system all the time. We try for 5 ppm to 25 ppm. Agribrom is available in tablet form so all you need to do is be sure your chlorinator remains full of tablets. There is a testing kit available to test the rate of bromine in the water. There is a manual regulator to adjust your flow but we have found that wide open is the best for us.

## RESULTS

It did take some time to see the results. The chemical must clean up your pipes first then it will start to work on the other areas of the house. By the next year of sticking rhododendron cuttings we had very little problem with *Rhizoctonia*. There was also very little algae or moss. We have seen no phytotoxicity to any of our crops. The only evidence of the bromine use is a brownish color on the misting lines. We did think at one time that there may have been a phytotoxic problem so we turned it off. Shortly after turning it off, we saw an increase in disease on our *Acer* grafts so we knew it was having some effect on disease. In another instance we noticed it was not working and we had an increase in algae.

We have seen some additional uses of the bromine. For example, when cleaning our cuttings prior to sticking we add a couple of tablets to the rinse barrel. This has proven to be beneficial. Also, in some of our poly houses where we have them installed, the diseases that we get throughout the winter seem to be less. Bromine is not the answer to all of our problems and our place can always be cleaner, but it is an inexpensive tool that certainly makes a difference.

# Propagating Clonal Rootstocks of *Pyrus communis*

**William M. Proebsting and Luigi P. Meneghelli**
Department of Horticulture, Oregon State University, 4017 ALS, Corvallis, Oregon 97331-7304

**Pear is difficult to propagate efficiently by cuttings. This is due, in part, to the sensitivity of cuttings to the stresses associated with propagation and declining rooting potential as stock plants mature. We found that the expanded, subapical portion of softwood shoots is resistant to stress and roots well. Furthermore, cuttings from young stock plants have high rooting potential. Based on this and other information, we propose a set of guidelines for propagating softwood cuttings of pear.**

## INTRODUCTION

Clonal rootstocks of pear are typically propagated by hardwood cuttings. In Oregon, cuttings are collected either early or late in dormancy, callused for 2 or 3 weeks to induce root primordia and then refrigerated until soil conditions permit field planting. Developing alternative methods would complement this process and enhance the supply of high quality liners. We have been conducting a systematic study of softwood cuttings of clonal pear rootstocks. We report here effects of stock plant age and cutting type on rooting.

## MATERIALS AND METHODS

*Pyrus communis* L. 'Old Home × Farmingdale (OH × F) 40', OH × F 97, and clones 708-2, 708-12 and 708-36 were used for this study. Stock plants were hard-pruned in February, fertilized with 100 lb nitrogen (46N-0P-0K) per acre, and well irrigated throughout the summer. Date of cutting collection varied as described in Results. Apical cuttings comprised the first 10 inches of softwood shoots. Sub-apical cuttings were the second (and third, if available) 10-inch sections. Leaves were removed from the 1-inch portion of the cutting placed in the medium. Cutting bases were dipped for 5 sec in 20,000 ppm KIBA. The propagation medium was perlite and peat (3 : 1, v/v) plus 2.5 pounds Osmocote (14N-14P-14K, Type 100) $yard^{-3}$ in 2¼ inch × 2¼ inch × 5 inch bands. Flats containing bands were placed in 4 ft × 17 ft benches enclosed on all sides by clear poly extending 3 ft above the bench. Mist was applied using the following program: 0700 to 0900 h, 24-min interval; 0900 to 1000 h, 16-min interval; 1000 to 1700 h, 8-min interval; 1700 to 1900 h, 16-min interval; and 1900 to 2000 h, 24-min interval, with 8-sec duration using a DE8PR2 mist controller (Davis Engineering, Canoga Park, California). Temperature of the medium was maintained at 70 to 75°F. Maximum air temperature was 85°F. Shading reduced light intensity to about 50% of ambient. Cuttings were evaluated the third week of September, unless otherwise stated. All rooting percentages were acceptably rooted cuttings, graded 7 on a 10-point scale. Cuttings rated 7 were well rooted, but had not grown to the wall of the band. Root systems rated 8, 9, or 10 contacted 25%, 50%, or 100% of the band wall, respectively.

Pear clones were established in tissue culture and micropropagated using the method of Dolcet-Sanjuan et al. (1990). After rooting, the plantlets were transplanted to clean potting medium (perlite, vermiculite, and peat, [1 : 1 : 2, by volume]), acclimated under mist, grown in a greenhouse, and ultimately planted in the field. Stock plants were also propagated by cuttings and by budding onto seedling rootstocks of pear.

