Propagation of *Quercus myrsinifolia* and *Quercus canbyi* by Stem Cuttings[1]

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Abstract

Stem cuttings of two clones (clone 1 and 2) of *Quercus myrsinifolia* Bl. (Chinese evergreen oak), and one clone of *Quercus canbyi* Trel. (Canby's oak), of seedling origin and in the adult growth phase, were taken on various dates representing specific growth stages. Cuttings of clone 1 of *Q. myrsinifolia* were collected at the semi-hardwood, hardwood, or softwood stages in addition to a transitional stage between softwood and semi-hardwood. For clone 2, stem cuttings were taken only at the softwood and transitional softwood/semi-hardwood stages. Cuttings of *Q. canbyi* were collected at the semi-hardwood, hardwood, or softwood stages. Cuttings of both species were treated with 0, 1500 (0.15%), 3000 (0.3%), 6000 (0.6%), or 9000 ppm (0.9%) indolebutyric acid (IBA) in 50% isopropanol. All cuttings were placed in a raised greenhouse bench and rooted under intermittent mist. Semi-hardwood or hardwood cuttings of *Q. myrsinifolia* or *Q. canbyi* did not root. Responses of stem cuttings of *Q. myrsinifolia* to IBA treatment varied by growth stage. For softwood cuttings response to IBA was quadratic with the greatest rooting noted for clones 1 (56%) and 2 (72%) when treated with 1500 and 3000 ppm IBA, respectively. Treatment with IBA had no effect on percent rooting of softwood/semi-hardwood cuttings of clone 1, with rooting ranging from 47% to 58%. However, a linear decrease in rooting in response to IBA was observed for clone 2 with the greatest rooting occurring for the nontreated cuttings (89%). Softwood cuttings of *Q. canbyi* responded quadratically to IBA treatment, with maximum rooting of 33% noted for cuttings treated with 1500 ppm IBA.

Index words: oak, auxin, indolebutyric acid, adventitious rooting, Chinese evergreen oak, Canby's oak, Fagaceae.

Significance to the Nursery Industry

Quercus myrsinifolia (Chinese evergreen oak) is an evergreen species and *Q. canbyi* (Canby's oak) is a deciduous to semi-evergreen species. Each is relatively unknown in the United States. However, both are adaptable to environmental conditions in the southern United States and have excellent potential for use in landscapes throughout this region.

This research demonstrated that cuttings from selected clones of *Q. myrsinifolia* and *Q. canbyi*, when in the adult growth phase, have the capacity for adventitious rooting. These findings may provide a means to propagate superior clones by stem cuttings. However, a critical factor in successful rooting is timing or the growth stage of the stock plant when cuttings are taken. Stem cuttings of *Q. myrsinifolia* were only rooted when in a softwood or softwood/semi-hardwood condition and cuttings of *Q. canbyi* only rooted when in a softwood growth stage. Responses of cuttings of *Q. myrsinifolia* following treatment with the free acid of IBA were variable and inconsistent, suggesting that the growth stage of the stock plant is more important for successful rooting than auxin treatment.

Introduction

Chinese evergreen oak, *Quercus myrsinifolia* Bl. (Fagaceae) is a large, evergreen tree indigenous to Japan, southern China, and Laos. It occurs in warm, temperate, broad-leaved, evergreen forests where it often dominates the forest canopy along with several other species of evergreen oak.

The species is a fast growing tree which may reach a height of 25 m (82 ft). Waxy foliage is dark green above and glaucus beneath. Leaves are lanceolate, 6–10 cm (2.4–4.0 in) long and 2–4 cm (0.75–1.5 in) wide with short, mucronate teeth on the upper half (11). New foliage in spring is dark maroon, a striking landscape feature (5).

Quercus myrsinifolia is one of several species of evergreen oaks in the subgenus *Cyclobalanopsis* (Oerst.) Schneid. (10). This particular species can be cold hardy to USDA Hardiness Zone 7 and has considerable potential as a landscape tree in the southern United States (5). In northern Japan, *Q. myrsinifolia* grows best in sunny locations and is used as a shade tree in gardens and in parks (11). In recent years *Q. myrsinifolia* has gained popularity as a landscape plant throughout the southeastern United States. It has survived winters in Washington DC, proving to be one of the hardiest of the evergreen oaks. It is also being planted as far south as Georgia, Alabama, and Florida where it has been utilized in parks and in urban situations (6).

