Cutting Propagation of Difficult-to-Root Woody Ornamental Plants©

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Rooting performances of softwood, semi-hardwood, or hardwood cuttings of 45 difficult-to-root deciduous and evergreen plant species or varieties were tested. The result showed that most difficult-to-root deciduous plants were successfully rooted by using softwood or semi-hardwood cuttings with proper sticking method from May to July. For difficult-to-root evergreen plants, hardwood cuttings from February to April or semi-hardwood cuttings from July to August were optimal growth stages for propagation.

INTRODUCTION

Cutting propagation is a simple and efficient way to propagate large numbers of homogenous plants. With the improvement of recent techniques, more and more difficult-to-root woody ornamental plants can now be propagated commercially by cuttings (Drew III and Dirr, 1989; Moon and Yi, 1993; Palzkill and Feldman, 1993; Rosier et al., 2004). However, there are still many difficult-to-root woody ornamental plants currently propagated either by grafting or by seedlings. These plants include Japanese maple, *Hamamelis*, *Quercus*, some *Magnolia* and *Michelia* (see *Magnolia*), *Cercis, Carpinus betulus, Parrotia persica, Cercidiphyllum japonicum, Ginkgo biloba, Daphniphyllum*, and many other plant species. The purpose of this study was to find the possible method that could be used commercially for cutting propagation of difficult-to-root woody ornamental plants.

MATERIALS AND METHODS

Softwood, semi-hardwood, or hardwood cuttings collected at different growth stages from 45 plant species or varieties were made about 10–12 cm long with 0.5–1.0 cm basal slice wounding. These cuttings were first applied STIM-ROOT Liquid plant rooting regulator at IBA concentration of 500–4000 ppm (most time using 2000 ppm unless specified) with quick-dip method, then stuck into 50-plug tray with propagation medium consisting of coarse perlite, fine perlite, and peat moss (1 : 1 : 1, by volume). After sticking, the cuttings were put inside propagation greenhouse under either fogging or mist system with shading.

RESULT AND DISCUSSION

Effect of IBA Concentration on Rooting of Japanese Maples. In order to figure out the effect of IBA concentration on rooting performance, four IBA concentrations and three Japanese maple cultivars were tested (Table 1). The results showed that rooting percentage was significantly improved when IBA concentration increased from 500 to 1000 ppm. However, continually increasing IBA concentration from 1000 to 4000 ppm did not further increase rooting performance.

Table 1. Effect of IBA concentration on rooting performance of Japanese maples.

IBA concentration (ppm)	Rooting (%)		
	Acer palmatum 'Enkan'	*Acer palmatum* 'Sango-kaku'	*Acer shirasawanum* 'Aureum'
500	57.8a*	70.5a	62.5a
1000	89.4b	91.8b	82.8b
2000	90.8b	93.5b	84.2b
4000	89.1b	91.2b	83.8b

*Numbers followed by the same letter within a column are not significantly different ($p<0.05$).

Effect of Cutting Sticking Methods on Rooting Performance. The effect of propagation media on rooting performance of cuttings has been tested extensively (Hartmann et al., 2010). We found that, in addition to propagation media, sticking methods significantly affected rooting performance. Our result showed that cuttings stuck from the center to nearly the bottom of the cell in the plug tray had higher rooting percentage than stuck from the center to the middle of the cell (Fig. 1). The cuttings stuck from the side to nearly the bottom of the cell with pressing to make the medium relatively tight had the highest rooting percentage; conversely cuttings stuck from the side to the bottom hole of the cell with pressing to make the medium relatively tight had the lowest rooting percentage, because cutting base exposed to the air in the hole stimulated callusing rather than rooting.

