promising. These deteriorate after specified periods, opening the beds to rainfall or irrigation and leave no mess to clean up. This year chrysanthemum plants planted through plastic were superior in color and growth to those grown with our standard mulch.

Yes, IPPS has indeed had a profound effect in improving nursery practices. But even greater challenges lie ahead.

PROPAGATION BY SOFTWOOD CUTTINGS FROM ROOT PIECES TO REINTRODUCE JUVENILITY IN A NEW DWARF ROOTSTOCK (OTTAWA 3)

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Abstract. Softwood cuttings of the dwarf apple rootstock *Malus* 'Ottawa 3' were successfully rooted using material obtained from shoots grown from root pieces of plants which were in an adult (fruiting) state. The data showed that the reversion of the material to a juvenile condition was directly related to the changes brought about in the root piece process. Rooting percentages were increased by using 0.8% IBA, wounding of the cutting bases, and using terminal cuttings.

INTRODUCTION

The use of size-controlling rootstocks in the apple industry has had a profound impact on the productivity of modern orchards. The Malling series of dwarf and semi-dwarf rootstocks has been the most important and readily available. However, in the province of New Brunswick, Canada, and in similar regions on the northerly limits of commercial apple production, problems with winter hardiness have hampered efforts to introduce these rootstocks. Complete or partial winterkill has kept production levels far below those which were initially expected, and the search for comparable but hardier dwarfing rootstocks has intensified.

One rootstock, introduced by Agriculture Canada, which seems to offer promise is 'Ottawa 3', a cross between Malling 9 and the hardy, semi-dwarf 'Robin' crabapple. Trees budded to 'Ottawa 3' will have an ultimate height of approximately 3 m, be exceptionally precocious and very productive (1). Semi-dwarf trees can be produced by using 'Ottawa 3' as an interstem between the desired cultivar and a hardy, well-anchored rootstock. The height of the tree can be adjusted by the length of the interstem piece (2).

A problem associated with the propagation of 'Ottawa 3' is that it is a shy rooter in the conventional stool bed (3). Because it fruits at an extremely early age, most propagation material available is in an adult state. Cuttings from this material, both hardwood and softwood, are generally very difficult to root. Conditions such as these tend to frustrate propagators and 'Ottawa 3' has been slow to appear on the market.

The first plants of 'Ottawa 3' which we received were 6 heavily cut crowns with a few roots. Ordinarily we would have planted these out and hilled them up to induce the shoot bases to root; however, a chance reading of an article by Dr. S.H. Nelson of the University of Saskatchewan prompted me to try cuttings as a propagation method. Dr. Nelson had showed that the progressive buildup of fibrous tissue in the phloem of juvenile apple wood (in this case 'Ottawa 3') was directly associated with the loss of rootability in the mother plants. These fibers were acting as mechanical inhibitors to the rooting process. The juvenile material that Dr. Nelson had was the result of the original 'Ottawa 3' material being cut down to nearly ground level where the plant was most juvenile (5).

Rather than cut our crowns down to ground level, we chose a different approach. Knowing that plants in the genus *Malus* generally can be propagated by root pieces (4), we decided to take pieces of root and force shoot growth from them in the greenhouse. Virtually all of our root pieces produced strong shoots within a month. Using this material we then proceeded to test these shoots for rootability.

MATERIALS AND METHODS

A total of 10 crops were taken during 1982 and 1983. These experiments were designed to demonstrate: (1) The rootability of material taken from the shoots derived from root pieces versus the rootability of the control adult phase material; (2) the influence of various concentrations of IBA on rooting speed and strength; and (3) the effect of mechanical wounding on rooting.

Cuttings were taken from mother plants grown in 1 gal pots in the greenhouse in a medium of peat (or finely shredded bark) and soil (2:1, v/v). The mother plants were fed with a soluble 20-20-20 fertilizer every 20 days. Both terminal and basal cuttings with 2 to 4 leaves were taken.

We used both a polyethylene humidity tent and an open misting bench. The humidity tent was watered intermittently as temperature dictated. The misting bench was misted every 30 min for 15 sec except during extremely warm periods when the cycle was shortened to every 15 min. No mist was applied at night.

Cuttings were placed in 2½ x 2½ x 4 in. plastic pots in three rooting media. The media used were: clean sand and sawdust (1:1, v/v), clean sand and peat (2:1, v/v), or washed 1 mm ground limestone rock and peat (6:1, v/v).

RESULTS

Juvenility Factor. Our first crop involved 50 cuttings from the shoots which we had grown from our root pieces (which we will refer to as the juvenile group). A control crop of 50 cuttings was taken off the plants from which we had taken the root pieces (the adult group). Forty-eight of the 50 juvenile cuttings rooted. None of the adult cuttings rooted. These cuttings were rooted in a humidity tent using a 0.8% IBA commercial talc preparation (Seradix #3).

Our original results were duplicated in our fifth crop when a control group of adult phase material was again used for comparison. After 20 days, 100% of the 384 juvenile phase cuttings had rooted with an average of 10 roots per cutting. Average root length was 2 cm with occasional roots to 5 cm. The 43 adult phase cuttings showed slight callusing with a few roots up to 1.5 cm long. After 2 months the ultimate survival rate of the juvenile material was 86% compared to 16% in the adult phase group. It should be noted that none of the adult phase plants survived the first winter, whereas losses in the juvenile group were less than 4%.

IBA Concentration and Its Effects on Rooting. After our initial experiments had established the ease with which cuttings rooted when taken from the root piece material, we experimented with various concentrations of IBA using commercially available talc preparations. We prepared 261 2-leaf cuttings using material taken from the previous crops. The results were as follows (Table 1).

