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Influence of Night Lighting with Red, Far Red, and Incandescent Light on Rooting of Chrysanthemum Cuttings[1]

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Abstract. **Night irradiation of stock plants and cuttings during the rooting period with red (R) or incandescent (INC) light resulted in statistical differences in rooting of cuttings of chrysanthemum (*Chrysanthemum morifolium* Ramat. cvs. Bright Golden Anne and Mrs. Roy) but differences were not large enough to be of commercial concern. Rooting was best when stock plants were irradiated with R light and cuttings were subsquently rooted under INC light and poorest when cuttings from INC irradiated stock plants were rooted under R light.**

Heins and Wilkins (4) have shown that a R light source used for low intensity photoperiodic control enhanced lateral branching and cutting production from chrysanthemum stock plants when compared to an incandescent (INC) light source. Since the *in situ* hormonal relationships required for shoot formation may differ from those for root formation, the possibility existed that light quality could also influence rooting. The purpose of this investigation was to determine if the quality of light used to maintain stock plants vegetative for cutting propagation or on the cuttings themselves would influence rooting.

Rooted cuttings of 'Bright Golden Anne' were planted in 10 cm pots on March 27, 1978 and placed under light sources of R (4.79 μW cm^{-2}, 650-700 nm; 0.94 μW cm^{-2}, 700-750 nm) and INC (303 μW cm^{-2}, 650-700 nm; 395 μW cm^{-2}, 700-750 nm) light. Two weeks after potting, the terminal growing point was removed. Four weeks after potting, uniform plants with 4 actively growing lateral shoots were selected. Plants were either irradiated for 4 hr starting 30 min prior to sundown (DC) or from 2200 to 0200 hr (NI). Temperatures were controlled to 20°C (day)/15° (night) by heating or fan and pad cooling, although temperature reached 30° on some warm days. Nutrients were applied when required as determined by weekly soil analysis.

Cuttings 5 cm long were removed on June 13, 1978 (Expt. I) and July 12, 1978 (Expt. II), from the upper 3 lateral shoots, leaving 2 nodes on the stock plant shoot. During rooting, the stem base was placed about 1.5 cm into a sand medium without hormonal rooting chemicals and the plants were misted for 5 sec every 5 min. Cuttings from the stock plants were irradiated with either R or INC light as a DC or NI. Thirteen cuttings were irradiated under the same light quality and duration as were the stock plants. Thirteen and 15 days later, Expt. I and II, respectively, newly rooted cuttings were removed from the propagation bench and the total number of roots and the longest root on each cutting were measured and recorded.

Experiment III began on June 21, 1979, when 5 cm long cuttings of 'Mrs. Roy', which has a slow rooting response, and 'Bright Golden Anne,' which has a rapid rooting response, were removed from stock plants irradiated by incandescent lights from 2200 to 2400 or 0100 to 0300 on alternating nights at Fort Meyers, Florida. These cuttings were sent by air freight to St. Paul, Minnesota.

Rooting started on June 26 under similar conditions as in Expt. I and II. On July 12 total number of root initials emerging through the epidermis and total fresh weight of all roots in each treatment were determined. All light treatments applied to cuttings were similar to Expt. I and II plus the addition of a far red (FR) fluorescent irradiance (1.77 μW cm^{-2}, 650-700 nm; 8.38 μW cm^{-2}, 700-750 nm) treatment. Fifteen cuttings were used in each treatment.

The overall results for the 3 experiments were similar. Adequate rooting occurred on all cuttings irrespective of previous stock plant treatment (Expt. I and II). There were significant differences for number of roots per cutting and root length and weights between treatments in all 3 experiments. However, the differences would have no practical importance in commercial rooting of chrysanthemum cuttings.

With 'Bright Golden Anne' the data for root number and length in Expt. I and II and for root length in Expt. III show an increase under INC light when compared to cuttings rooted under R light (Table 1 and 2). Cuttings removed from INC irradiated stock plants and then rooted under R light had less root

Table I. Influence of irradiating stock plants and cuttings with red (R) or incandescent (INC) light on number of roots and length (mm) of roots on 'Bright Golden Anne' chrysanthemum cuttings.