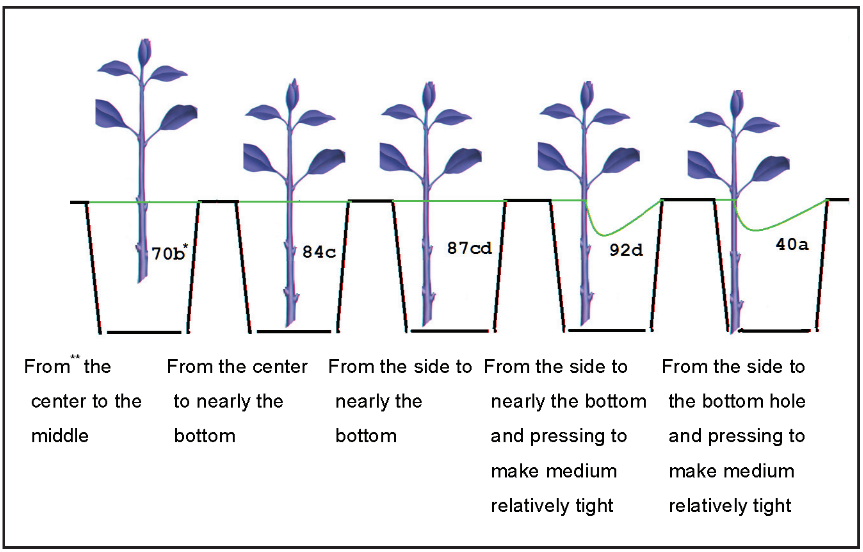

Figure 1. Effect of cutting sticking method on rooting percentage of *Acer palmatum* 'Sango-kaku'. * Numbers followed by the same letter are not significantly different ($p<0.05$), **Cutting sticking method.

Effect of Plant Species and Varieties on Rooting Performance. More and more varieties of *Acer rubrum* and *A. cappadocicum* are propagated by cuttings. However, the Japanese maples (*A. palmatum, A. japonicum,* and *A. shirasawanum*) are, so far, still merely propagated commercially by grafting. This is mainly because Japanese maples are difficult to root. Our results showed that although Japanese maples were more difficult to root than *A. rubrum* and *A. cappadocicum;* the softwood and semi-hardwood cuttings of eight Japanese maple cultivars collected at optimal growth stage were successfully rooted by using proper cutting sticking methods (Table 2). Among the three Japanese maples, the rooting percentages of *A. palmatum* and *A. shirasawanum* were higher than *A. japonicum*. Cutting basal slice wounding is important for Japanese maple root initiation. With basal slice wounding, even hardwood cuttings of Japanese maple taxa were rooted successfully.

Evergreen *Magnolia*, *Michelia* (see *Magnolia),* and *Manglietia* (see *Magnolia)* are usually more difficult to root than most deciduous *Magnolia*. Our results showed that using hardwood (February to April) or semi-hardwood (July to August) cuttings with basal slice wounding, these evergreen plant species could be successfully rooted and some of them even had higher rooting percentages than deciduous *Magnolia* (Table 2). Cutting propagation of other difficult-to-root woody evergreen plants including *Sciadopitys verticillata*, *Berberis aquifolium* 'Compactum', *Arbutus unedo* 'Compacta', *Daphniphyllum glaucescens*, *D. himalense* subsp. *macropodum*, and *Q. myrsinifolia* also showed that hardwood or semi-hardwood cuttings with basal slice wounding successfully stimulated rooting. Among the evergreen plants tested, cutting basal slice wounding for *B. aquifolium* 'Compactum', as an exception, did not increase rooting performance; conversely, cutting basal slice wounding enhanced disease infection and rot. For cutting propagation of *B. aquifolium* 'Compactum', controlling air and keeping medium moisture relatively low was important.

Using softwood or semi-hardwood cuttings from May to July, *Hamamelis, C. betulus*, *Parrotia persica* 'Vanessa', *C. japonicum* 'Red Tint', *Davidia involucrata*, *Styphnolobium* (syn. *Sophora*) *japonica* 'Flavirameus', *Cercis canadensis* and *C. chinensis, G. biloba*, and *Crataegus laevigata* 'Crimson Cloud' were successfully rooted. For most of these plant species, cutting basal wounding improved rooting performance except *C. betulus*, *P. persica* 'Vanessa', and *C. japonicum* because the roots of these plants mainly initiated from lenticels. The rooting percentages of *C. canadensis* 'Forest Pansy' and *Robinia pseudoacacia* 'Frisia' were very low, because the cuttings of both plants rotted easily, plus the leaves of the cuttings fell off readily.

Effect of Callusing on Rooting. Adventitious roots can develop either naturally on the stem cutting or in response to wounding (Koyuncu and Balta, 2004). Adventitious roots may originate from living parenchyma cells, young secondary phloem, vascular rays, cambium, phloem, lenticels, and pith (Hartmann et al., 2010). Callus formation may be favorable for rooting. Our result showed that callusing and rooting were independent of each other and the roots arose directly from lenticels in cuttings of relatively easy-to-root plant species including *C. betulus*, *P. persica*, *C. japonicum* (Figs. 2A and 2B). In most species that are difficult-to-root, initiation of roots occurred from callus. Example plant species were *S. verticillata*, *Arbutus unedo*, *D. glaucescens*, *D. himalense* subsp.