Table 1. Percentage of rooted cuttings at 20 day inspection

IBA concentration	Percentage of cuttings rooted
Control (no hormone)	0
0.1% (Seradix #1)	0
0.3% (Seradix #2)	5
0.8% (Seradix #3)	61

Ultimate survival of the cuttings treated with 0.8% IBA was nearly 100%. Survival of cuttings treated with the lower concentrations was very low.

We felt that higher concentrations of IBA using pure crystals suspended in an alcohol/water solution might be advantageous. In our sixth crop 1422 cuttings were dipped for 5 sec in various concentrations of IBA. The high concentrations severely burned the soft wood and gave low percentages of rooting. Only the control group, which used a 0.8% talc preparation, had an acceptable rooting percentage (Table 2).

Table 2. Percentage of successfully rooted cuttings.

IBA concentration	Percent rooted
20,000 ppm	5
16,000 ppm	14
12,000 ppm	22
0.8 % IBA (8,000 ppm) in talc	96

It is possible that concentrations in the 10,000 ppm range used for a 2 to 3 sec dip might prove useful, but we feel that the high percentages obtained by using readily available commercial talc preparations makes their use preferable.

Wounding of the Cutting Bases. The effect of wounding the bases of the cuttings was investigated. It was found that wounding was conducive to more rapid rooting and that wounded cuttings had a greater number of roots. In our third crop, it was found that after 20 days 91% of those wounded had at least 1 root over 2 cm in length. This compared to 77% for those which had not received wounds.

Terminal vs. Basal Cuttings. Although we have rooted cuttings taken from the basal portion of shoots, we have shown that terminal cuttings have a considerably higher success rate due to their ability to continue growth during and immediately after rooting. This ability becomes particularly important as the photoperiod shortens making it difficult to force the dormant buds on basal cuttings into active growth so that the cuttings can proceed into dormancy in a healthy, hardy condition. This, of course, reduces the number of cuttings that can be taken from the mother plants. In our opinion, however, only terminal cuttings should be used.

Propagation Chambers. Successful crops of cuttings were raised both under mist and in a polyethylene humidity chamber. We definitely favor the humidity chamber. Our best results occurred in Crop #4 using a high walled polyethylene tent suspended over a greenhouse bench. We feel the presence of moisture in the form of humidity at 100% rather than in the form of a heavier film of water on the leaves helps the cuttings retain their leaves without leaching of nutrients. Our misted crops tended to lose their leaves and recovery was much slower and losses higher.

Rooting Medium. We continually decreased the quantity of water retentive materials in our rooting medium. At present, we feel a medium of 6 parts coarse sand to 1 part peat (or its equivalent) provides a well-drained medium with enough water retention to hold moisture between waterings. Similar results could probably be obtained with comparable mixes using materials such as perlite and peat.

DISCUSSION

It is our feeling that use of the techniques described in this paper for inducing juvenility in 'Ottawa 3' could provide a viable alternative to producing rootstocks from more conventional methods.

Such techniques might also be applied to the production of certain apple cultivars on their own roots. We intend to force root growth on the stems of grafted whips of ornamental crabs and spur or genetically dwarfish cultivars. Once we obtain root pieces we will use the shoots forced from these to begin cutting production.

Once the initial bulking of juvenile material has taken place, we believe this method would produce uniform trees of predictable height and habit, free of incompatibility related problems. In addition, many problems associated with unsterile field conditions could be avoided.

Although the success of our methods may vary with the cultivar in question, we intend to pursue the use of this technique in our fruit tree production and we urge others to try these methods and hopefully confirm our results.

Acknowledgement. We would like to express our deep appreciation to the National Research Council of Canada whose funds have allowed us to carry on this research.

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LEN STOLTZ: Usually quick-dips give more uniform rooting than powders. I would urge that you not give up on quick-dips. With the soft cuttings you are using I would recommend that you start at 2,000 ppm.

CHARLIE PARKERSON: We think that the injury problem is related to the alcohol used to dissolve the IBA. We have changed to the potassium salt and cut with water.

RALPH SHUGERT: I would recommend lower rates of IBA/NAA because of the soft condition of your wood.

OUTDOOR ROOTING UNDER A WHITE POLYETHYLENE TENT[1]

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Abstract. A white polyethylene tent was used for 3 years to successfully root softwood cuttings of 16 shrubs and ground cover plants. Three treatments, intermittent mist with and without bottom heat, and watering 3 times daily with spray stakes without bottom heat, were successful procedures for rooting most kinds of plants. A heated rooting medium was detrimental for rooting some kinds of plants. The heated medium reached a higher temperature on sunny days than unheated medium. When the outdoor temperature reached 26°C (82.4°F), air temperatures in the tent were not detrimental to the cuttings.

REVIEW OF LITERATURE

We have identified a variety of landscape shrubs adapted for northern landscapes (5). To encourage northern nurserymen to propagate these without major investment in equipment, we investigated several methods for summer outdoor rooting of cuttings under a white polyethylene tent.

Paul Joly, Windsor Road Nursery, Cornish, N.H., has used a white polyethylene tent for rooting cuttings during the summer. We adapted his structure for our studies because we felt that a white polyethylene tent would result in acceptable maximum temperatures and prevent rapid drying of cuttings which occurs if an intermittent mist system fails in an open frame. Nurserymen have successfully rooted cuttings under light transmitting covers during summer (1,4). Some light reduction by covers did not inhibit rooting of cuttings (3).

[1] Vermont Agr. Exp. Sta. Jour. Art. No. 532.