PHOTOSYNTHESIS AND GROWTH DURING ROOT INITIATION AND ROOT DEVELOPMENT IN POINSETTIA CUTTINGS

SVEN E. SVENSON[1] AND FRED T. DAVIES, JR.

Department of Horticultural Sciences
Texas A & M University
College Station, Texas 77843

Abstract. Net photosynthesis of apical stem cuttings of poinsettia (*Euphorbia pulcherrima Willd. ex Klotzsch*) was studied during the development of adventitious roots Photosynthesis in cuttings was low before root primordia formation, increased slightly upon root initiation and increased rapidly upon root emergence. Dedifferentiation and root initiation was apparently independent of photosynthetic rate while photosynthetic rate increased with the development of adventitious roots. There appears to be no benefit from using higher light intensities under mist propagation until after poinsettia cuttings have initiated roots

INTRODUCTION

The range of 400 to 450 μmol $m^{-2}s^{-1}$ PPF (80 to 90 W m^{-2}, or 2700 to 3000 footcandles) has been suggested as the optimum light intensity for rooting of poinsettia cuttings (8, 9). Use of relatively high light intensity is based on the assumption that photosynthesis by cuttings enhances rooting. However, the recent review by Davis (2) indicated that there is limited evidence to support or reject this assumption. Researchers (7, 11) have suggested, but did not document that higher light intensities would be beneficial only after root initiation. To date no studies have separated out the effect of light intensity and consequent photosynthesis, or growth regulator concentrations, on the developmental stages of rooting. Hence, if adventitious root formation is only being evaluated at the termination of a propagation experiment, the potentially higher light needed for later root development may be masking potentially lower light requirements needed during earlier root initiation stages.

The few studies evaluating light levels during rooting of poinsettia have found better rooting with lower light treatments (1, 4). However, these studies did not distinguish light intensity from photosynthetic or growth regulator effects on the separate processes of root initiation and root development.

The objective of this research was to determine the relationship of photosynthesis with the discrete developmental stages of adventitious rooting in poinsettia.

[1] Present address: Fort Lauderdale Research and Education Center, 3205 College Avenue, Ft. Lauderdale, FL 33314

MATERIALS AND METHODS

Stem tip cuttings (11.5 cm) of 'V-10 Amy' and 'Lilo' poinsettia were inserted into 6.25 cm pots containing a fully moistened perlite:peat (3:1 by volume) medium. Rooting compounds were not used, and leaves were not removed from the cuttings.

Cuttings were rooted in a growth chamber having the following environmental conditions: 24 °C day/night temperature; 380 ± 10 ppm ambient CO_2 concentration; 16-hr uninterrupted photoperiod; 180 μmol m^{-2} s^{-1} (36 W m^{-2}) PPFD, increased to 250 μmol m^{-2} s^{-1} (50 W m^{-2}) on day 16; 95% or greater day/night relative humidity, reduced to 80 ± 8% on day 16. Light was supplied by cool-white fluorescent lamps, plus 80-watt incandescent bulbs.

Before measurement of photosynthesis cuttings were removed from the growth chamber and acclimated for 30 min. under a high-pressure sodium lamp filtered through a 10.0 cm water filter. Gas exchange was measured under environmental conditions of: 22.1 °C ambient temperature; 382.7 ± 9.4 ppm ambient CO_2 concentration; 423.7 ± 5.5 μmol m^{-2} s^{-1} (85 W m^{-2}) PPF; and 30.7 ± 5.8% relative humidity. Foliar net photosynthesis of the abaxial leaf surface was measured on the leaf nearest the apex having at least 4 cm^2 of surface area using a LI-COR LI6200 portable photosynthesis system (LI-COR, Inc., Lincoln, Nebraska, USA). After 10 cuttings of each cultivar were measured, cuttings were harvested to determine cutting dry weight and percent rooting.

The experiment was a completely randomized design. Photosynthesis data was similar for both cultivars, so the data were pooled and then analyzed for significant change by day using analysis of variance and orthogonal linear contrasts. Least squares means and standard errors were used to present the data.

RESULTS

Net photosynthesis was initially very low and remained low until 12 days after cuttings were stuck (Table 1). If unrooted cuttings were measured at 160 μmol m^{-2} s^{-1} instead of 423 μmol m^{-2} s^{-1}, there was no difference in the photosynthetic rate (data not shown), suggesting that Pn was saturated at or below 160 μmol m^{-2} s^{-1}.

Table 1. Photosynthesis, percent rooting, and total dry weight during adventitious root formation of poinsettia cuttings

Day	Percent rooting	Photosynthesis (μmol m^{-1} s^{-2})	Total dry weight (g)
Day 1	0	0.94±0.42	0.49±0.08
Day 4	0	1.21±0.42	0.50±0.08
Day 6	0	1.25±0.42	0.60±0.07
Day 8	0	1.21±0.42	—[z]
Day 10	0	1.35±0.42	0.58±0.07
Day 12	0	2.12±0.42	0.67±0.08
Day 16	77	8.01±0.42	0.79±0.07
Day 23	100	9.01±0.42	0.83±0.07
Orthogonal contrasts			
Day 4 differs from day	NS[y]	NS	NS
Day 6 differs from days 1-4	NS	NS	NS
Day 8 differs from days 1-6	NS	NS	—
Day 10 differs from days 1-8	NS	NS	NS
Day 12 differs from days 1-10	NS	*	NS
Day 16 differs from days 1-12	***	***	**
Day 23 differs from days 1-16	***	***	**