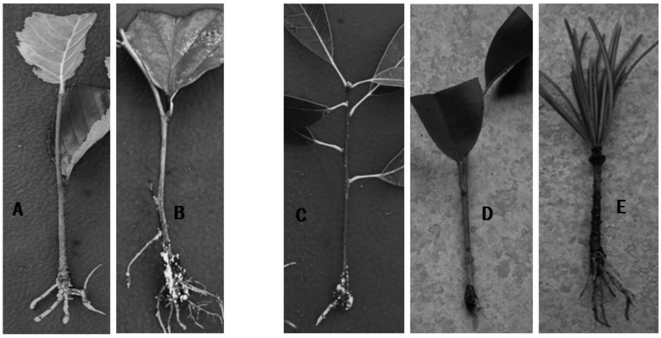

Figure 2. Effect of callusing on rooting: (A) *Carpinus betulus*, (B) *Parrotia persica*, (C) *Quercus myrsinifolia*, (D) *Magnolia* (syn. *Michelia*) *maudiae*, (E) *Sciadopitys verticillata.*

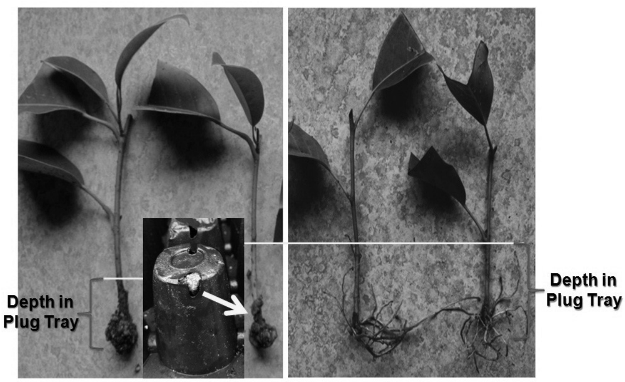

Figure 3. Effect of cutting sticking depth on callusing and rooting of *Magnolia* (syn. *Michelia*) *maudiae.*

macropodum, *Q. myrsinifolia*, *Michelia* and *Manglietia* (see *Magnolia)*, *G. biloba*, *C. laevigata*, etc. (Figs. 2C, 2D and 2E). Some plant species have direct root formation in juvenile cuttings and indirect root formation from callus in cuttings from more mature plants. Example plant species were Japanese maples, deciduous *Magnolia*, *Hamamelis, Nyssa sinensis*, etc.

The initiation of roots from callus of difficult-to-root woody ornamental plants has been found previously in many plant species (Haeman and Owens, 1972; Hartmann et al., 2010). For this kind of plant species, callusing is the first step of rooting. However, we found that excessive callusing inhibiting root initiation became the main problem for cutting propagation of difficult-to-root woody ornamental plants. Our results showed that by increasing the depth of cuttings stuck in the

Table 2. Effect of plant species, variety, and cultivar on rooting performance

Plant name	Rooting (%)	Cutting type
Acer rubrum, A. cappadocicum 'Aureum', and *A. cappadocicum* 'Rubrum'	85–90	Softwood or semi-hardwood (May–July)
Acer palmatum		
A. palmatum 'Shōjō-nomura', 'Enkan', *'Sango-kaku'*, 'Kashima', and var. *dissectum* 'Seiryū'	65–93	Softwood or semi-hardwood (May–July)
Acer japonicum 'Aconitifolium'	50–75	Softwood or semi-hardwood (May–July)
Acer shirasawanum 'Aureum'	75–84	Softwood or semi-hardwood (May–July)
Magnolia (deciduous)		
M. denudata, M. zenii, and *M. kobus*	82–90	Softwood or semi-hardwood (May–July)
M. salicifolia	78–92	Semi-hardwood (July–Aug.)
Magnolia (evergreen)		
M. grandiflora	60–70	Hardwood (Feb.–Apr.)
Magnolia (syn. *Michelia*) (evergreen)		
M. maudiae, M. platypetala, M. figo M. yunnanensis, M. alba, and *M. martinii*	70–85	Hardwood (Feb.–Apr.) Semi-hardwood (July–Aug.)
Magnolia (syn. *Manglietia*) (evergreen)		
M. insignis and *M. chingii*	70–90	Hardwood (Feb.–Apr.) Semi-hardwood (July–Aug.)
Sciadopitys verticillata	40–60	Hardwood (Feb.–May) or semi-hardwood (July–Aug.)
Berberis aquifolium 'Compactum' (syn. *Mahonia aquifolium* 'Compactum')	50–80	Hardwood (Feb.–July), firm semi-hardwood (July–Sept.)
Arbutus unedo 'Compacta'	60–85	Hardwood (Feb.–July), semi-hardwood (July–Sept.)
Daphniphyllum glaucescens and *D. himalense* subsp. *macropodum*	60–85	Hardwood (Feb.–May), Semi-hardwood (July–Sept.)

