Effects of Fertilizer and Night Interruption on Overwinter Survival of Rooted Cuttings of *Quercus* L.[1]

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Abstract

The effects of night interruption (NI) and fertilizer (F) on the overwinter survival of rooted cuttings, collected on May 15 and June 18, of *Quercus lyrata* Walter, *Q. phellos* L., *Q. robur* L., *Q. rubra* L., and *Q. virginiana* Mill.. were determined. Ideally, after *Quercus* cuttings root, a growth flush must be induced in order to insure overwinter survival (OS). For the May 15 cuttings that produced at least one flush of growth prior to dormancy, OS was 100%, regardless of species or treatment. *Quercus lyrata* survived 100% regardless of treatment or cutting date. *Quercus phellos* survived best under a night interruption-no fertilizer (NI-NF) treatment. When no growth flush occurred prior to overwintering, cuttings of *Q. robur* under short day-no fertilizer (SD-NF) and NI-NF survived in the highest percentages.

Cuttings from the June 18 sample data generally overwintered best under NI-NF treatment. *Quercus lyrata* OS was 100% under the SD-NF and NI-NF treatments. NI-NF produced the greatest OS of *Q. phellos*, *Q. rubra* and *Q. virginiana*. With the exception of *Q. lyrata*, all rooted cuttings that broke bud prior to overwintering survived 100%.

Shoot growth produced by the rooted cuttings was greatest under NI-F for all species except *Q. rubra*. The amount of growth varied according to species.

Index words: propagation, photoperiod, growth and development.

Plants used in this study: Overcup Oak (*Quercus lyrata* Walter); Willow Oak (*Q. phellos* L.); English Oak (*Q. robur* L.); Red Oak (*Q. rubra* L.); and Live Oak (*Q. virginiana* Mill.).

Significance to the Nursery Industry

Methodology to root and successfully overwinter *Quercus* (oak) cuttings has been developed. Superior oaks can be selected for summer and fall color, lack of leaf retention, growth habit, and rapidity to caliper. To insure overwinter survival after rooting of *Q. lyrata*, *Q. phellos*, *Q. robur*, and *Q. virginiana*, a four-hour night interruption photoperiod should be initiated. To maximize growth of the rooted cuttings after bud break, a 200 mg/l(ppm) liquid N application should be applied once per week. For those plants which do not break bud, fertilizer should be withheld.

For nursery practice, oak cuttings should be rooted as soon as the first growth flush has hardened (generally mid-

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May in Athens, GA). After rooting, they should be placed under 75 watt bulbs for 6 to 10 weeks until bud break is evident and then fertilized with 200 ppm N liquid fertilizer once per week until mid to late August and allowed to acclimatize for winter.

Introduction

For newly rooted cuttings of *Acer* L., *Hamamelis* L., *Parrotia* C.A. Mey, *Stewartia* L., and *Viburnum* L. species to survive the overwintering period, a flush of growth prior to this period is important (13). Apparently, the new growth results in increased carbohydrate production and accumulation (14). Smalley *et al.* (14) demonstrated that cuttings of *Acer rubrum* 'October Glory' which produced a flush of growth prior to overwintering had a 95-100% survival rate and root carbohydrate levels of 18%. Only 68% of those which did not produce a growth flush survived and had 9% root carbohydrates. Other researchers (6, 12, 13) have reported similar overwinter survival (OS) responses for various plants. Factors that effect OS of rooted cuttings are collection date, photoperiod, fertility, rooting environment, and carbohydrate levels (13,16). All influence the plant's capacity to store sufficient carbohydrates for winter survival.

Fertilizer and extended photoperiod or night-break interruption (NI) have induced growth flushes and promoted continuous growth on newly rooted cuttings (7, 11, 15). Fertilizer and photoperiod have an effect on OS (13, 14, 16). Stimart *et al.* (16) noted that cuttings of *Acer palmatum* Thunb. 'Bloodgood' that were fertilized and produced a growth flush suffered less cold damage than those which were fertilized and did not flush. However, OS was highest on unfertilized plants.

The factors affecting successful *Quercus* cutting OS are uncertain, but preliminary work with a *Q. phellos* × *Q. palustris* hybrid (3) also indicated that a flush of growth promoted overwinter survival and recent work (5) showed that *Quercus* cuttings could be rooted. This study examined night interruption and fertility to determine their effects on growth and subsequent OS.

