FLUORESCENT LIGHT INTENSITY AND PROPAGATION UNDER A SEMI-CONTROLLED ENVIRONMENT

SIDNEY WAXMAN
University of Connecticut
Storrs, Connecticut

INTRODUCTION

In a previous paper presented to the Society on the rooting of blueberry cuttings, the author mentioned the possible economic benefit of rooting cuttings under fluorescent light rather than sunlight (7).

The major reason the use of fluorescent light may be more economical than sunlight is not due to the source of light, but to the types of structures that are used in conjunction with these sources of light.

In using sunlight, one is limited to the use of a glass or plastic greenhouse in which the heat losses are rather high. By the use of fluorescent light, on the other hand, almost any type of structure may be used. Ideally, of course, it would be one that is well insulated.

The advantage of using an insulated building is that its heat losses during the winter months would be far less than that of a greenhouse.

Another and equally important advantage is that within such a building, considerable control of the environment is possible. Rapid changes in temperature and humidity that occur in greenhouses do not occur in the insulated house because these conditions are not so easily influenced by changes in the weather (4,5).

Cuttings placed under a uniform environment, i. e., one that does not have wide fluctuations of light, temperature, and humidity, would, most likely, have rooting percentages that are far more consistent than would cuttings placed in greenhouses where these fluctuations occur spontaneously with each cloud that passes by the sun.

The decision as to whether the insulated propagation house is truly an improvement over the glass or plastic propagation house rests mainly on their costs of operation.

In the insulated propagation house where sunlight cannot enter, the major expense will be the cost of providing an artificial source of light, the fluorescent lamp.

The amount of light necessary to keep cuttings healthy and at the same time encourage root initiation, will determine the approximate cost of lighting.

Fortunately, many improvements in the manufacture of fluorescent lamps have taken place in the past twenty years. The life expectancy of the lamp has been increased to approximately 12,000 hours (1).

Since 1950, the 40 watt cool white fluorescent lamp has had its initial light output increased 48% (1). In addition, there have been developed fluorescent tubes capable of provid-

ing wave lengths of light reported to be particularly effective for plant growth purposes (3).

In this study an attempt was made to determine whether certain selected ornamentals would root under fluorescent light, and, if so, determine the influence of light intensity on the numbers of roots initiated.

The idea of rooting cuttings under fluorescent light in insulated buildings was reported by Stoutemyer, Close and O'Rourke in 1945 (4), Stoutemyer and Close in 1946 (5), and by Chadwick in 1949 (2). However, this system proved to be unsuccessful when attempted on a commercial scale. Perhaps, with the use of mist, and with the improved fluorescent lamps that are now avaailable, these concepts may now be carried out successfully and be competitive with greenhouse propagated cuttings.

Methods and Materials

Two propagation benches used in this experiment were placed in an unused room of an apple storage building. A bank of fluorescent lamps placed on an angle provided a range of light intensities. Each bench was partitioned with aluminum foil-backed paper to provide a total of six compartments, each having a different intensity range.

In the compartment nearest the lamps, the intensity ranged from 430 to 470 footcandles. The compartment farthest from the lamps was illuminated with only 35 to 60 footcandles (Table 1).

With the exception of the three chrysanthemum varieties, all cuttings were taken from plants that had made a flush of

Table 1 Rooting of Cuttings under Mist while Exposed to various intensities of Fluorescent Light

Name	Per Cent Rooted					
	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc
Berberis Chenaultii	100	100	100	100	100	100
Buxus 'Vardar Valley'	58	50	91	50	41	50
Juniperus hor. Doug.	20	88	88	20	100	100
Juniperus hor. Wiltoni	80	40	80	90	100	90
Kalmia latifolia #137	0	60	20	30	30	0
Rhod. carol. pink	60	50	90	60	50	40
Rhod. mucron.	75	70	85	85	75	90
Rhod. 'Exb. hyb.'	83	100	100	83	100	100
Ilex crenata	100	100	100	100	100	100
Pachistima Canbyi	100	100	100	100	100	100
Pachysandra term.	100	100	100	100	100	100
Mean	70.5	78.0	86.7	74.3	81.5	79.0

growth and whose stem tissue had recently become firm.

The chrysanthemum cuttings were made of tender terminal shoots in active growth. In the latter case, the tender cuttings, presumably low in stored carbohydrates, were used to determine if such cuttings would survive the low intensities used in this study.

All cuttings were rooted while under a mist system which provided two seconds of mist every 10 minutes. A temperature of 70° F., was maintained in the medium throughout the experiment. The air temperature varied from 50 to 75° F.

The light sources were eight-foot-long cool-white fluorescent lamps, in addition to several incandescent lamps which were employed to provide the longer wave lengths of light in which the cool white lamps were deficient.

All species were treated with Hormodin #3 plus Captan except for the ericaceous plants which were dipped in "Jiffy-gro" one-tenth strength.

