, namely, continuous mist out-of-doors and intermittent mist out-of-doors and in the greenhouse. With soft tip cuttings it was found that continuous mist was the best technique, but not very superior to the intermittent mist out-of-doors. Both, however, were superior to the intermittent mist in the greenhouse to a high degree of significance, as shown in Table 1.

Table 1—Results of soft tip cuttings of Malus robusta #5

Treatment	Average per cent rooting	
	Check	Chloromone
Continuous mist out-of-doors	96	94
Intermittent mist out-of-doors	88	92
Intermittent mist in greenhouse	34	42
L. S. D. 5% level	3.8	2.3
L. S. D. 1% level	5.5	3.4

The leaf-bud cuttings, the intermittent moist out-of-doors and continuous mist out-of-doors treatments gave results that were very similar and were superior to the intermittent mist in the greenhouse. The results, however, were insignificant, except with the active non-scored type with no hormone. No explanation for this exception is apparent.

When the media were considered, there were no significant differences between treatments. There were, however, definite preferences as far as the operator was concerned. Vermiculite was found to be rather messy under the misting systems, and tended to settle. With sphagnum moss, severe settling occurred, and although rooting was extensive, considerable breakage occurred in extracting the roots from the medium.

Possibly both of the faults could be overcome, to a degree, by finely shredding the sphagnum. From the propagator's view, sharp sand, or sand plus peat, was the easiest to work with and very satisfactory.

Table 2—Media comparison for rooting Malus robusta #5

Media	Average per cent rooting	
	Tip	Leaf-bud active, scored
Sand	88	78
Sand plus peat	96	74
Sphagnum moss	100	72
Vermiculite	92	56

Only two of nine comparisons between chloromone treated and check cuttings proved to be significant in favor of the addition of this hormone. Hormodin powders were also used along with cloromone in four comparisons. As shown in Table 3, Hormodin #2 and Hormodin #3 gave the greatest rooting in the early maturity and were highly significant over the check. It was noted with Hormodin #3 that there was some toxicity, but with chloromone there was killing of the tissue wherever the liquid touched. This killing was in the immediate region, and rooting occurred above the injured area, but the percentage rooting, although greater than the check, was significantly reduced below the other hormone treatments. With the late maturity the same general pattern existed with the tip cuttings. However, with the leaf-bud cuttings this pattern did not exist and maybe caused by the relatively low percentage rooting and high degree of abscission at this maturity.

Table 3—Summary of hormone treatments

Treatment	Type of cutting and average per cent rooting			
	Early maturity		Late maturity	
	Leaf-bud not active, scored	Tip	Leaf-bud not active, scored	Tip
Check	26	34	8	38
Hormodin #1	68	84	16	68
Hormodin #2	80	88	16	60
Hormodin #3	78	76	34	68
Chloromone	66	42	50	28
L. S. D. 5%	4.9	2.7	3.2	4.6
L. S. D 1%	6.8	3.7	4.5	6.3

It is also apparent, in the last table presented, that maturity played an important part in the rooting ability of the leaf-bud cuttings. Cuttings taken in the last week of June were very much superior to those taken near the middle of August. With tip cuttings this difference is not apparent with the check treatment, but the addition of hormone was less effective on the later date.

Physiological age of the parent material was also of the utmost importance with *Malus robusta* #5. When tip cuttings were taken from

adult trees, only the odd success was encountered, and abscission of the leaves was common. With leaf-bud cuttings no rooting occurred, and the leaves abscissed almost 100 per cent. On the other hand, with the cuttings taken from the stool beds, where the severe annual pruning retains the juvenile character, rooting occurred as previously described in the various treatments.

The last, and possibly the most important comparison is the actual type of cutting used. Soft tip cuttings were the most successful, followed closely by the leaf-bud cuttings. The majority of the statistical comparisons were not significant when scoring was considered, but, like results with most plant material, there were exceptions without a conceivable expanation. Furthermore, when considering the comparison of active to non-active buds, there is no consistent pattern and no correlations with treatments. It is apparent, however, on the basis of this work, that active buds do not cause the cutting to root more readily, as might be suspected. Actually, in many cases, the reverse is true.