Material and Methods

Rooted cuttings of *Q. lyrata*, *Q. phellos*, *Q. robur*, *Q. rubra*, and *Q. virginiana* were used in the experiments (May 15th and June 18th sample dates). The procedures for rooting the cuttings were described previously (5).

The rooted cuttings were placed in one of the four following treatments: short day-no fertilizer (SD-NF); short day-fertilizer (SD-F); night interruption-no fertilizer (NI-NF); or night interruption-fertilizer (NI-F). The SD treatment consisted of natural light from 8:00 am to 5:00 pm. The NI treatment was a natural photoperiod from 8:00 am to 5:00 pm with a night interruption period occurring from 10:00 pm to 2:00 am. The night-break interruption was accomplished by using 75 watt (10 μmoles·m^{-2}·sec^{-1}) incandescent bulbs suspended approximately one meter (3.3 ft) above the plants, with one bulb per 0.9 m × 0.9 m (3 ft × 3 ft) plot. Blackcloth was pulled over all treatments at 5:00 pm to exclude natural light and was removed at 8:00 am.

The experiment was a split-split plot with 6 randomized blocks. Main plots consisted of night interruption (NI) and short day (SD) treatments; the subplots were fertilizer (F) and no fertilizer (NF). Due to the limited number of plants available for each species at each date (May 15 or June 18), each subplot consisted of 2 observations of each species (12 per treatment).

The fertilizer treatments consisted of no fertilizer (NF) and 200 mg/l Peter's water soluble fertilizer 20N-8.7P-16.6K (20-20-20) applied to saturation once a week throughout the course of the experiment. Additional water was provided when needed.

Rooted cuttings of *Q. lyrata*, *Q. phellos*, and *Q. robur* were used from the May 15, 1987 cutting date (group I cuttings) and rooted cuttings of *Q. lyrata*, *Q. phellos*, *Q. rubra*, and *Q. virginiana* were used from the June, 18, 1987 cutting date (group II cuttings). The use of two different groups of species was necessitated by insufficient numbers of rooted cuttings of the same species for the two dates.

Group I cuttings were placed under the treatments on July 28, 1987, removed and placed outdoors under 55% Saran shade cloth on October 15, 1987. Group II cuttings were placed under the treatments on August 25, 1987, removed and placed outdoors with group I on December 10, 1987. While outdoors, the plants were irrigated as needed. Plants were sprayed as needed with acephate (Orthene) to control aphids.

All cuttings from both groups were randomly placed in the single layer clear polyhouse in respective light treatments on December 22, 1987. Extra plants were placed around the perimeter of the group to minimize edge effects due to temperature and water fluctuations.

The lowest overnight temperature recorded was −3°C (27°F). Plants were watered as needed. Abscised leaves were removed to reduce disease problems. The polyhouse door was opened on warm days for ventilation and to reduce excessive humidity. In mid-April, the ends of the house were removed to reduce temperatures and the polyethylene was completely removed at the beginning of May. To assess the treatment effects, plants were evaluated as living or dead, and shoot growth measured on May 30, 1988 after the first growth flush had ceased.

Results and Discussion

Overwinter Survival. One hundred percent of the *Q. lyrata* cuttings survived (Table 1) regardless of treatment. Although the treatments did not affect overwinter survival, bud break was significantly less under the shortday-no fertilizer (SD-NF) than other treatments. Shortdayfertilizer (SD-F) and night interruption-fertilizer (NI-F) promoted maximum budbreak. In previous studies a growth flush after rooting was necessary for high OS of *Acer rubrum* 'Red Sunset' (14). The reason for the 100% OS of the species is unknown, since the other oak species that did not break bud prior to overwintering had survival rates of 0 to 100% (Tables 1 and 2).

All *Q. phellos* cuttings that broke bud survived (Table 1). The only non-budbreak cuttings that survived 100% were those provided NI-NF. The next highest survival occurred under SD-NF. These data suggest that if *Q. phellos* cuttings do not break bud prior to onset of winter then fertilizer should not be applied. In nursery practice, night interruption without fertilizer would prove realistic. Goodman and Stimart (6) reported maximum OS of *Acer palmatum* 'Bloodgood' and *Cornus florida* L. var. *rubra* West. when no fertilizer was applied either during the propagation or

Table 1. The effects of light and fertilizer treatments on the overwinter survival percentages of rooted cuttings of *Quercus lyrata, Q. phellos,* and *Q. robur* that broke bud (BB) and did not break bud (NBB) prior to the overwintering period. (Cuttings stuck May 15, 1987).