[z] Data not available.
[y] NS, *, **, ***, indicate not significantly different or different at the 5%, 1%, or 0.1% levels, respectively

Visible roots were not observed until day 16, indicating that a significant increase in Pn occurred prior to visible root emergence (Table 1). On the day that photosynthesis started to increase, microscopic analysis of cross-sections of the rooting zone of the cuttings revealed the presence of root initials and primordia, but no primordia elongation. Rooting was 70% and 85% for 'V-10 Amy' and 'Lilo', respectively, on day 16. All cuttings had rooted by day 19 or 23 for 'Lilo' and 'V-10 Amy', respectively.

Growth continued in all parts of the cuttings as indicated by steady increases in dry weight (Table 1). The carbon fixed from the low rates of photosynthesis may have been required for growth processes.

DISCUSSION

Previous studies have indicated that net photosynthesis in cuttings steadily declines, and then rapidly increases upon visible root emergence (2). Similarly, stomatal conductance of *Cornus alba* cuttings remained low until after root emergence (3). In the present study the steady initial decline in photosynthesis was not observed, and net photosynthesis increased prior to visible root emergence. The difference in initial response could be due to differences in species, cutting growth habit, species-cutting stomatal sensitivity, environmental conditions used (particularly light levels), and techniques used to measure photosynthesis. An increase in photosynthetic rate prior to root emergence has been previously reported for bean leaf cuttings but without anatomical observations. (5).

Temporary increases in the net photosynthesis of leaves of intact maize plants was correlated to the emergence of nodal stem adventitious roots and paralleled increased cytokinin activity (6).

Jesko (6) suggested that hormones exported from the newly emerging roots are the main factor controlling the temporary changes in photosynthesis. A similar explanation could resolve the photosynthetic response in cuttings. Regardless of the presence of visible roots or preformed root initials, an increase in cutting photosynthetic rate could be correlated to the newly developing roots' ability to export hormones. Variability in cytokinin export from roots would explain why cuttings of different species have increased photosynthetic rates, either before or after root emergence. Any temporary shortage in available carbohydrate upon root elongation is probably avoided by mobilizing the photosynthetic apparatus prior to the high carbohydrate demand needed for rapid root growth.

Since unrooted poinsettia cutting photosynthetic rate was the same at 160 μmol m^{-2} s^{-1} and 423 μmol m^{-2} s^{-1} of light, and since photosynthetic rate before root emergence was low, it appeared that lower light levels (which reduce water stress) could be used during the early stages of root initiation, and higher light intensities used just prior to root emergence to maximize adventitious root formation. Hence, in poinsettia there appears to be no benefit from using higher light intensities during propagation until after the cuttings have initiated roots. This research gives scientific evidence for current recommendations for poinsettia propagation (4, 10).

LITERATURE CITED

1 Carpenter, W. J , Hansen, E. N., and Carlson, W H 1973 Medium temperature effect on geranium and poinsettia root initiation and elongation. *Jour. Amer. Soc. Hort. Sci* 98.64-66

2. Davis, T. D 1988. Photosynthesis during adventitious rooting IN· Adventitious Root Formation in Cuttings, Davis, T. D , Haissig, B E , and Sankhla, N., eds., pp. 79-87 Dioscorides Press, Portland, Oregon

3. Gay, A P , and Loach, K. 1977. Leaf conductance changes of leafy cuttings of *Cornus* and *Rhododendron* during propagation *Jour. Hort. Sci.* 52:509-516

4 Gislerod, H R. 1983. Physical conditions of propagation media and their influence on the rooting of cuttings. III The effect of air content and temperature in different propagation media on the rooting of cuttings *Plant and Soil* 75, 1-14

5. Humphries, E C., and G N. Thorne. 1964. The effect of root formation on photosynthesis of detached leaves. *Ann Bot* 28.391-400.

6. Jesko, T 1981. Inter-organ control of photosynthesis mediated by emerging nodal roots in young maize plants. IN. Structure and Function of Plant Roots, Brouwer, R , Gasparikova, O., Kolek, J , and Loughman, B. C , eds pp 367-371 Martinus Nijhoff/Dr W Junk Publishers, Boston.

7 Loach, K. and A. P. Gay. 1979. The light requirement for propagating hardy ornamental species from leafy cuttings *Scientia Hortic.* 10 217-230.

8. Schroeter, G. 1988. Producing quality poinsettia cuttings Presentation at Texas Greenhouse Growers' and Interiorscapers' Conf., November 17, College Station, TX.

9 Shanks, J. B 1980 Poinsettias IN. Introduction to Floriculture, Larson, R A , ed., pp. 301-326 Academic Press, New York

10.Sheldrake, R. 1988. Growing my way—poinsettias for 1988. *Geiger News* 23(3).1-2. E C Geiger, Inc., Harleysville, PA.

11 Struve, D. K. 1981 The relationship between carbohydrates, nitrogen, and rooting of stem cuttings *Plant Propagator* 27(2):6-7