very drop-tolerant and this clone is, of course, a selection for a fruitless quality. It is a dioecious species; we have selected a male form, a fruitless form, and one with an upright, well-branched head. The species itself is a very good tree; bright green, always healthy, very drop-tolerant, and then the male clone, of course, additionally eliminates the possibility of any seed which would be messy if it were used as a street or yard tree.

MODERATOR LEISER: Our next speaker on this symposium is Jack Crossley from the Canada Department of Agriculture, Saanichton, B.C., Canada. His crop specialties are flowering bulbs, chrysanthemums, holly and nursery crops; his current research is in the latter two areas. Today he will tell us of some of that research, 'The relationship of temperature and light to the growth and flowering of seedlings and cuttings of *Rhododendron molle* hybrids". Jack:

MR. J. H. CROSSLEY: I have enjoyed the visit to California immensely. I found it very stimulating and certainly entirely different from what I have been used to. I do want to thank you in all sincerity, on my own behalf, and I am sure the delegation — the other seven from British Columbia — are equally grateful for the way you throw things open to us with no holds barred. When you come up our way we hope we can reciprocate in some small way.

LIGHT AND TEMPERATURE TRIALS WITH SEEDLINGS AND CUTTINGS OF RHODODENDRON MOLLE

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Plant propagators are always searching for ways to reduce the growing period of seedlings and rooted cuttings. This paper deals with only two factors, supplemental light and temperature, as aids to growth stimulation, marketable size and flower initiation of *Rhododendron molle.*

Stimulation of shoot growth by supplementary lighting of *Rhododendron molle* was reported in 1960 and 1963 by Weiser and Blaney (1, 2), by Spicer (4) and in 1964 by Goddard (3). Stimulation of seedlings of rhododendron (*R. catawbiense*), azalea (*R. japonicum* x *R. molle*) and their hybrids with supplementary illumination was reported in 1955 by Doorenbos (5). Weiser and Blaney showed that shoot growth of several clones was greatly stimulated by supplementary low-intensity fluorescent light (150 f.c.) between dusk and dawn. They also reported stimulated growth with prolonged illumination at light intensities of 35 to 50 f.c. and by incandescent light. They experimented with deciduous azaleas under constant illumination and grew them to marketable size in less than a year from time of taking the cuttings (2). Spicer (4) working with Ilam decidu-

ous azaleas of which *R. molle* is a parent, reported satisfactory shoot growth with as little as three hours' supplementary illumination using 100-watt globes, 3 feet above the bench covering 12 square feet. Spicer also stated that if plants were left under the lights, kept pinched and fed, they would make strong well-formed plants, 18 to 24 inches high, in a 3-inch pot. This, Spicer claimed, was undesirable; his preference was to give only sufficient time to get them into growth and shift them to a covered frame to harden off, when the cover was removed for winter.

Goddard (3) in 1962 used dusk-to-dawn supplementary illumination to produce winter cuttings from summer-rooted stock plants and concluded that growth under 60-watt incandescent lamps in a 45° F. night minimum plastic greenhouse was unsatisfactory. On the other hand. excellent results were obtained with Gro-Lux in standard fixtures under similar conditions. He stimulated stock plants derived from June cuttings, 18 inches high at 12 months and well branched after yielding 3.5 cuttings each. At 3 months, these made salable 6-inch liners.

Doorenbos (5), exploring the possibility of shortening the breeding cycle of seedling rhododendrons and azaleas found optimum results when plants were grown in the greenhouse at a photoperiod of 24 hours (natural days extended to 24 hours) by "weak incandescent" 60-watt lights. Lateral shoots were kept removed. When plants were kept in a "very long" photoperiod at 59 to 68° F., the number of growing periods was increased; the majority of the plants grew about twice as fast as plants grown in natural days and in one experiment, 7 of 10 azalea seedlings initiated flowers in about 16 months from sowing. When 30 plants were moved outside in May, 14 months after sowing, only twelve formed flower buds.

Materials and Methods

Experiment 1 (1963-64) *Effect of light duration on seedlings.*

Two hundred *R. molle* plants sown in January, 1963, and potted in August were grown under five different light regimes in a greenhouse maintained at a 45° F. minimum from September 6, 1963 to February 14, 1964.

The five light treatments were:

1. 24 hours light (normal daylight, then Gro-Lux fluorescent dusk to dawn).
2. 20 hours light (normal daylight, then Gro-Lux fluorescent commencing at dusk).
3. 16 hours light (normal daylight, then Gro-Lux fluorescent commencing at dusk).
4. Normal daylight plus one-half hour Gro-Lux fluorescent at *midnight.*
5. Normal daylight.

Each plot received supplementary light by two 40-watt tubes, 20 inches above pot rims covering a 3 by 4 foot bench. Plot layout was four randomized blocks.A plot consisted of 20

plants in 4½-inch square plastic pots. Plants were fed and pinched periodically to encourage bushiness. On February 14, 1964, plant grade and height were recorded.