Quercus myrsinifolia	65–85	Hardwood (Feb.–Apr.) or semi-hardwood (July–Aug.)
Quercus robur	60–80	softwood or semi-hardwood (May–July)
Hamamelis		
H. ×intermedia 'Rubin', *H. ×intermedia* 'Jelena'		Softwood or semi-hardwood (May–July)
H. ×intermedia 'Diane' and *H. ×intermedia* 'Arnold Promise'	75–85	
Cercis		
C. canadensis and *C. chinensis*	75–90	
C. canadensis 'Forest Pansy'	20–48	Softwood or semi-hardwood (May–July)
Carpinus betulus	75–92	Softwood or semi-hardwood (May–July)
Parrotia persica 'Vanessa'	80–90	Softwood or semi-hardwood (May–July)
Cercidiphyllum japonicum 'Red Tint'	75–90	
Davidia involucrata	75–90	Softwood or semi-hardwood (May–July)
Davidia involucrata 'China Compact'	60–75	Softwood or semi-hardwood (May–July)
Ginkgo biloba	80–90	Softwood or semi-hardwood (May–July)
Crataegus laevigata 'Crimson Cloud'	60–75	Softwood or semi-hardwood (May–July)
Styphnolobium (syn. *Sophora*) *japonica* 'Flavirameus'	60–80	Softwood or semi-hardwood (May–July)
Robinia pseudoacacia 'Frisia'	30–50	Softwood or semi-hardwood (May–July)
Nyssa sinensis (potted young seedlings)	85–95	Softwood or semi-hardwood (May–July)
Nyssa sinensis (field mature trees)	3–5	Softwood or semi-hardwood (May–July)
Nyssa sinensis (young grafted tree in shade)	70–75	Softwood or semi-hardwood (May–July)

plug tray, the rooting percentage of *M. maudiae* increased while excessive callusing decreased (Fig. 3).

Effect of Rejuvenation on Rooting Performance. The age and maturity of the mother tree from which cuttings are taken has been reported to significantly affect cutting rooting performance (Amissah and Bassuk, 2007; Schaffalitzky de Muckadell, 1959). Our results showed that softwood or semi-hardwood cuttings from *N. sinensis* young seedlings were very easy to root. However, the rooting percentage of cuttings from field mature *N. sinensis* trees was only 3%–5% (Table 2). Rejuvenation has been used in improving rooting performance in many woody plants by severe pruning (Amissah and Bassuk, 2005; Morgan et al., 1980), grafting (Moon and Yi, 1993; Siniscalco and Pavolettoni, 1988; Zaczek and Steiner, 1997), shading (Amissah and Bassuk, 2007) and etiolation (Amissah and Bassuk, 2007). When grafting the scion wood from mature trees onto *Nyssia sinensis* young seedling rootstocks grown inside greenhouses with shading, our results showed that the rooting percentage of rejuvenated softwood cuttings from the grafted tree increased to 70%–75%.

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QUESTIONS AND ANSWERS

Douglas Justice: Have you tried other media like Oasis foam to get the good water-air ratios?

Pinghai Ding: We haven't tried any of the foam products. We have tried coconut fiber and other less expensive media.

Michael Hicks: Can you say a little more about *Berberis acquifolium* 'Compactum'? Did you use bottom heat? How much mist were you using? What was the concentration of the rooting hormone?

Pinghai Ding: We used a 2000-ppm quick-dip. We used bottom heat at 25 °C. The misting frequency changed with time of year.

Nevin Smith: Did you have any problems with transplanting *Davidia* or *Robinia* 'Frisia'? In our experience they often lose their leader after transplanting.

Pinghai Ding: Most of the time they have been okay, but we've also seen some lose their leader.

Rosemary Prufer: Do you do a pre-soak on your *Sciadopitys*? We've found that a 48-h pre-soak increases rooting. We believe the pre-soak reduces the amount of sap that's released from the cuttings.

Pinghai Ding: No, we don't do that. It's a good idea.

Eric Hammond: Do you wound *Daphniphyllum*?

Pinghai Ding: Yes, it's wounded.