Only one clonal rootstock has been discussed. Another one, 0-524, was tried, but poor rooting and a high percentage of abscission was the result. These results are similar to those obtained from the adult form of *M. robusta* #5, and suspicion is now focused on the fact that we may not have the juvenile stage in this rootstock. This is substantiated by its performance in a stool bed, since it is not nearly as prolific as the juvenile *M. robusta* #5.

In summary, the following points should be reiterated:

1. Mist systems offer a greater insurance against loss than plastic tents and other propagation boxes. Further, these mist systems are better located out-of-doors.

2. Under mist, the four media tested showed no significant differences, and the choice can be left fairly well to the propagator's preference.

3. Hormones are beneficial, but toxicity will occur if they are used in too strong a concentration. Hormodin #2, or its equivalent, is about the maximum.

4. Date of taking cuttings is important, and although further work is needed, the last week in June gives satisfactory results. As yet, the limits of this period have not been defined.

5. Tip cuttings are the most successful form, but leaf-bud cuttings propagate readily also. Since scoring is apparently not necessary, these cuttings can be made readily, and use made of a lot of parent material that is normally wasted.

6. The physiological age of the parent plant is of utmost importance. Very poor success was encountered with adult material. To date, we have been taking our juvenile M. robusta #5 cuttings from the stool beds, where the crowns are pruned to ground level annually. Whether we can allow this stock to form a hedge row, subject it to severe annual pruning, and still retain juvenility is not known.

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DR. NELSON: I forsee several questions which I will answer now. The first is, I cannot answer whether the EM rootstocks will come from leaf-bud cuttings or not. Work along this line has been done in England

and they have reported that most of the stocks are in the adult stage. Frankly, the only two that rooted from leaf-bud cuttings or soft-wood cuttings were EM V and EM VIII. Neither of these is as important as EM IX, EM VII, EM XVI, or EM XII.

The second question which could be answered now is the length of time that it takes these leaf-bud cuttings to make buddable trees. From the preliminary work at Ottawa, it was shown that by planting the rooted cuttings in beds in the fall and letting them grow the following summer, they would be ready for budding in about a year and a half.

MODERATOR BLAIR: Thank you, Mr. Nelson. We will now have questions on these two talks, before proceeding to the remainder of the panel.

MR. HOOGENDOORN (Hoogendoorn's Nursery, Newport, R.I.); Dr. Nelson, how do you get these active leaf-buds? Do you pinch the top of the shoots?

DR. NELSON: The formation of laterals of *M. robusta* No. 5 is a natural process. One of the characteristics of the juvenile form is that it does branch prolifically so that the single shoot coming up at a very young age sends out laterals.

MR. HOOGENDOORN: Have you experimented with varieties such as Hopa?

DR. NELSON: That is rather hard to answer. I have taken a few cuttings. I certainly would not want to be quoted on anything I say because the number has been so small. One of the ornamental crabs, Bakatong, which is the one we are recommending at Ottawa, did root about 50 percent, but only from soft tip cuttings. I have no information on any of the other species.

DR. NITSCH (Cornell University, Ithaca, New York): Do you have any explanation for the better rooting obtained out-of-doors compared to rooting in the greenhouse?

DR. NELSON: I think we should ask Jim Wells that. He was the first to recommend taking the glass out of the greenhouse and installing a mist system. There, I had glass. Whether it was the light factor or not, I do not know, but there was a side bench in the greenhouse and also of light energy was reflected from this sloped glass that never got to the cuttings. This may be one consideration.

DR. MAHLSTEDE (Iowa State College, Ames, Iowa): There is some data to be presented at the session on mist propagation which may be interesting in this respect.

MR. CHARLES HESS, SR. (Hess Nursery, Mt. View, N.J.): Is any work being done on dwarf understock for ornamental flowering crabs?