Experiment 2 (1964-65) *Effect of temperature and light on seedlings.*

From September 13, 1964, until April 29, 1965, 800 spring-sown, hand-pollinated *R. molle* seedlings were grown in greenhouses under two temperatures and four light treatments to determine the effect on growth and subsequent flower-bud formation. The temperatures were 45° and 65° F. night minimum provided by eight identical compartments equipped with automatic separately-controlled light, temperature and ventilation facilities. Each compartment was divided into four sub-plots, 4½ by 4½ feet consisting of 25 plants, by curtains raised at dusk lowered at 8:00 A.M., providing the four light treatments. Lights were placed 24 inches above the pot rims. Plants were pinched to encourage bushiness, an given liquid feeding until mid-August.

1. 24 hours light (normal daylight, then Gro-Lux fluorescent 160 watts, 50 to 70 f.c. dusk to dawn).
2. 24 hours light (normal daylight, then incandescent 400 watts, 30 to 100 f.c. dusk to dawn).
3. 16 hours light (normal daylight, then Gro-Lux fluorescent 160 watts, 50 to 70 f.c. commencing at dusk).
4. Normal daylight only.

Light-temperature treatment terminated April 29 (228 days). After a hardening-off period, April 29 to May 29, in unheated greenhouses, the plants were transferred to fully exposed outdoor conditions to complete their growth.

Growth increment data and plant grade were first recorded March 2 and again on September 15 when flower buds were also counted.

Experiment 3 (1964-65) *Effect of light quality on rooted outtings.*

From November 6, 1964 until April 29, 1965 ninety plants from August cuttings were given dusk-to-dawn supplementary illumination with five different kinds of lights. The object was to determine the effect of light quality on shoot growth and subsequent flower-bud formation.

Lights as listed below were placed 36 inches above the pot rims. Plot area was nine square feet of bench.

1. Mercury vapour (H.P.) Total wattage-400; f.c. 180-300
2. Fluorescent, Gro-Lux Total wattage-400; f.c. 20- 38
3. Fluorescent, Daylight Total wattage- 80; f.c. 50- 95
4. Fluorescent, Verd-A-Lite (industrial) Total wattage- 80; f.c. 40- 90
5. Fluorescent, DSW/29 (industrial) Total wattage- 80; f.c. 40- 70

Night minimum greenhouse temperature was 65° F. Cultural methods were similar to Experiment 2.

Results

Experiment 1 (*Table* 1)

Increasing the total hours of light to 16, 20 or 24 hours by supplementary illumination with Gro-Lux fluorescent in a greenhouse set for a night minimum of 45° F. resulted in graduating increase in height (3.9, 4.5 and 5.3 inches respectively) and also in percentage of grade one plants (17, 35 and 50 percent respectively) for the 161-day test period. While one-half hour of supplementary illumination at midnight with Gro-Lux resulted in a significant increase in height compared to natural day treatment, it was valueless for production of grade one, and nearly so for grade two plants.

Table 1. Effect of supplementary illumination on growth increment and grade of *R. molle* seedlings, 1964

Light treatment Sept 6 to Feb 14, 161 days (min night temp 45°F)	Hgt Incr Av [1]	% Plants grading[2] Good	Fair	Poor
	ins			
24 hrs (Gro-Lux dusk to dawn)	5.3a	50	13	37
20 hrs (Gro-Lux starting dusk)	4.5ab	35	35	30
16 hrs (Gro-Lux starting dusk)	3.9b	17	10	73
Natural days + ½ hr. midnight	3.3b	0	7	93
Natural days	0.6c	0	0	100

[1]Values with a letter in common are not significantly different (P = 05)
[2]Arbitrary grade based on leafiness and bushiness

Table 2. Effect of temperature ranges and supplementary illumination on *R. molle* seedlings, 1965

Trt No	Treatment: Night Min Temp	Treatment: Light (Sept 13 to Apr 29, 228 days)	Growth results[1] in 170 days: Hgt Inc	Av Pinches/ Plant	% Gr 1[2] Plants	Grade[2] Index (all)
			ins			
1.	45° F.	24 hrs (Gro-Lux dusk-dawn)	0.7c	1.0b	19.1b	19.2b
2.		24 hrs (Incand. dusk-dawn)	1 0c	1 7c	35 3c	22.7c
3.		16 hrs (Gro-Lux start dusk)	0.1a	0 4a	0.1a	10.0a
4.		Natural days	0.1a	0.5a	0.1a	10.2a
5.	65° F.	24 hrs (Gro-Lux dusk-dawn)	2.4d	2.7d	61 7d	26 0d
6.		24 hrs (Incand. dusk-dawn)	2.3d	2.8d	73.9d	27.7d
7		16 hrs (Gro-Lux start dusk)	1.2b	1.4c	39.7c	23 0c
8.		Natural days	0 1a	0.4a	0.1a	10.7a