## RESULTS

In order to study the effect of stock plant age or maturity on rooting potential, we micropropagated stock plants of OH × F 40 and 97. The first year cuttings were available, cuttings of both clones collected from 2-year-old micropropagated stock plants rooted better than cuttings collected from 6-year-old, cutting-propagated

**Table 1.** Effect of stock plant age and propagation method on rooting of apical cuttings of pear. Cuttings were collected 23 June 1998. Data are percentages of acceptably rooted cuttings.

| Clone | Stock Plant | Rooting (%) |
|---|---|---|
| 40 | 6 yr, cutting | 62.5 |
| | 2 yr, micro | 78.6 |
| 97 | 6 yr, cutting | 60.4 |
| | 2 yr, micro | 90.2 |

**Table 2.** Effect of stock plant age and propagation method on rooting of apical cuttings of pear. Cuttings were collected 23 June 1998. Data are percentages of acceptably rooted cuttings.

| | Clone | | |
|---|---|---|---|
| Stock Plant | 708-2 | 708-12 | 708-36 |
| 4 yr, grafted | 81.5 | 81.3 | 61.0 |
| 2 yr, grafted | 82.9 | 95.0 | 77.1 |
| 2 yr, cutting | 79.2 | 93.8 | N.A.* |
| 2 yr, micro | 95.8 | N.A.* | 83.3 |

*Not available

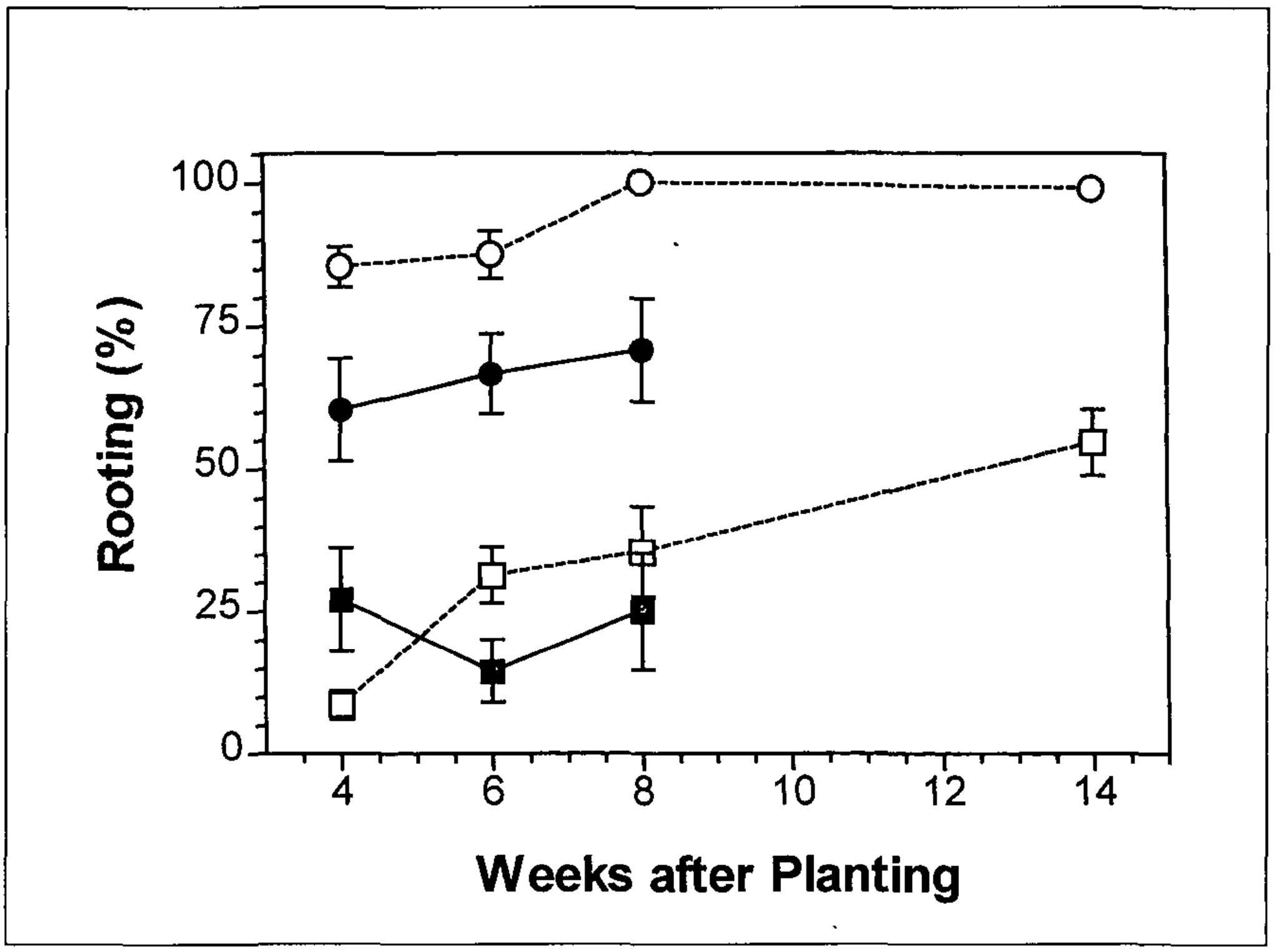


**Figure 1.** Rate of root formation following sticking of softwood cuttings of clone 708-12. Cuttings were collected from 5-year-old cutting-propagated stock plants and divided into apical (■) and sub-apical (●) cuttings, or collected from 3-year-old micropropagated stock plants and divided into apical (□) and sub-apical (○) cuttings.