Another species having potential for landscape use in the southeastern United States is *Quercus canbyi* Trel. (Canby's oak). The species is indigenous to the highlands of the Sierra Madre region of Nuevo Leon in northeastern Mexico (9) and grows as a shrub or small tree (14). In its native habitat the species occurs as an open, airy tree growing in xeric conditions of well drained shale at elevations of 300–900 m (1000–3000 ft) (Carl Schoenfeld, personal communication).

The foliage of *Q. canbyi* is deciduous to semi-evergreen, glossy green, and quite glabrous (14). Leaves are deeply lobed, 6–10 cm (2.4–4.0 in) long and 1.5–4.5 cm (0.6–1.8 in) wide, and similar in shape to those of *Q. rubra* L. (northern red oak).

Specimens of *Q. myrsinifolia* and *Q. canbyi* growing on the campus of North Carolina State University and at the North Carolina State University Arboretum, Raleigh, have performed well. The excellent performance of these species strengthens their potential for use in landscapes of the southern United States.

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Traditionally, most species of oak (*Quercus* L.) have been propagated by seed. However, since members of this genus are extremely heterozygous, sexual propagation results in great genotypic and phenotypic variability (3). Development of efficient techniques for asexual propagation of oaks would benefit the nursery industry as this would lead to selection and production of particular clones with desirable landscape characteristics. In a preliminary investigation, stem cuttings of *Q. myrsinifolia* and *Q. canbyi* produced robust root systems under intermittent mist following treatment with indolebutyric acid (IBA). Therefore, the following research was conducted to develop protocols for propagation of these two species by stem cuttings. Specifically, the influence of timing (growth stage) and IBA treatment on rooting were investigated.

Materials and Methods

Stock plants. Stem cuttings were taken from two clones of *Q. myrsinifolia*, and one clone of *Q. canbyi* all of which were of seedling origin and in the adult growth phase. One clone of *Q. myrsinifolia*, hereafter referred to as clone 1, was a 10-year-old specimen growing at the North Carolina State University Arboretum (USDA Hardiness Zone 7). It exhibited vigorous growth and was 4.6 m (15 ft) tall. The second specimen of *Q. myrsinifolia* (clone 2) was approximately 30 years old and was growing on the campus of North Carolina State University. It had attractive branching with a handsome trunk and was 15.2 m (50 ft) tall with a spread of 7.6 m (25 ft).

The specimen of *Q. canbyi* which served as a stock plant was growing at the Arboretum. It was 5 years old, multistemmed and shrub-like, 1.8 m (6 ft) tall with an equal width.

All stock plants appeared to be relatively free of insect and disease problems. They also appeared tolerant of a wide range of soil conditions because of the different sites on which they were growing. Clone 1 of *Q. myrsinifolia* and the specimen of *Q. canbyi* have withstood winter temperatures of –18C (0F) with no apparent injury. Similar observations have been noted for the second clone of *Q. myrsinifolia* which survived –22C (–9F).

Rooting procedures. Terminal cuttings with fully expanded leaves were taken from clone 1 of *Q. myrsinifolia* on four dates that represented specific growth stages: October 7, 1994 (semi-hardwood), February 15, 1995 (hardwood), May 23, 1995 (softwood), and June 8, 1995 (transitional growth between softwood and semi-hardwood). Similar cuttings were taken from the second clone of the species on May 15, 1995, and June 6, 1995, representing softwood and softwood/semi-hardwood cuttings, respectively. Cuttings were taken from the lower half of the crown of each tree.

Similar terminal cuttings were taken from the specimen of *Q. canbyi* on October 7, 1994 (semi-hardwood), February 15, 1995 (hardwood), and April 25, 1995 (softwood). Cuttings were removed throughout the entire plant.

For both species, stem tissue of semi-hardwood and hardwood cuttings was firm and a distinct snapping sound was noted when broken. Application of pressure to the cuttings (bending the cuttings) resulted in breakage and separation of the pieces at the point at which pressure was applied. Stem tissue of the softwood and softwood/semi-hardwood cuttings was soft yet sufficiently firm so as not to appear flaccid. Application of pressure to the softwood and softwood/semi-hardwood cuttings resulted in breakage but the stem pieces held together, not separating at the break point. Softwood cuttings of *Q. myrsinifolia* were collected a few days after the pronounced burgundy color of the newly emerging tissue had disappeared.