	Percentages[z]											
	Quercus lyrata				*Quercus phellos*				*Quercus robur*			
	BB	Survival	NBB	Survival	BB	Survival	NBB	Survival	BB	Survival	NBB	Survival
Shortday—fertilizer	100 a[y]	100	0 b[y]	—	50 ab[y]	100	50 bc[y]	20	67 a[y]	100	33 b[y]	50
Shortday—no fertilizer	33 b	100	67 a	100	0 c	—	100 a	67	17 b	100	83 a	70
Night interruption—fertilizer	100 a	100	0 b	—	75 a	100	25 c	0	67 a	100	33 b	0
Night interruption—no fertilizer	83 a	100	17 b	100	33 bc	100	67 bc	100	33 ab	100	67 ab	63

[z]Data collected May 30, 1988 from cuttings stuck May 15, 1987, placed under treatments July 28, 1987, removed Oct. 15 and placed in a polyhouse to overwinter on Dec. 22, 1987.

[y]Data analyzed by ANOVA and ranked by LSD, 0.05.

Table 2. The effects of light and fertilizer treatments on the overwinter survival percentages of rooted cuttings of *Quercus lyrata, Q. phellos, Q. rubra* and *Q. virginiana* that broke bud (BB) and did not break bud (NBB) prior to the overwintering period. (Cuttings stuck June 18, 1987).

	Percentages[z]															
	Quercus lyrata				*Quercus phellos*				*Quercus rubra*				*Quercus virginiana*			
	BB	Survival	NBB	Survival	BB	Survival	NBB	Survival	BB	Survival	NBB	Survival	BB	Survival	NBB	Survival
Shortday—fertilizer	50 ab[y]	67	50 b[y]	100	8 b[y]	100	92 a[y]	18	8 a[y]	100	92 a[y]	55	67 a[y]	100	33 b[y]	50
Shortday—no fertilizer	33 bc	100	67 ab	100	0 b	—	100 a	58	8 a	100	92 a	45	0 b	—	100 a	83
Night interruption—fertilizer	100 a	83	0 c	—	50 a	100	50 b	0	8 a	100	92 a	36	50 ab	100	50 ab	67
Night interruption—no fertilizer	0 c	—	100 a	100	0 b	—	100 a	75	0 a	—	100 a	75	50 ab	100	50 ab	100

[z]Data collected May 30, 1988 from cuttings stuck June 18, 1987, placed under treatments Aug. 23, 1987, removed Dec. 10, 1987, and placed in a polyhouse to overwinter on Dec. 22, 1987.

[y]Data analyzed by ANOVA and ranked by LSD, 0.05.

overwintering phases. Kelly (8) also showed maximum OS of one-gallon containerized *Pyracantha coccinea* L. 'Lalandei' when plants received no fertilizer prior to overwintering. *Q. phellos* is the most popular lawn, street, and park oak species in zones 7 to 9 (1).

Overwinter survival of *Q. robur* was 100% for all plants that broke bud regardless of treatment (Table 1). The highest OS of plants that did not break bud occurred under SD-NF followed by NI-NF. This indicates that if *Q. robur* does not break bud, fertilizer should be withheld.

Q. lyrata survived 100% under SD-NF and NI-NF regardless of bud break (Table 2). The highest bud break occurred under the NI-F treatment with a resultant 83% OS. The 100% OS of non-budbreak plants was similar to the Group I cuttings. The difference in survival of plants which broke bud in Group I and Group II may be due the greater dormancy of the Group II cuttings when placed under the treatments. Also, the Group I light and fertilizer treatments were initiated approximately four weeks earlier than Group II (July 28 vs. Aug 23) possibly with resultant longer photosynthetic period and greater carbohydrate accumulations that resulted in higher OS.

For June 18th cuttings of *Q. phellos*, those that broke bud survived 100%; however, this represented only 8% (of 12) under SD-F and 50% (of 12) under NI-F (Table 2). The greatest survival occurred under NI-NF followed by SD-NF. The data show that bud break is greatest when cuttings are harvested early (Table 1 vs. 2). Therefore, cuttings of *Q. phellos* should be collected as soon as the first flush is firm. The NI-NF treatment should be applied as soon as the cuttings have rooted.