The lights were controlled by a time-clock and were on 16 hours daily. A mixture of equal parts of peatmoss and Perlite served as the rooting medium.

Responses of the various species to the six different light intensity ranges were judged by the size of their root systems.

Roots were counted on those species whose primary roots were easily distinguishable, while those species having contiguous roots and difficult to count, were given an arbitrary category according to the overall size of the root mass.

Results

All species initiated roots with fluorescent light as the sole source of radiant energy. For the majority of the species, the percentage of cuttings rooted was similar among the ranges of light intensity employed. (Tables 1, 2, 3, 4, 5).

With few exceptions, the percentage rooting was 100% in all intensities for the Exbury Hybrid azalea, *Ilex crenata, Berberis Chenaultii, Pachistima Canbyi, Pachysandra terminalis,* and the chrysanthemum varieties: 'Grandchild,' 'Sleighride,' and 'White Keepsake' (Table 1, 4).

Table 2 Rooting of Cuttings under Mist while Exposed to various Intensities of Fluorescent Light

Average Number of Roots/Rooted Cutting

Name	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc
Berberis Chenaultii	2.4	1.8	2.2	2.0	2.2	2.8
Buxus 'Vardar Valley'	2.3	2.7	6.2	2.7	1.8	2.0
Juniperus hor. Doug.	1.0	12.6	11.6	11.5	20.0	15.4
Juniperus hor. Wiltoni	4.3	3.0	4.3	3.7	3.6	5.0
Mean	2.5	5.3	6.1	5.0	6.9	6.3

Table 3 Rooting of Cuttings Under Mist While Exposed to various Intensities of Fluorescent Light.

Name	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc
	Degree of Rooting *					
Ilex crenata	1.2	2.3	2.7	2.8	2.8	3.0
Kalmia latifolia #137	0.0	2.0	3.0	1.0	2.0	0.0
Pachistima Canbyi`	1.0	2.0	3.0	3.0	3.0	3.0
Pachysandra term.	2.0	2.0	2.0	2.0	3.0	3.0
Rhod. carol. pink	1.7	1.8	2.7	1.8	2.2	2.0
Rhod. 'Exb. hyb.'	3.0	2.8	3.0	3.0	2.5	3.0
Rhod. mucron.	2.5	2.9	2.3	3.0	2.5	3.0
Mean	1.6	2.3	2.7	2.4	2.6	2.4

* 0 ..... no roots
1 ..... few roots
2 ..... med roots
3 ..... many roots

The percentage rooting of *Juniperus horizontalis* Wiltoni and *Juniperus horizontalis* Douglasi was over 80% at all intensities except for three groups in which rotting was observed at the bases of the cuttings.

The remaining species belong to the category of plants known to be difficult to root. Of these, *Rhododendron mucronulatum* rooted at percentages of 70 through 90 and exhibited no correlation between light intensity and percent rooting. Buxus 'Vardar Valley' and *Rhododendron carolinianum* 'pink' had percentages between 40 and 60 at all intensities except for 90% and 91% at the medium range of 160 to 180 footcandles. Again, no correlation could be made between intensity and rooting percentages.

Mountain laurel, *Kalmia latifolia* #137, notoriously diffi-

Table 4 Rooting of Cuttings under Mist while Exposed to various Intensities of Fluorescent Light.

3/3/67 — 3/17/67

Name	35-60 fc	90-120 fc	160-180 fs	185-250 fc	325-430 fc	430-470 fc	Greenhouse Rooted
	Per Cent Rooted						
Hardy Mums:							
Chrys. "Grandchild"	90	100	100	100	100	100	100
Chrys. "Sleighride"	100	100	100	100	100	100	100
Greenhouse Mum							
Chrys. "White Keepsake"	100	100	100	100	100	100	100
Mean	96.6	100.0	100.0	100.0	100.0	100.0	100.0

cult to root, rooted in all ranges except for the lowest and highest intensities (Table 1).

Differences in the numbers of roots developed (Table 2) or degree of rooting (Table 3) that may be correlated to light intensity appeared on only four species: *Juniperus horizontalis* Douglasi, *Ilex crenata, Pachistima Canbyi,* and *Pachysandra terminalis.* Although there are indications of retarded root development under the lowest intensity ranges, the differences are small (Table 2, 3).

Chrysanthemum cuttings exhibited differences in root development according to the intensity to which they were exposed. For all three varieties, the smallest mass of roots appeared on those cuttings exposed to the 35 to 60 footcandle range. The remaining groups were similar and illustrated no definite correlation between intensity and root initiation.

Chrysanthemums rooted under the fluorescent lamps compared favorably with those rooted in sunlight in a greenhouse (Tables 4, 5).

