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Shading and IBA Treatment Do Not Improve Rooting of Stem Cuttings of *Quercus phillyraeoides* 'Emerald Sentinel'[1]

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Abstract

Shoot tip cuttings of *Quercus phillyraeoides* A. Gray 'Emerald Sentinel' ('Emerald Sentinel' oak), in a transitional growth stage between softwood and semi-hardwood, were collected from containerized plants growing under uniform fertility on June 4, 1998. Cuttings were treated with talc formulations of indolebutyric acid (IBA), ranging from 0 to 8000 ppm (0.8%), and placed under intermittent mist with shade levels excluding 0%, 30%, 60% or 90% of full solar irradiance. After 14 weeks, percent rooting averaged 18% and was unaffected by either IBA concentration or shading regime. Similarly, both mean root number per rooted cutting and mean root length were unaffected by IBA concentration or shading. Roots per rooted cutting and mean root length averaged 2.6 and 41 mm (1.6 in), respectively. Results suggest that shading stem cuttings of 'Emerald Sentinel' during propagation does not affect rooting.

Index words: Fagaceae, indolebutyric acid, irradiance, oak, propagation.

Significance to the Nursery Industry

Application of shade is one method propagators use to moderate ambient temperature during rooting of stem cuttings. Frequently, a shading compound or shade cloth is applied to greenhouses to achieve this effect. Shading reduces solar irradiance entering the greenhouse, thereby maintaining cuttings at a cooler temperature and increasing humidity. A recent report (19) suggested that shading woody stem cuttings during propagation might stimulate rooting of difficult-to-root taxa, such as *Quercus* L. spp. (oaks). In the current study, we were able to maintain similar temperatures [± 2C (3.5F)] throughout four shading regimes (0%, 30%, 60%, and 90%) when attempting to root stem cuttings of a difficult-to-root cultivar of *Quercus phillyraeoides* A. Gray (ubame oak), and observed no stimulatory rooting response to the varying levels of shade or indolebutyric acid (IBA) treatments. Percent rooting (18%), mean root number (2.6), and mean root length [41 mm (1.6 in)] were unaffected by shading or IBA treatments.

Introduction

Propagation by stem cuttings is achieved commonly under some form of shaded structure, however, irradiance is seldom measured or reported. Sunlight increases leaf temperature and transpiration, and may subject the cutting to moisture stress (12). Shading reduces the amount of sunlight reaching the cuttings and helps minimize water loss. Light presumably inhibits adventitious root development at some level when cuttings are subjected to irradiance in excess of what is necessary for survival (15).

Behrens (1) applied light shade (10–200 $W \cdot m^{-2}$) to stem cuttings of *Acer palmatum* Thunb. (Japanese maple) and increased rooting from 53% with supplementary lighting to 72% with shade. Others have conducted similar shading studies (10, 19) or have reported on the effects of supplemental lighting (7, 8, 9). Discussions on the influence of irradiance during cutting propagation have also been published (2, 15, 16).

The root promoting effects of various auxins are well established, as are the effects of light on auxin stability and longevity (11). An interaction between light and auxin may influence adventitious root formation. Previously, researchers have reported decreased rooting under conditions of high light when the cutting base was exposed to light (6). However, basal application of IBA overcame the inhibitory effects of light and stimulated rooting.

Cuttings of *Pinus sylvestris* L. (Scots pine) were prepared from seedlings grown under high or low light and rooted under either light regime (18). Cuttings from seedlings grown under low light and subjected to the low light rooting environment rooted in higher percentages than cuttings from seedlings grown under low light and placed in the high light environment. As with the previously mentioned experiment, IBA overcame the light inhibition.

Recently, dense shade (91% and 97%) has been reported to stimulate adventitious rooting of some difficult-to-root taxa (19). However, in seven of the eight woody taxa tested, percent rooting of the shade treatments were either not significantly different from the control treatment (83% shade) or less than the control. Therefore, the objectives of this investigation were to study the effects of shading, IBA, and potential interactions on adventitious rooting of stem cuttings of *Quercus phillyraeoides* A. Gray 'Emerald Sentinel' ('Emerald Sentinel' oak).

'Emerald Sentinel' is a fastigiate, vase-shaped clone of the evergreen *Q. phillyraeoides* (ubame oak) that originated

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as a seedling at the JC Raulston Arboretum, Raleigh, NC. Although recently described as an easy-to-root cultivar (4), a thorough rooting study (17; referred to as clone 2) had previously shown rooting to be ≤ 58%, and that IBA formulation or concentration had little, if any, stimulatory effect.

Materials and Methods

Shoot tip cuttings were collected from containerized plants growing under uniform fertility at Taylor's Nursery, Inc., Raleigh, NC, on June 4, 1998. Plants were in the adult growth phase (reproductive) and stem tissue was in a transitional growth stage between softwood and semi-hardwood as has been described previously (17). As cuttings were collected they were placed in plastic bags, packed on ice, and transported to the Horticultural Science Greenhouses, Raleigh. Shoot tip cuttings were prepared by trimming the initial material to lengths of 6 to 7 cm (2.4 to 2.8 in), removing leaves from the lower half of the cuttings, and treating the basal 1 cm (0.4 in) with talc formulations of IBA at 0, 2000, 4000, 6000 or 8000 ppm (0.0%, 0.2%, 0.4%, 0.6% or 0.8%). These treatments were selected based on a report by McGuigan et al. (17).