MR. BLAIR: The answer to that is very simple. Very little, if any, experimental work has been done. This does not mean that ornamental crabs have not been grown on the EM rootstocks at Ottawa for we have propagated several varieties on a range of EM rootstocks. They have behaved similar to commercial apple varieties.

MR. HESS: Which would you recommend as a dwarf rootstock for flowering crabs?

MR. BLAIR: If you want a tree of small stature, you must use EM IX. There is compatibility with most varieties, however Bechtel's crab is an exception and is not compatible on EM IX.

MR. MICHAEL P. SEBIAN (Sebian Nurseries, Painesville, O.): Dr. Nelson, you mentioned injury to tissues by the use of Chloromone. Was the Chloromone used full strength or was it diluted?

DR. NELSON: All of the work was done with full strength, however care was taken to dip only the cut surface of the cutting in the hormone material.

MR. LESLIE HANCOCK (Woodlawn Nursery, Cooksville, Ont.): I would like to report to Charles Hess Sr. that we have found seedlings of *Malus sargenti* to be suitable understock for Bechtel's crab and Olmey rosy bloom, but incompatible for Eleyi and Scheideckeri.

MR. ROSCOE FILLMORE (Fillmore's Valley Nursery, Centreville, Nova Scotia): I would like to suggest to Mr. Hess, that judging from the orchard at Vineland, Ontario, and their use of EM VII for the propagation of commercial apples, that EM VII should give a very nice ornamental crab provided it is well enough anchored, whereas with EM IX you almost have to hang it in the air to keep it standing up on account of the root system.

MR. BLAIR: Actually, this is almost a subject in itself, but I think that probably I should go into it a little more fully than I have.

As I said before, EM IX gives the most dwarfing type of root stock but unfortunately the stock is brittle. Therefore the trees have to be staked. It is quite probable from an ornamental point of view that you wouldn't want to stake the trees and that would rule out the EM IX stock.

The next stock along the line in dwarfing habit, as Mr. Fillmore has pointed out, is EM VII. EM VII, unfortunately, has not been tested in North America too long. In the original root stock trial plantings in this country, EM VII was not included so the experiences with it extend only over a period of about ten years. However, the indications at the New York Experiment Station at Geneva and at the Vineland Station in Ontario are that it will give a smaller tree than the variety propagated on EM I or II. We thought we had an almost ideal type of stock for the commercial grower, but along came hurricane "Hazel" about a year ago and in some of our plantings where we had EM VII, every tree was uprooted. This made us stop and think whether we should go ahead and plant commercial orchards on that stock. So, although EM VII will give the desired shape tree, it doesn't have the anchorage we would like.

Now in the Okanagan, we were all set to recommend EM VII in our apple orchards out there. We found that as soon as the trees got in full bearing, they fell over and we had to drop it from our recommendations. With all of these stocks it takes quite a long while before we can fully evaluate them. Sometimes you have to wait many years to get a certain set of conditions and that is what you are up against in root stock evaluation trials.

I think the answer is that, at the present time, we don't know what the best dwarf stock would be for ornamental crab.

MR. BRUCE VANDERBROOK (Vanderbrook's Nursery, Manchester, Conn.): I would like for Dr. Nelson to define what he means by "juvenile" stock?

DR. NELSON: It is a physiological stage that the plants go through. I tried to correlate it with humans when talking with someone yesterday. For example, a baby gets a set of baby teeth. When they are lost, they are replaced with permanent teeth and the baby teeth cannot return. Likewise an apple tree goes through stages of growth. It has a juvenile stage just as the baby has. However, in the apple the stage is not lost, but rather becomes buried and is retained throughout the life of the individual tree.

This is true, however, only when starting from the seedling. Buds which are usually used for budding purposes are adult, not juvenile, and consequently the propagating material, which is adult, produces budded trees with the adult habit. The line of demarkation between juvenility and adulthood is not too well defined, but most people consider that a tree has reached the adult stage when it starts to flower.