Q. rubra survived 100% (Table 2) if the plants broke bud; however, but break percentages were only 8% (of 12) under SD-F, SD-NF, NI-F and 0% under NI-NF. The greatest number of non-budbreak plants survived under NI-NF. Unfortunately, there were insufficient *Q. rubra* rooted cuttings from the May 15 sample date to determine the most effective OS treatments. *Q. rubra* completed a growth flush earlier than the other oaks used in this study and may have been in a more dormant state; hence, the bud break response was minimal. Maximum rooting of *Q. rubra* occurred with the June 18th cuttings. If this rooting response is indicative of the species, then the data suggest that a NI-NF treatment maximizes OS.

All *Q. virginiana* plants that broke bud survived 100% (Table 2). Night interruption-no fertilizer also resulted in 100% survival of those that did not break bud. Previous work by Morgan (10) showed that *Q. virginiana* could be rooted and overwintered. Although the OS problem does not appear as severe as with other species, NI-NF treatment is recommended.

The survival of the fertilized rooted cuttings in Group II was considerably less than Group I. Goodman and Stimart (6) showed similar results with *Acer palmatum* 'Bloodgood' and *Cornus florida* var. *rubra.* They suggested that decreases in OS of the fertilized rooted cuttings were related to a lack of acclimatization rather than inadequate carbohydrate production. Other researchers (4, 9, 14) showed a strong correlation between OS and carbohydrate levels. In this study, the temperature in the overwintering polyhouse did not drop below −3°C (27°F) suggesting that cuttings which did not survive the overwintering period probably did so because of inadequate carbohydrate reserves or reasons other than winter injury.

Work with *Hamamelis* × *intermedia* Rehd. 'Arnold Promise' showed a strong relationship to time of cutting collection and OS (2). The earliest rooted cuttings overwintered in the highest percentages even though a growth flush did not always occur. Perhaps the increased OS of the early rooted cuttings is related to the increased time of photosynthetic activity and resultant carbohydrate accumulation. Smalley and Dirr (13) reported that the presence of roots on a cutting is correlated with increased photosynthetic activity. Obviously a cutting rooted early in the season has the facility to accumulate greater carbohydrate reserves than those rooted later.

Shoot Growth. The NI-F treatment produced the most growth in Group I cuttings. Average growth per plant for NI-F ranged from 15.2 to 54.5 cm (6 to 22 in.) depending on the species (Table 3). Group II showed similar trends except for *Q. rubra* which produced maximum growth under SD-F (Table 3). However, shoot growth under SD-F averaged only 1.4 cm (0.6 in.).

In all instances, cuttings which were fertilized grew more than those not fertilized. For *Q. phellos* and *Q. robur*, a NI treatment resulted in significantly greater growth than SD.

The increased growth in the Group I cuttings is related to the longer growing season. Comparisons of *Q. lyrata* and *Q. phellos* which are common to both groups indicate this assumption is justified. The Group II cuttings did not receive fertilizer treatments until Aug. 25, 1987, almost one month later than the Group I cuttings. Therefore, plants from the later harvest date did not produce new growth as early or grow as vigorously before the onset of dormancy.

Based on the data for OS and growth, the best method of handling newly rooted *Quercus* cuttings necessitates the initial use of NI on the cuttings until bud break occurs. Then plants should be placed on a fertilizer regime in order to maximize growth. Cuttings that did not break bud would remain under NI. This method ensures the greatest cutting survival and at the same time produces the greatest amount of growth. The cuttings should be taken as soon as the stock material reaches a rootable stage. These guidelines can also be adapted to different woody species. For high economic value nursery crops, manipulation of the post-rooting environment is justified to produce the greatest OS and growth.

Table 3. The effects of light and fertilizer treatments on the average shoot growth of *Quercus lyrata, Q. phellos, Q. robur, Q. rubra*, and *Q. virginiana*.

	Shoot Growth (cm)			
Treatments	SD-F[z]	SD-NF	NI-F	NI-NF
Group I[y]				
*Quercus lyrata**	34.4	3.7	54.5	3.9
*Quercus phellos***	4.1	0.0	15.2	1.6
*Quercus robur****	6.1	0.4	22.7	3.0
Group II[x]				
*Quercus lyrata***	7.9	1.0	35.9	0.0
*Quercus phellos***	1.1	0.0	7.5	0.0
*Quercus rubra*****	1.4	0.1	0.5	0.0
*Quercus virginiana*****	3.8	0.0	11.3	1.8

*Comparisons
NF vs F—Significant at 0.05 level.
SD vs NI—No Significance.
NF vs F*SD vs NI—No Significance.