Stock Plant treatment	Cutting treatment: Expt. I R[z]	Expt. I INC	Expt. II R	Expt. II INC
	Number of roots			
DC[y]-R	14.8 bcd[w]	19.9 a	19.7 abc	19.9 ab
NI[x]-R	16.8 ab	18.2 ab	21.5 a	21.4 a
DC-INC	13.7 cd	14.7 bcd	16.0 c	19.7 ab
NI-INC	13.5 cd	14.1 cd	17.1 bc	17.2 bc
Mean	14.7	16.7	18.6	19.6
ND	12.9 d			
	Root length (mm)			
DC-R	40.3 a	41.5 a	44.2 a	39.6 ab
NI-R	38.8 a	40.0 a	38.8 ab	43.7 a
DC-INC	41.9 a	40.6 a	36.7 ab	36.4 b
NI-INC	32.5 b	40.2 a	37.3 ab	38.4 ab
Mean	38.4	40.6	39.3	39.5
ND	31.2 b			

[z]Irradiation spans the same as stock plants.
[y]Plants were irradiated for 4 hr starting 30 min before sundown.
[x]Plants were irradiated from 2200 to 0200 hours.
[w]Mean separation within variable and experiment by Duncan's multiple range test, 5% level.

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Table 2. Influence of irradiating cuttings with red (R), far-red (FR) or incandescent light (INC) on the average number of roots and fresh weight (g) of roots present on 'Mrs. Roy' or 'Bright Golden Anne' chrysanthemum cuttings.

Rooting treatment	'Mrs. Roy'				'Bright Golden Anne'			
	R	FR	INC	Mean	R	FR	INC	Mean
				Number of roots				
DC[x]	6.9 a[y]	6.5 ab	5.6 bc	6.3	16.9 bcd	15.4 cd	14.8 d	15.7
NI[z]	5.1 c	6.5 ab	5.9 abc	5.8	18.9 ab	17.2 bc	19.8 a	18.6
Mean	6.0	6.5	5.8		17.9	16.3	17.3	
ND	5.1 c				16.8 bcd			
				Total weight of roots (g)				
DC	0.68	0.71	0.49	0.63	11.8	9.3	10.6	10.6
NI	0.63	0.90	0.40	0.64	18.9	10.5	18.7	16.0
Mean	0.66	0.81	0.44		15.4	9.9	14.7	
ND	0.43				9.0			

[x]Plants were irradiated for 4 hours starting 30 minutes before sundown.

[y]Mean separation within cultivar and variable by Duncan's multiple range rest 5% level.

[z]Plants were irradiated from 2200 to 0200 hrs.

development while R irradiated stock and INC irradiated cuttings tended to have greater rooting (Table 1).

In Experiment III, the number of roots formed on 'Mrs. Roy' cuttings was smallest on the cuttings rooted under ND and NI-R (Table 2). No significant differences existed between the NI-FR and INC and DC-R and FR treatments. The root weights were measured as a group so no sampling error is available. However, the greatest weights of roots were observed on cuttings irradiated with FR light for 'Mrs. Roy' and INC for 'Bright Golden Anne'. Root numbers of 'Bright Golden Anne' cuttings were greater under NI-INC or NI-R compared to the ND control. Maximum root weight also occurred with these treatments (Table 2). In Expt. III light treatments stimulated rooting over ND.

In 3 experiments with 'Bright Golden Anne' R light reduced the number of roots in 2 of the 3 experiments. With 'Mrs. Roy', a difficult and slow rooting cultivar, FR treatments stimulated root numbers and weights.

From these three experiments we have concluded that the influence of light quality on the upper canopy of plants indeed may influence root regeneration and growth. Further, what is the influence of light quality on stock plants to be used for *in vitro* culture and indeed light on these cultures?

The tendency towards lateral shoot development under R light conditions (4) and rooting under INC light (current results) may indicate some control of endogenous hormonal balances by light quality. Exogenous applications of cytokinins induce lateral branching (2,3,7) and inhibit rooting (3). Conversely, exogenous applications of auxins inhibit lateral branching (5,6,8) and enhance rooting (1). Red light may stimulate cytokinin production and/or inhibit auxin synthesis or enhance auxin degradation while INC light, which is higher in the FR region of the spectrum, may give the opposite response. Further analysis of endogenous hormonal levels are needed to clarify this hypothesis.

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