MR. BRUCE VANDERCOOK: How can you recognize juvenility?

MR. BLAIR: There is a marked morphological difference with apple. From the nurseryman's point of view, the main difference between juvenility and adult growth is the type of bark. In juvenile trees, the bark is rough, whereas the bark of a two-year-old tree in the adult form is smooth. The thorny type of growth, characteristic of juvenility, is lost when the plant becomes four or five years old. It gradually looses the spuriness and become smooth. If you propagate from the smooth type, rooting is poor, while cuttings made from the thorny type of growth root quite readily.

MR. CASE HOOGENDOORN: How long can you keep the plants juvenile?

MR. BLAIR: You can keep them in the juvenile stage indefinitely. It is primarily a matter of keeping the plants cut back severely.

MR. JAMES IE. ILGENFRITZ (Ilgenfritz Nurseries, Monroe, Mich.): I would like for Mr. Blair to comment on the Malling Merton stocks and the EM IV stocks, which I understand are in quie frequent use.

MR. BLAIR: EM IV root stock is less vigorous than both EM I and EM II but more vigorous than EM IX and even EM VII. In other words, it gives a tree approaching that of EM I and EM II. The most outstanding characteristic of EM IV is that it is very precocious, that is, it bears very heavily at a young age. It is more precocious than any other of the EM series. Unfortunately, it is a very poor rooter. This rootstock is losing favor fairly rapidly on the Continent where it was used very extensively ten and fifteen years ago. Most of the new commercial plantings in Europe are on EM IX.

The Malling Merton series is a new group of understocks which were developed from crosses made at the East Malling Research Station and at the John Innes Breeding Station. They are crosses between the Malling

series and Northern Spy. The objective of this work was to develop a series which were resistant to root aphids. Since they are highly resistant to the insect, this series should be of interest to any nurseryman where root aphids are a problem. The fruiting characteristics are probably not superior to that of the EM series.

The outstanding one is MM 104. It has about the same vigor as EM II but it bears earlier and gives a heavier crop during the first ten years in the orchard. It is not a small dwarf tree. None of the MM series will develop a tree as small as EM IX or EM VII. In Germany, it was found that these stocks are extremely tender. In preliminary trials at Ottawa, the MM rootstocks have shown considerable winter injury.

MR. HESS: Have the Paradise and Doucin apples, which were formerly used in Europe, been discarded?

MR. BLAIR: They have not been discarded. EM II is Doucin "English Paradise" and is one of the most widely used in England. EM I is Broad-leaf "English Paradise." These European rootstocks have been classified at the East Malling Station and are now known as the EM series.

PRESIDENT FILLMORE: This afternoon we have with us, Mr. R. C. Simpson of the Simpson Orchard Company, Vincennes, Indiana. Mr Simpson has had a long experience in the propagation and production of ornamental crabs. He was educated at Purdue University, but this afternoon he is going to give a practical talk on the propagation of apples by budding and grafting.

Mr. Simpson presented his talk, entitled "The Propagation of *Malus* by Budding and Grafting." (Applause)

THE PROPAGATION OF MALUS BY BUDDING AND GRAFTING

ROBERT C. SIMPSON
Simpson Orchard Company
Vincennes, Indiana

Propagation of horticultural plants by budding and grafting is one of the oldest horticultural practices. In ancient Greece the technique was well known and stock and scion effects noted. Today the actual mechanics are commonly known and relatively simple. Results, however, may depend upon a long series of factors.

First I will briefly outline our operation, then mention some of the problems we have encountered. Finally I will go over some of the points we think we have learned. And may I add, I do not presume to speak as an authority, only as one intensely interested in the subject. There are many present who have had more years of experience. If I draw conclusions they know to be in error, I and the rest present will welcome correction.

Our understocks are ordered on a five year basis to obtain a price discount, with minor seasonal adjustments made usually by July. The understocks arrive in January or early February. These are unpacked,