[1]Values with a letter in ommon are not significantly different (P = 05)
[2]Visual grading for leafiness, foliage color, plant vigor and bushiness, Grade index 3 = Gr 1, 2 = Gr 2, 1 = Gr 3

Experiment 2 (*Tables* 2, 3, *and* 4) — *Initial effect.*

Data for the initial growing period in the greenhouse, September 13 to April 29, 1965 indicated that growth stimulation

Table 3. Residual* effects in 139 days of temperature ranges and supplementary illumination on *R. molle* seedlings, 1965

Treatment			Percentage of plants[1]		
No	Night Min Temp	Light	Gr 1	Gr 1 & 2	w/flower buds
1	45° F	24 hrs (Gro-Lux dusk-dawn)	3 7abc	10 5b	42 3cd
2.		24 hrs (Incand. dusk-dawn)	3 0abc	11 2b	47 0d
3		16 hrs (Gro-Lux start dusk)	1.7ab	6 5a	22 0b
4		Natural days	4.7c	13 0b	30 0bc
5	65° F	24 hrs (Gro-Lux dusk-dawn)	5 0c	10 2b	60 7ef
6		24 hrs (Incand. dusk-dawn)	4.0bc	11 0b	65.7f
7		16 hrs (Gro-Lux start dusk)	3 5abc	10 7b	47.4dc
8.		Natural days	1 0a	6 0a	7.0a

[1]Values with a letter in common are not significantly different (P = 05)

*Based on original treatment period, 228 days (Sept 13 to April 29) and total growth period of 367 days (Sept 13 1964 to Sept 15, 1965)

of *R. molle* during the dormant season is governed by both temperature and daylength. For example, the responses in height increment and average number of pinches per plant were practically nil under natural days at both 45° and 65° F. minimum temperature ranges, but under 24 hours light, growth increased significantly, particularly at the higher temperature.

Data also show that growth of grade one plants and grade index were most satisfactorily promoted by the higher temperature and 24 hours of light (illumination dusk to dawn, treatments 5 and 6). At 65° F. the two kinds of supplementary illumination were not significantly different. Reducing the total light period materially reduced growth and the number of grade one plants from 61.7% for 24 hours to only 39.7% for 16 hours (treatments 5 and 7).

Residual Effect

Plants with flower buds. Dusk-to-dawn illumination with either Gro-Lux or incandescent lights (24 hours) plus a minimum night temperature of 65° F. resulted in over 60 percent of plants initiating flower buds. This compared with only 30 percent from the higher yielding check treatment (natural days at 45° F. night minimum).

For 65° F. night minimum 16 and 24 hours of total light were equally effective when Gro-Lux was the supplementary source, but 16 hours with Gro-Lux was not as effective as 24 hours when incandescent was supplementary.

Plant grade. One hundred and thirty-nine days following termination of lighting, with grade based on plant size and appearance but not flower buds, no improvement was shown from supplementary illumination.

Experiment 3 (*Tables* 5 *and* 6)

In general, growth stimulus during the 122-day test period with mercury vapour and four fluorescent supplementary lightings was not appreciably different though mercury vapour did

Table 4. Residual effects of temperature ranges and supplementary illumination on *R. molle* seedlings after treatment, comparing Saanichton (SG) and Goddard (GG) gradings.

Trt No	Original treatment[1]		Percentage of plants				Percent plants w/flower buds all grades
	Min Night Temp	Light	Grade 1		Grade 1 & 2		
			SG	GG	SG	GG	
1.	45° F.	24 hrs (Gro-Lux dusk-dawn)	3.7abc[2]	29.3c[2]	10.5b[2]	60 5bc[2]	42.3cd[2]
2.		24 hrs (Incand. dusk-dawn)	3.0abc	24 2bc	11.2b	72.7cde	47.0d
3.		16 hrs (Gro-Lux start dusk)	1.7ab	11.1ab	6.5a	54.0ab	22.0b
4.		Natural days	4.7c	28.1c	13.0b	71.4cde	30.0bc
5	65° F	24 hrs (Gro-Lux dusk-dawn)	5 0c	30.1c	10.2b	82.1de	60.7ef
6.		24 hrs (Incand. dusk-dawn)	4 0bc	22.9bc	11 0b	87.8e	65 7f
7		16 hrs (Gro-Lux start dusk)	3 5abc	21.3bc	10 7b	69.7bcd	47 4dc
8.		Natural days	1.0a	7.1a	6 0a	42 8a	7.0a

[1]Sept 13 to April 29, 1965 (228 days)
[2]Values with a letter in common within columns are not significantly different (P = 05)