As cuttings were collected, they were placed in plastic bags and kept cool during transport to the Horticultural Science Greenhouses, Raleigh. After collection, cuttings of *Q. myrsinifolia* were trimmed from the bases resulting in lengths of 12 cm (4.7 in) and the leaves were removed from the basal 5.0 cm (2.0 in). Remaining leaves on the cuttings were cut in half to prevent contact with the rooting medium. Cuttings of *Q. canbyi* were trimmed from the bases resulting in lengths of 8 cm (3.1 in) and leaves were removed from the basal 3.0 cm (1.2 in). The basal 1.0 cm (0.4 in) of each cutting of *Q. myrsinifolia* and the basal 0.5 cm (0.2 in) of each cutting of *Q. canbyi* was then treated with 0, 1500 (0.15%), 3000 (0.3%), 6000 (0.6%), or 9000 (0.9%) ppm reagent grade IBA in 50% isopropanol for 1 to 2 sec. The cuttings were then air-dried for 15 min before insertion into a raised greenhouse bench containing a steam pasteurized medium of peat and perlite (1:1 by vol).

Cuttings from a stock plant at each growth stage were arranged within the propagation bench in a randomized complete block design. At each rooting trial, for each clone, there were five auxin concentrations, six blocks, and six cuttings (subsamples) per treatment per block.

Cuttings were maintained under natural photoperiod and irradiance with days/nights of 24 ± 4/16 ± 4C (75 ± 7/61 ± 7F). Intermittent mist operated daily for 6 sec every 3.3 min. during daylight hours. To control fungi, cuttings were sprayed initially and weekly thereafter alternating 3a,4,7,7a-tetrahydro-2[(trichloromethyl)thiol]-1H-isoindole-1,3(2H)-dione (captan) and tetrachloroisophthalonitrile (daconil) at 2.4 g/liter (0.32 oz/gal) and 2.5 ml/liter, (0.32 oz/gal), respectively.

Cuttings were harvested after 8 weeks for each growth stage, and data were recorded on percent rooting, number of primary roots ≥ 1 mm (0.04 in) in length, and root length. Data for root number and length were based on the actual number of cuttings which rooted. Data were subjected to analysis of variance procedures and regression analysis (12).

Results and Discussion

Results demonstrated that propagation of *Q. myrsinifolia* and *Q. canbyi* by stem cuttings is feasible. Cuttings of *Q. myrsinifolia* rooted only at the softwood or softwood/semi-hardwood stages whereas rooting of *Q. canbyi* was only observed with softwood cuttings.

For softwood cuttings of *Q. myrsinifolia*, the response to IBA treatment was quadratic with the greatest rooting noted for cuttings of clones 1 (56%) and 2 (72%) when treated with 1500 and 3000 ppm IBA, respectively (Table 1). Several weeks later when cuttings were in a softwood/semi-hardwood condition, rooting was generally greater for both clones, particularly clone 2. Although rooting ranged from 47% to 58% for clone 1, the response to IBA treatment was nonsignificant. For clone 2, cuttings rooted in higher percentages with the greatest response (89%) occurring for the nontreated cuttings. Treatment with IBA resulted in a linear decrease in rooting.

Table 1. **Effects of rooting treatments on percent rooting of stem cuttings of *Q. myrsinifolia* taken at two growth stages.[z]**

	Growth stage			
	Softwood		Softwood/semi-hardwood[y]	
Treatment	Clone 1	Clone 2	Clone 1	Clone 2
Nontreated	30.6	19.4	47.2	88.9
1500 ppm IBA	55.6	52.8	50.0	80.6
3000 ppm IBA	13.9	72.2	55.6	72.2
6000 ppm IBA	13.9	58.3	52.8	75.0
9000 ppm IBA	0.0	58.3	58.3	61.1
Linear	NS	NS	NS	*
Quadratic	*	*	NS	NS

[z]Each value is based on 36 cuttings.

[y]Transitional growth stage between softwood and semi-hardwood.

NS, *, Nonsignificant or significant at the 5% level, respectively.

