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Growth and development of different types of pot plants under different lighting regimes

Belysningstidspunktets betydning for potteplanters vækst og udvikling

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Summary

Hibiscus rosa-sinensis, Hedera helix and *Schefflera arboricola* were grown under different lighting regimes during the winter time.

The photoperiod was prolonged to 18 h with artificial light. *Hibiscus rosa-sinensis* and *Hedera helix* were grown under a photon flux density of 30 +/– 4 μmol /m^2.s and *Schefflera arboricola* under 45 +/– 5 μmol /m^2.s from high pressure sodium lamp.

The artificial light treatment was given at different times during the diurnal cycle:

a: The light was turned on after a 6 h night period after sunset and turned off at sunrise.
b: The light was turned on at sunset and turned off 6 h before sunrise.
c: Two artificial light periods, one before sunrise and one after sunset.
d: The artificial light was turned on 3 h after sunset and turned off 3 h before sunrise.

Control: Natural irradiance and daylength.

In the first experiment with *Hibiscus rosa-sinensis* the lighting resulted in a slight but significant increase in growth. In the second experiment the plants, which received artificial light, had significantly more leaves and sideshoots. In the third experiment the plant grew equally in all treatments. The growth rate of *Schefflera arboricola* was significantly increased by artificial lighting in all three experiments, no differences were found between the artificial lighting regimes.

The growth rate of *Hedera helix* was significantly increased by artificial light in all three experiments.

Key words: Artificial lighting, high pressure sodium lamp, *Hedera helix, Hibiscus rosa-sinensis, Schefflera arboricola.*

Resumé

Hedera helix, Hibiscus rosa-sinensis og *Schefflera arboricola* blev dyrket under kunstlys i væksthus. Kunstlyset blev givet på forskellige tidspunkter på døgnet.

a: kunstlyset blev tændt 6 timer efter solnedgang og slukket ved solopgang.
b: kunstlyset blev tændt ved solnedgang og slukket 6 timer før solopgang.
c: kunstlyset blev tændt ved solnedgang og slukket kl. 21.00. Kunstlyset blev tændt igen kl. 03.00 og slukket igen ved solopgang.
d: kunstlyset blev tændt 3 timer efter solnedgang og slukket 3 timer før solopgang.

Som kontrol blev brugt planter dyrket under naturlig indstråling og daglængde. Som lyskilde blev brugt højtryksnatrium lampen. Indstrålingen var 30 +/– 4 μmol /m^2.s for *Hedera helix* og *Hibiscus rosa-sinensis* og 45 +/– 5 μmol /m^2.s for *Schefflera arboricola.*

Alle plantearter reagerede positivt på kunstlys, mens der ikke var forskelle af betydning mellem de forskellige behandlinger.

Nøgleord: Kunstlys, højtryksnatrium lampe, *Hedera helix, Hibiscus rosa-sinensis, Schefflera arboricola.*

Introduction

In the last decade artificial lighting has become a common practice in the production of greenhouse plants during the winter months. Artificial light is used as photosynthetic active radiation to increase the growth rate and to improve plant quality.

Several plant species show a fluctuation in the rate of photosynthetic activity during the diurnal cycle (1, 5, 7, 9). Such observations have been made under constant climatic conditions and high irradiance as well as in field experiments (5).

The fluctuation in net photosynthesis is not fully understood, but it has been proposed to assimilate accumulation in the leaf could lead to a depression in net photosynthetic rate at the end of the day.

During the winter months bright days with high natural irradiance is occurring. If a decrease in net photosynthesis is a result of a high level of assimilates or other factors depending on high irradiance a low efficiency of applying artificial light may be expected.

The breaking of sideshoots and stem elongation is depending on the phytochrome system. Therefore spectral distribution of the lamp and length of the night will play an important role in the development of the plant when artificial light is used.

Morphological changes have been found when tomato plants were grown under an intermittent lighting regime (10). This regime consisted of a 9 h continuous lighting period followed by 7 periods of 1 h light interrupted by 1 h darkness. The control plants were grown under 16 h light and 8 h darkness. The plants grown under the intermittent lighting regime were smaller with shorter internodes and less leaf area.

In *Zea maize* an increase of leaf area, specific dry matter content of the leaf, and a decrease of root dry matter content were found if the plants were grown in a cycle of 30 min of light and 15 min of darkness compared with a cycle of 16 h light and 8 h darkness. If the plants were grown in a cycle of 15 min of light and 7.5 min of darkness the specific leaf weight decreased and the root weight increased compared to the cycle of 16 h of light and 8 h of darkness (6).

In all three treatments the plants received the same amount of light during the diurnal cycle.

It is of interest to find out in which part of the night period artificial light has the greatest effect on growth rate and plant quality.

Materials and methods

The experiment was performed with three species of pot plants: *Hibiscus rosa-sinensis* L., *Schefflera arboricola* Hayata and *Hedera helix* L., cv. 'Susanne'.