stock plants (Table 1). The 708 series of pear clones root well. However, 2-year-old stock plants, whether grafted, cutting, or micropropagated, produced cuttings that rooted as well as, or better, than those from the original stock plants which were 4-years old at the time (Table 2).

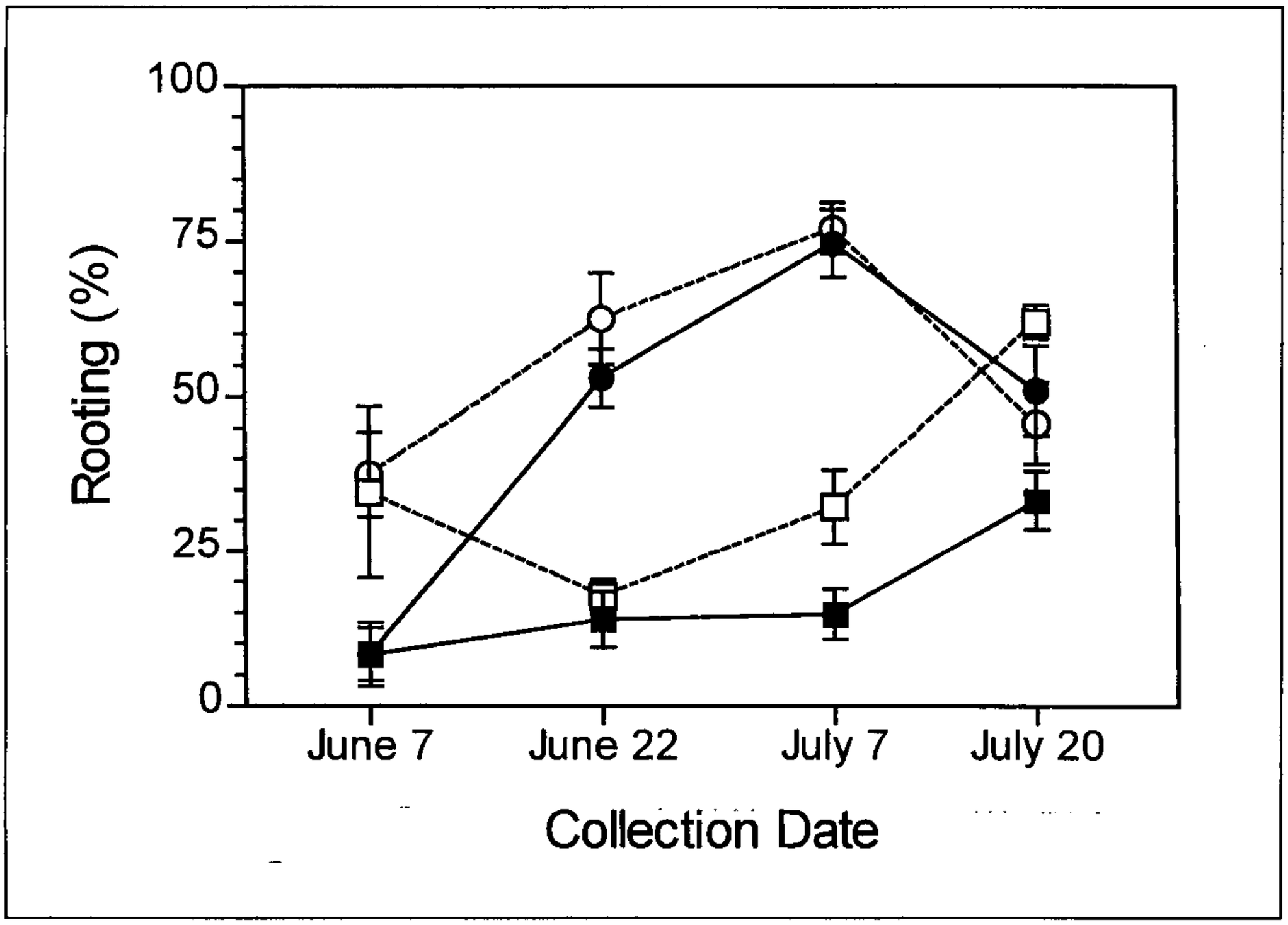


**Figure 2.** Relationship of cutting collection date, stock plant age and cutting type to the percentage of acceptable rooted cuttings of 'Old Home × Farmingdale 97'. Cuttings were collected from 7-year-old cutting-propagated stock plants and divided into apical (■) and sub-apical (●) cuttings, or collected from 3-year-old micropropagated stock plants and divided into apical (□) and sub-apical (○) cuttings.