Table 5 Growth results (122 days, November 6 to March 8) with five supplementary lightings on rooted cuttings of *R. molle,* 1965

Treatment (24 hours light (suppl illumin dusk to dawn)	Growth[1] incr	Av [1] No pinches/ plant	Percent Gr 1	Grade Index all plants
	ins			
1. Mercury vapour	1 8c	1 1b	10 0	1 7
2 Fluorescent Gro-Lux	0 6a	0.4a	10.0	1 8
3 Fluorescent Daylight type	1 4bc	0 5a	12.5	1 8
4 Fluorescent Verd-A-Lite	1 4bc	0 5a	15 0	1.9
5 Fluorescent DSW/29	0 9ab	0.5a	2 5	1 8
			N.S.	N.S

[1]Values with a letter in common within columns are not significantly different (P = 05)

result in more pinches per plant. This is not surprising as energy output is greater from mercury vapour than fluorescent (in this case, 400 compared to 80 watts). What is surprising is that with daylight fluorescent or the industrial Verd-A-Lite, growth increment surpassed the Gro-Lux fluorescent treatment, a type primarily designed for optimum plant growth. Results are inconclusive but it appears that with dusk-to-dawn supplementary illumination, quality of light is not a highly important factor of growth stimulus and early flower initiation of young azalea plants.

Table 6. Residual growth effect of five supplementary illuminations on rooted cuttings of *R. molle,* 139 davs after treatment

Original treatment[1] (24 hrs light - suppl illumination dusk to dawn)	% Grade 1 plants	% Grade 1 & 2 plants	% Plants w/flower buds
1 Mercury vapour	5.6	33.3	72
2. Fluorescent Gro-Lux	0.1	16.6	77
3 Fluorescent Daylight type	11.1	22.2	44
4 Fluorescent Verd-A-Lite	27 7	49 9	77
5 Fluorescent DSW/29	11.1	38.8	38
	N S	N S.	N.S.

[1]Based on original treatment period, 174 days (November 6 to April 29, 1965 and total growth period, 313 days, (November 6 to September 15, 1965).

Summary and Conclusions

Three experiments dealing with the effect of supplementary illumination on growth stimulus, grade of plant and flower bud initiation of young *R. molle* seedlings and rooted cuttings were carried out in 1963-64 and 1964-65. A total of 1,090 plants were subjected to not less than 161 days of treatment in which temperature, and fluorescent, incandescent and mercury vapour lightings were variables, though not necessarily in all experiments.

Maximum growth response, *initially* determined immediately after the lighting period, and based on height increment,

number of pinches per plant, percentage of grade one plants and grade index, resulted from 65° F. night minimum plus 24 hours light (supplementary illumination dusk to dawn). Gro-Lux fluorescent and incandescent were equally effective.

Final independent gradings by a nurseryman and the author in September, 139 days following termination of lighting with grade based on size and appearance only, revealed no improvement as a result of supplementary illumination.

On the other hand, dusk-to-dawn illumination with either Gro-Lux fluorescent or incandescent plus a minimum temperature of 65° F. resulted in over 60 percent of the plants initiating flower buds compared to 30 percent for the higher yielding check (natural days and 45° F. night minimum). Light for 16 hours, where Gro-Lux is supplementary, is equal to dusk-to-dawn lighting with lighting with Gro-Lux, but less than equal to dusk-to-dawn with incandescent.

Light quality from mercury vapour and four kinds of fluorescent used in this experiment, is not considered critical for dusk-to-dawn supplementary illumination where growth stimulation of *R. molle* is the objective.

LITERATURE CITED

1. Weiser, C J. and Blaney, L. T. 1960. Constant illumination stimulates growth of softwood azalea cuttings. *Oregon Orn. and Nursery Digest* 4:2
2. Weiser, C. J. and Blaney, L. T. 1963 Rooting and night-lighting trials with deciduous azaleas and dwarf rhododendrons *Amer. Hort. Magazine* 42:2 pp 95 - 100.
3. Goddard, W. 1963. Forestalling dormancy and continuous growth of *Azalea mollis* with supplementary light for winter propagation. *Proc. Plant Propagators' Soc.* 13: 276-278.
4. Spicer, C. R. 1963. The rooting and growing of Ilam deciduous azaleas from cuttings. *The Plant Propagator* 9:4 pp 6-7.
5 Doorenbos, J. 1955. Shortening the breeding cycle of rhododendron. *Euphytica* 4: 141-146.

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MODERATOR LEISER: Our next speaker is Gottlob "Rudy" Wagner from C. and O. Nursery at Wenatchee, Washington. Rudy!

PROPAGATING APPLE ROOTSTOCKS BY THE METHOD OF CONTINUOUS LAYERING

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The increasing use of vegetatively propagated rootstocks in our fruit tree nursery, in search for better rooted liners and for a constant source of supplies, made us decide in 1962 to grow