Except for a single cutting, all cuttings of all varieties rooted within 14 days. The extent of root initiation of the hardy varieties: 'Grandchild,' and 'Sleighride' propagated under fluorescent light intensities greater than 90 foot candles, was

Table 5 Rooting of Cuttings under Mist while Exposed to various Intensities of Fluorescent Light

Name	Degree of Rooting *						
	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc	Greenhouse Rooted
Hardy Mums:							
Chrys. "Grandchild"	1.5	2.0	2.3	2.0	2.6	2.9	1.9
Chrys. "Sleighride"	1.6	2.5	2.8	2.3	2.6	2.9	2.4
Greenhouse Mum:							
Chrys. "White Keepsake"	1.8	1.9	2.5	2.1	2.7	2.2	2.9
Mean	1.63	2.13	2.53	2.13	2.63	2.67	2.37

* 0 ..... no roots
1 ..... few roots
2 ..... med. roots
3 ..... heavy roots

Table 6 Growth of Chrysanthemum var 'White Keepsake' subsequent to its Propagation under various Intensities of Fluorescent Light*

Dates	Average Increase of Growth in Height (mm)						
	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc	Greenhouse Propagated
3/17/67-4/7/67	15.8	15.9	16.5	13.2	14.7	15.9	15.6
3/17/67-4/19/67	36.5	34.0	38.0	29.2	29.8	32.8	36.4

* Propagation under Fluorescent Light 3/3/67-3/17/67

equal to the cuttings propagated in sunlight in a greenhouse (Table 4).

The greenhouse variety, 'White Keepsake' did not develop as large a root system under fluorescent light as it had in sunlight (Table 5). However, the subsequent growth of this variety, after transfer to a greenhouse, was similar to those propagated in the greenhouse (Table 6).

Discussion and Summary

The intensities of fluorescent light used in this experiment, especially those in the lower ranges, are much too low to support continuous growth of most trees and shrubs.

Ordinarily, most woody species require a range of approximately 1500 to 3000 footcandles for optimum growth and survival. Although an intensity of 100 footcandles is too low for the growth of the species used in this study, it apparently is sufficient for the period of time it takes them to initiate roots. This would especially be true of the "shade-loving" species, seven of which were used in this study.

One factor that probably contributed to the high percentages of rooting was the store of reserve foods within the stems at the time they were severed.

In this study, most cuttings were taken at a particular stage of growth in which the recently developed terminal shoot had been dormant long enough to accumulate a store of carbohydrates, but not so long that the tissues had become excessive ly lignified and probably detrimental to rapid root initiation.

Root initiation of tender terminal shoots taken during the active growth stage is often more rapid than woody shoots taken during summer dormancy (6). The limited supply of stored energy in the tender chrysanthemum cuttings probably would not have been sufficient to maintain their vigor for an extended period of time while exposed to low light intensities used in this test. Rooting of the chrysanthemum occurred in less than two weeks and, as a consequence, no serious depletion of stored energy was exhibited. This was brought out by the rate of growth of plants transferred from the low fluorescent light intensities to sunlight and compared with plants propagated and grown continuously in sunlight ,Table 6).

The most striking results of this study are that there was, generally, no correlation between light intensities and root initiation among the intensities used. Cuttings that are easy to root in a greenhouse rooted easily under fluorescent light under all intensities.

The lowest range, 35 to 60 footcandles, apparently was sufficient to keep the cuttings alive while they were expending their energy in the process of developing a root system.

According to the results of this test, and to the reports of Stoutemyer, et. al. (4,5), the minimum light requirements for the propagation of many woody ornamental species are of such

low order that it would be feasible to use fluorescent light for propagation on a commercial scale.

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MODERATOR CANNON: Our next paper is by Dr. John McGuire. Dr. McGuire is at the University of Rhode Island and will speak on the entrance of growth regulators into cuttings.

ENTRANCE OF SYNTHETIC GROWTH REGULATOR IAA-2-14C INTO CUTTINGS OF ILEX CRENATA 'CONVEXA'

JOHN J. MCGUIRE
University of Rhode Island
Kingston, Rhode Island

Since the late 1930's when synthetic growth regulators were found to be effective in promoting rooting of cuttings, a wide variety of methods have been used to introduce these materials into stem tissues. We are all familiar with talc preparations used as a dust, and aqueous solutions used either as long term dilute soaks or short duration concentrated dips. The relative efficiency of these carriers and methods was covered extensively at a meeting of this society in 1959 (5,6,9). It was concluded that concentrated basal dips were superior to other methods of application.

It has been shown that crystalline indoleacetic acid (IAA) can enter the fatty portion of the cuticle of leaves without the aid of a solvent. Crystals have been applied to stems after the stem was scraped to facilitate rapid uptake of the auxin (3,4). Auxin has been soaked into wooden pegs and the pegs have been inserted into holes drilled into the cuttings (10). In England and America, cuttings have been exposed to vacuum and then aqueous solutions of auxins have been forced into the stem when atmospheric pressure was again applied (1,11).

Contribution #1262 of the Rhode Island Agricultural Experiment Station