In a separate set of experiments, we tested the relationship of cutting position on a shoot to rooting. Fifty-five percent of apical cuttings rooted acceptably, whereas 92% of sub-apical cuttings rooted acceptably. We observed that sub-apical cuttings rooted quickly and remained healthier than the apical cuttings.

The following year we studied the interaction of stock plant age and cutting position. Root development on apical and sub-apical cuttings from 3- and 5-year-old stock plants was evaluated by sampling cuttings beginning 4 weeks after sticking and at intervals thereafter. Most rooting on sub-apical cuttings occurred within 4 weeks and was complete by 8 weeks (Fig. 1). Apical cuttings from 3-year-old stock plants rooted slowly and did not match the performance of the sub-apical cuttings. Overall, cuttings from 3-year-old, micropropagated stock plants rooted better than cuttings from 5-year-old, grafted stock plants. However, sub-apical cuttings from the older plants were superior to the apical cuttings, but did not match the sub-apical cuttings from the younger source.

Similar sets of cuttings from OH × F 97 were collected and stuck on four dates in June and July. Rooting of sub-apical cuttings was best in late June and early July and was superior to rooting of apical cuttings during this period (Fig. 2). During this optimal period, sub-apical cuttings from 7-year-old, cutting-propagated stock plants rooted about as well as sub-apical cuttings from 3-year-old, micropropagated stock plants.

## DISCUSSION

In initial studies of several Old Home × Farmingdale clones, we observed that softwood pear cuttings were very sensitive to propagation environment, in particular mist frequency and duration, medium composition, and air movement. The conditions described in the methods section reflected our attempts to optimize these factors. Furthermore, auxin treatment of pear was very important. Gilliam et al. (1988) reported the differential response of *P. calleryana* to IBA and KIBA treatment. We have confirmed that 20,000 mM KIBA is the optimal auxin treatment for *P. communis*, as well.

Stock plant age or maturity is increasingly recognized as a factor limiting cutting propagation of many species. Various methods have been used to improve rooting potential, but micropropagation has proven particularly effective for several species (Howard et al., 1988; Struve and Lineberger, 1988), including pear (Jones and Webster, 1989). Jones and Webster observed small effects of micropropagated stock plants on rooting of two very difficult-to-root clones. The clones we worked with were less difficult and micropropagation significantly improved rooting potential. We also observed that grafting and cutting propagation of stock plants resulted in comparable improvement. The long-term effects of these propagation methods remained undetermined, however.

Pear cuttings taken from the fully expanded, sub-apical, portion of the shoot rooted better than the apical section. Sub-apical cuttings are more resistant to stress and also retained high rooting potential. Rooted cuttings can be transplanted directly to the field. If moved early enough in the summer, shoot growth resumed and substantial growth obtained.

## SUMMARY

We have identified several factors important to rooting softwood cuttings of pear. One of these is the use of young stock plants. A simple, optimal propagation strategy would use recentlymicropropagated stock plants as the source of sub-apical cuttings that would be handled as we described. Current results of these studies are also discussed on our web page at http://www.orst.edu/dept/hort/faculty/proebst.htm

## LITERATURE CITED

**Dolcet-Sanjuan, R., D.W.S. Mok,** and **M.C. Mok.** 1990. Micropropagation of *Pyrus* and *Cydonia* and their responses to Fe-limiting conditions. Plant, Cell, Tissue and Organ Culture 21:191-199.

**Gilliam, C.H., W.A. Dozier, Jr.,** and **J.W. Knowles.** 1988. 'Bradford' pear propagation by softwood cuttings. J. Environ. Hort. 6:81-83.

**Howard, B.H., R.S. Harrison-Murray, J. Vasek,** and **O.P. Jones.** 1988. Techniques to enhance rooting potential before cutting collection. Acta Hort. 227:176-186

**Jones, O.P.** and **C.A. Webster.** 1989. Improved rooting of conventional cuttings taken from micropropagated plants of *Pyrus communis* rootstocks. J. Hort. Sci. 64:429-434.

**Murashige, T.** and **F. Skoog.** 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant. 15:473-497.

**Struve, D.K.** and **R.D. Lineberger.** 1988. Restoration of high adventitious root regeneration potential in mature *Betula papyrifera* Marsh. softwood stem cuttings. Can. J. For. Res. 18:265-269.