Following auxin treatment, cuttings were inserted into plastic flats constructed of 64 individual cells (one cutting per cell). Each cell was 5 cm × 5 cm × 8 cm (2 in × 2 in × 3 in) and contained a rooting medium of 100% perlite. Flats were then placed on carts, modified with an overhead intermittent mist system, at the NC State University Phytotron. Carts were positioned in a controlled-environment greenhouse with 9 hr days/15 hr nights of 26C/22C (79F/72F) with a 3 hr dark interruption from 11:00 PM to 2:00 AM provided by incandescent bulbs. Varying layers of cheesecloth were placed over individual carts to create shaded 'chambers' of 0%, 30%, 60% or 90% shade measured as photosynthetically active radiation (PAR) with a LI-COR model LI-185A Quantum/Radiometer/Photometer (LI-COR, Lincoln, NE). Four measurements were recorded per chamber and averaged to determine PAR within the chamber. Shading within chambers was maintained daily within ± 2% of desired levels. Relative shade levels throughout the day in each chamber were obtained by suspended aluminum foil between chambers to prevent light penetration through adjacent chambers. At 12:00 PM measured PAR was 1680, 1200, 520 and 177 $\mu mol \cdot m^{-2} \cdot sec^{-1}$ for 0%, 30%, 60% and 90% shade, respectively (for brevity this is the only series of measurements presented). Mist operated 5 sec every 5 min from 8:00 AM to 7:00 PM, and again during the night interruption from 11:00 PM to 2:00 AM.

The experimental design was a split plot with five replications. Shade levels were whole plots and IBA treatments were sub-plots with 12 cuttings per treatment per plot.

At 14 weeks, cuttings were harvested and data recorded. Data included percent survival, percent rooting, number of primary roots ≥ 1 mm (0.04 in) in length, and individual root lengths. Data were subjected to analysis of variance and regression analysis.

Results and Discussion

Regardless of shade level or IBA treatment, overall percent rooting was poor (18%), which supports previous work indicating that this cultivar is difficult to root (17). Also, neither shade, IBA concentration nor interactions between these factors affected percent rooting, mean root number, or mean root length (Tables 1 and 2). Mean root number averaged over all treatments was 2.6 roots per rooted cutting, and was consistent among the treatments. Mean root length was 41 mm (1.6 in) and was unaffected by treatments. There was no meaningful difference in percent survival averaged across shade levels (77%) although visual differences in leaf color were observed. Leaves of cuttings in shaded chambers were darker green than leaves of cuttings in 0% shade, which showed symptoms of chlorosis and necrosis.

Although high rates of photosynthesis are not necessary for adventitious rooting, reducing light below 20% of full irradiance might reduce photosynthesis sufficiently to inhibit rooting. In some cases, photosynthesis may decrease to the compensation point and remain constant until roots develop (5). Previous research has demonstrated the importance of light to adventitious root production in two cultivars of *Rhododendron* L. (rhododendron) (7, 14).

While the necessity of light in rooting stem cuttings is unchallenged, the effects of irradiance, photoperiod, and spectoral composition remain subjects of debate. Experiments such as the present study are difficult to design due to temperature fluctuations. Increasing shade decreases ambient

Table 1. Effects of shading and IBA treatment on percent rooting, mean root number, and mean root length of stem cuttings of *Quercus phillyraeoides* 'Emerald Sentinel'.

Shade level (%)	Rooting (%)	Mean root no.[z]	Mean root length (mm)
0	12	2.2	45
30	20	2.0	41
60	19	2.3	43
90	20	3.8	34
Linear	NS	NS	NS
Quadratic	NS	NS	NS
IBA concn. (ppm)			
0	12	1.6	35
2000	21	2.4	39
4000	20	3.0	43
6000	19	2.5	44
9000	18	3.4	40
Linear	NS	NS	NS
Quadratic	NS	NS	NS

[z]Based on the actual number of cuttings that rooted. NS = nonsignificant at $P \leq 0.05$.

Table 2. Analysis of variance for percent rooting of stem cuttings of *Quercus phillyraeoides* 'Emerald Sentinel'.

Sources	df	SS	*F*-value
Replication (R)	4	0.162	2.28^{NS}
Shade level (S)	3	0.109	2.04^{NS}
R × S	12	0.213	0.98^{NS}
IBA	4	0.108	1.48^{NS}
S × IBA	12	0.218	1.00^{NS}
Error	64	1.164	
Total	99	1.974	

[NS]Nonsignificant at $P \leq 0.05$.

temperature, thereby adding confounding factors to the experiment. Differences in ambient temperature among shade levels were noted previously by Zaczek et al. (19) who found 83% shade, which they considered a control, was the least amount of shade that could be imposed and still maintain consistent temperatures. In the current study, ambient temperature within chambers was measured for two consecutive, clear, sunny days. Using small shaded structures in a controlled environment greenhouse enabled the use of a wide range of shade environments with relatively constant ambient temperature within each chamber. The greatest temperature variation occurred between 0% and 90% shade and varied at most only 2C (3.5F).

Our results agree with those of others who have reported little differences in percent rooting under varying levels of light (3, 7, 8, 9). On the other hand, Grange and Loach (10) demonstrated that rooting stem cuttings of *Viburnum* x *bodnantense* Stearn. 'Dawn' ('Dawn' viburnum) was affected negatively by high light. They suggested that decreased rooting may be attributed to an interaction between leaf and stem osmotic potentials. Other investigators (3, 13) have postulated the affect of shading may be due to allocation of photosynthates.

In the present study, similar temperatures were maintained under a wide range of irradiance levels during rooting of 'Emerald Sentinel', with no light or IBA effect on any measurements of rooting. An identical study was conducted by the authors in 1997. However, due to mechanical complications that affected mist distribution, we were hesitant to report the results, and decided to repeat the study in 1998. Nonetheless, results from the 1997 study were similar to 1998, suggesting mist distribution did not affect the 1997 data. In both years, analysis of variance failed to detect any influence of shading on rooting stem cuttings of 'Emerald Sentinel'.

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