Table 2. **Effects of rooting treatments on mean root number of stem cuttings of *Q. myrsinifolia* taken at two growth stages.[z]**

	Growth stage			
	Softwood		Softwood/semi-hardwood[y]	
Treatment	Clone 1	Clone 2	Clone 1	Clone 2
Nontreated	2.3	1.8	3.0	7.4
1500 ppm IBA	2.6	1.9	2.1	3.7
3000 ppm IBA	1.7	2.3	2.0	4.9
6000 ppm IBA	1.9	3.8	2.5	4.6
9000 ppm IBA	0.0	4.3	2.5	3.5
Linear	NS	**	NS	*
Quadratic	NS	NS	NS	NS

[z]Each value is based on the number of cuttings which rooted for a particular treatment.

[y]Transitional growth stage between softwood and semi-hardwood.

NS, *, **, Nonsignificant or significant at the 5% or 1% level, respectively.

Auxin treatment of softwood cuttings of clone 1 had no effect on root number with mean root number ranging from 1.7 to 2.6 roots per cutting (Table 2). The same relationship was observed for softwood/semi-hardwood cuttings, except, over all treatments, root number increased slightly, ranging from 2.1 to 3.0 roots per cutting. Conversely, stem cuttings of clone 2 were influenced significantly by IBA treatment. For softwood cuttings of clone 2, there was a linear increase in root number with the highest value (4.3) occurring for cuttings treated with 9000 ppm IBA. At the softwood/semi-hardwood stage the opposite was observed with IBA treatment causing a linear decrease in root number. The highest root number (7.4) was realized for the nontreated cuttings.

Root lengths of softwood cuttings of clone 1 of *Q. myrsinifolia* were unaffected by auxin treatment, with root lengths ranging from 13 to 27 mm (0.5 to 1.1 in) (Table 3). At the same growth stage, the response of clone 2 was quadratic with the greatest response [88 mm (3.4 in)] observed for cuttings receiving 1500 ppm IBA. A quadratic relationship was also noted for both clones at the softwood/semi-hardwood stage, with the greatest root length occurring for clones 1 [30.7 mm (1.2 in)] and 2 [74.5 mm (2.9 in)] when treated with 3000 or 1500 ppm IBA, respectively.

The variable and inconsistent responses of stem cuttings of both clones of *Q. myrsinifolia* to IBA treatment suggest that recommended treatments for one clone might not be applicable to another. However, percent rooting and root number were generally greatest for cuttings taken at the softwood/semi-hardwood stage and not treated with IBA.

The greatest rooting (33%) for cuttings of *Q. canbyi* occurred for cuttings treated with 1500 ppm IBA (Table 4). These results were disappointing because a preliminary study the previous year involving softwood cuttings of the same clone and another clone indicated that rooting > 90% was possible. Why rooting decreased in 1995 is unknown and may have been related to unseasonably cool temperatures and excessive rainfall from mid-April to late June 1995. These conditions stimulated multiple growth flushes in comparison to previous years when only one flush of growth was observed. The cool-wet period encountered during 1995 may have prevented maturation of stem tissues which always appeared too soft and succulent for rooting. Those cuttings of *Q. canbyi* which rooted, generally produced one to two roots ≥ 100 mm (3.9 in) long. Data for actual root number and root length are not included in Table 4 since values for some treatments would only be based on one observation.

Table 3. **Effects of rooting treatments on mean root length (mm) of stem cuttings of *Q. myrsinifolia* taken at two growth stages.[z]**

	Growth stage			
	Softwood		Softwood/semi-hardwood[y]	
Treatment	Clone 1	Clone 2	Clone 1	Clone 2
Nontreated	20.6	39.3	16.2	30.5
1500 ppm IBA	26.6	88.1	29.6	74.5
3000 ppm IBA	12.6	80.6	30.7	64.7
6000 ppm IBA	16.8	66.6	30.0	60.9
9000 ppm IBA	0.0	57.0	24.4	53.8
Linear	NS	NS	NS	NS
Quadratic	NS	**	*	**

[z]Each value is based on the number of cuttings which rooted for a particular treatment.

[y]Transitional growth stage between softwood and semi-hardwood.

NS, *, **, Nonsignificant or significant at the 5% or 1% level, respectively.

Table 4. **Effects of rooting treatments on percent rooting of softwood cuttings of *Q. canbyi*.[z]**

Treatment	Rooting (%)
Nontreated	2.8
1500 ppm IBA	33.3
3000 ppm IBA	8.3
6000 ppm IBA	2.8
9000 ppm IBA	2.8
Linear	NS
Quadratic	**

[z]Each value is based on 36 cuttings.