**Comparisons
NF vs F—Significant at 0.05 level.
SD vs NI—Significant at 0.05 level.
NF vs F*SD vs NI—Significant at 0.05 level.

*** Comparisons
NF vs F—Significant at 0.05 level.
SD vs NI—Significant at 0.05 level.
NS vs F*SD vs NI—No significance.

****Comparisons
NF vs F—No Significance.
SD vs NI—No Significance.
NF vs F*SD vs NI—No Significance.

[z]SD-F = Short day—Fertilizer
SD-NF = Shortday—No Fertilizer
NI-F = Night Interruption—Fertilizer
NI-NF = Night Interruption—No Fertilizer

[y]Cuttings stuck May 15, 1987; placed under treatments July 28, 1987; evaluated Nov. 30, 1987.

[x]Cuttings taken June 18, 1987; placed under treatments Aug. 25, 1987; evaluated Nov. 30, 1987.

Removed from treatments on Oct. 15, 1987, for Group I, and on Dec. 10, 1987, for Group II.

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Seasonal Phenology, Management, and Host Preferences of Potato Leafhopper on Nursery-Grown Maples[1]

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Abstract

Seasonal phenology and control of the potato leafhopper (*Empoasca fabae* (Harris)) on red maples (*Acer rubrum* L.) were studied for three years in nurseries in central Kentucky. Migratory adult leafhoppers were first captured on yellow sticky traps in early May. Peak population density ranged from late May to late June. The second flush of leaves was most heavily damaged in each year. Foliar sprays of cyfluthrin (Tempo 2), a synthetic pyrethroid, beginning 1 to 2 weeks after first capture of leathoppers and repeated at biweekly intervals during May and June, greatly reduced symptoms of injury. Acephate (Orthene) was less effective than cyfluthrin, whereas treatment of the soil with disulfoton (Di-syston) was ineffective. Oviposition and development of the leafhopper on red maple were confirmed. Field evaluations of selected cultivars showed that red maples were more severely damaged than sugar (*A. saccharum* L.) or Norway (*A. platanoides* L.) maples. 'Autumn Blaze', an *A. rubrum* × *saccharinum* hybrid, was relatively resistant.

Index words: *Empoasca fabae*, insect resistance, *Acer rubrum*, pest management

Significance to the Nursery Industry

Feeding by the potato lealhopper on nursery-grown maples causes severe cupping and stunting of expanding leaves, browning of leaf margins, "witches' brooming," loss of annual growth, and reduced market value of trees. This study shows that nurserymen can greatly reduce damage caused by potato leafhoppers by using yellow sticky traps to monitor for first appearance of the migratory adults, followed by timed, biweekly applications of cyfluthrin (Tempo 2) during the period of greatest leafhopper activity in May and June. Field evaluations of selected cultivars showed that red maples (*Acer rubrum* L.) were more severely damaged than sugar (*A. saccharum* L.) or Norway (*A. platanoides* L.) maples. 'Autumn Blaze', an *A. rubrum* × *saccharinum* hybrid, was relatively resistant.

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Introduction

The potato leafhopper (PLH), *Empoasca fabae* (Harris) (Homoptera: Cicadellidae), is a common destructive pest of nearly 200 kinds of plants including forage legumes, vegetable crops, and deciduous nursery stock (1). Adults are small (3.5 mm), wedge-shaped, and pale green. Adults and nymphs feed mainly from the undersides of succulent young leaves, inserting their piercing-sucking mouthparts into plant tissue and removing sap. Physical damage to phloem and reaction to salivary phytotoxins cause affected leaves to become severely stunted and cupped downward, with necrotic margins. Severely damaged trees suffer "witches' brooming" of shoots, loss of annual growth, and reduced market value. In Kentucky and neighboring states the PLH causes severe economic damage to maples, especially *Acer rubrum*, in nurseries and landscape settings.

The PLH overwinters along the Gulf of Mexico and migrates northward each year, typically arriving in the north-central states between late April and early June (3). In central Kentucky, dates of first collection of adult PLH from mature alfalfa ranged from 4 May to 30 May, with populations peaking in early July (4). Development from egg to adult takes about 3 weeks during warm weather; several overlapping generations may occur during each growing season. Uncertainty regarding the dates of first occurrence of PLH in nurseries and the period of greatest damage to maples have resulted in some nurserymen applying as many as 10 cover