NS, **, Nonsignificant or significant at the 1% level, respectively.

Results reported herein have important implications regarding selection and propagation of superior clones of *Q. myrsinifolia*. Based on data for softwood and softwood/semi-hardwood cuttings it appears clone 2 has a greater capacity for adventitious rooting than clone 1. Regardless of growth stage, stem cuttings of clone 2 always rooted in higher percentages with greater root numbers than cuttings of clone 1. The apparent tree-to-tree variation in rooting is not surprising since the same phenomenon has also been reported for other species of oaks including *Q. phillyreoides* A. Gray (ubame oak) (7), *Q. ilex* L. (holly oak) (2), and *Q. virginiana* Mill. (live oak) (8). Thus, nurserymen who desire to clone superior selections of *Q. myrsinifolia* by stem cuttings would need to select specimens with desirable morphological characteristics, as well as high capacity for adventitious rooting.

The greater capacity for adventitious rooting of stem cuttings of clone 2 in comparison to cuttings of clone 1 was surprising since clone 2 was considerably older (30 vs. 10 years), although both trees were in the adult (flowering/reproductive) growth phase. The age factor is also important in terms of selection. For many species, rooting capacity decreases with stock plant age (4, 8) and desirable morphological features do not become recognizable until the adult growth phase is reached.

The intriguing results that the older clone (clone 2) of *Q. myrsinifolia* rooted better than the younger clone (clone 1) are similar to a report by McGuigan et al. (7). They found that stem cuttings from a 40-year-old clone of *Q. phillyreoides* rooted in much higher percentages, whether taken at the softwood or softwood/semi-hardwood stages, than cuttings from an 8-year-old clone taken at the same growth stages.

Whether stem cuttings of *Q. myrsinifolia* or *Q. canbyi* need to flush following rooting to ensure overwinter survivability is unknown since this was not addressed in the present study. McGuigan et al. (7) found that with cuttings of *Q. phillyreoides*, 93% of rooted softwood cuttings which flushed prior to the onset of fall survived the winter whereas survival of 37% was noted for softwood/semi-hardwood cuttings which did not flush prior to overwintering. Based on these data, as well as indications that *Q. myrsinifolia* can achieve acceptable rooting at the softwood stage, it may be more advantageous if cuttings of *Q. myrsinifolia* were collected at the softwood stage. Although rooting might be reduced at this stage, as suggested by data in table 1, the reduction in rooting might be offset by greater overwinter survival.

Rooting data for softwood and softwood/semi-hardwood cuttings of *Q. myrsinifolia* were recorded 8 weeks after the cuttings were placed in the propagation bench. At these times, some leaf drop was observed, which was greater for the softwood cuttings. Leaf drop following rooting is often observed with fast rooting species (1). For species which root rapidly, it is often best to gradually begin a reduction in misting, otherwise extensive leaf drop will occur resulting in high mortality (1). Based on root length and the woody nature of the roots, we suspect rooting occurred quite fast and data could have been recorded 2 or possibly 3 weeks earlier. From a production standpoint it appears that once stem cuttings of *Q. myrsinifolia* are placed under intermittent mist they should be monitored constantly for rooting, paying close attention to water relations. Once satisfactory rooting occurs, a hardening off period should be initiated during which misting frequency is reduced gradually.

Another consideration would be to root cuttings in small individual containers or flats (trays) consisting of individual cells. Although rooted cuttings of *Q. myrsinifolia* had robust roots, the roots were coarse, brittle and easily broken during harvest. Damaging roots during harvest would contribute to transplant shock. Rooting individual cuttings as described previously would reduce or eliminate transplant shock and allow easy and fast removal of rooted cuttings from the rooting bench. This might also be beneficial from an overwintering standpoint since reports have indicated that for some species, cuttings left undisturbed once rooted survive the subsequent winter in higher percentages (13).

Basal stem necrosis was observed on most softwood cuttings of *Q. myrsinifolia* treated with IBA and roots formed above the injured tissue. If such injury could have been avoided, rooting may have been greater. One suggestion to reduce/eliminate basal stem injury and/or reduce variability to auxin treatment would be to investigate treatment of cuttings with different formulations of IBA.

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