Hibiscus rosa-sinensis

In the experiments with *Hibiscus* 7 weeks old plants with two plants in each pot were used. The plants were pinched to three nodes just before the start of each experiment. They were spaced with 47 plants/m^2. For growth retardation Cycocel extra in a concentration of 0.35‰ (161 mg chlormequat /l) was applied once by spraying when the average length of the sideshoots was 3 cm.

The first experiment was conducted from week number 40 to 47. The second experiment was conducted from week number 47 to 4. And the third experiment was conducted from week number 4 to 12.

The photon flux was 30 +/– 4 μmol /m^2.s from the artificial light source measured in the top of the plant canopy.

Each experiment had two replications with 10 plants per replicate.

Schefflera arboricola

The experiment with *Schefflera* was based on rooted cuttings with one cutting per pot.

In the first, second, and third experiment the average number of leaves per plant was 1.2, 1.6, and 2.2, respectively.

The first experiment was conducted from week number 43 to 49. The second experiment was conducted from week number 46 to 2. And the third experiment from week number 50 to number 9.

The plants were spaced with 30 plants /m^2.

The photon flux density was 45 +/- 5 μmol /m^2.s from the artificial light source.

Each experiment had two replications with 10 plants per replicate.

***Hedera helix* cv. 'Susanne'**

In all experiments four weeks old plants were used. There were nine rooted cuttings in each pot. The average length of the four longest vines per pot is used as an expression for the growth.

The first experiment was conducted from week number 40 to 45. The second experiment was conducted from week number 46 to 1. And the third experiment from week number 2 to 11.

The plants were spaced with 58 plants /m^2.

The photon flux density was 30 +/- 4 μmol /m^2.s from the artificial light source.

Each experiment had two replications with 10 plants per replicate.

Research facility

The greenhouse was divided into six compartments which were separated by black lightproof polyethylene covered with white polyethylene to improve light distribution.

A single luminaire was mounted in each compartment except in the compartment with natural light condition. The light source was a 400 W high-pressure sodium lamp.

The minimum temperature was 18°C and ventilation at 24°C.

The CO_2 level was 600 ppm and kept constant by a CO_2-scanner. The CO_2 was dosed 24 h per day except when the ventilators were open.

The natural daylength varied from 7 to 12 h during the experimental period and was totally prolonged to 18 h in all the lighting regimes except in the control.

The lighting regimes were:

a) 6 h darkness after sunset before the light was turned on. The light was turned off at sunrise.
b) The light was turned on at sunset and turned off 6 h before sunrise.
c) The night break of 6 h was given in the middle of the night. Two artificial lighting periods were given in connection with sunset and sunrise. The two periods were of equal length.
d) The artificial light was given during the middle of the night. The two dark periods were given in connection with sunset and sunrise. Both dark periods had a duration of 3 h.

Control: Natural daylength and light conditions.

The treatments is scheduled in Fig. 1.

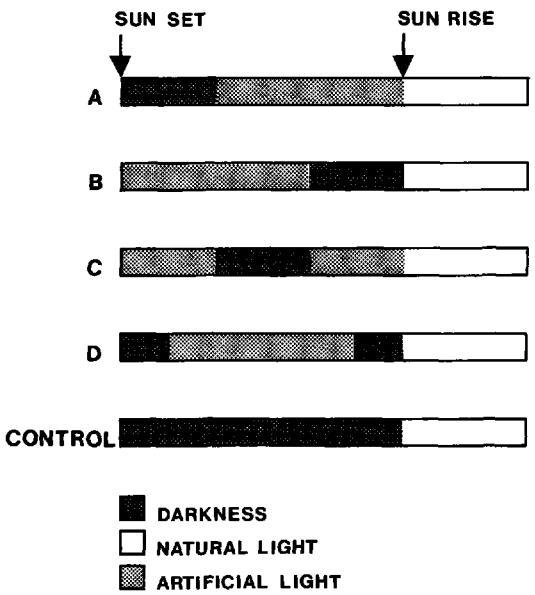

Fig. 1. Schedule for the lighting regimes.

Results

No negative effects in form of stem elongation, inhibition in breaking of sideshoots or changes in leaf size, shape and pigmentation were found during a visual estimation in any of the plant species.

Hibiscus rosa-sinensis

In the first experiment there was only a slight but significant effect of artificial light. The plant height and number of leaves were affected by the light but not the number of sideshoots (Table 1a).

In the second experiment there was an effect of artificial light on plant height, number of leaves and sideshoots which were significantly increased. There were no differences between the different lighting regimes except plant height (Table 1b).

Table 1. *Hibiscus rosa-sinensis.* Plant height, number of leaves and sideshoots with level of significance.

Lighting regime	Plant height (cm)	Number of leaves	Number of sideshoots
a) Experiment 1			
a	16.8	22.3	4.5
b	15.1	19.0	4.8
c	16.5	21.4	4.8
d	16.0	20.4	5.1
Control	15.0	18.4	4.4
Significance	*	**	N.S.
LSD	1.8	3.0	–
b) Experiment 2			
a	15.4	19.3	4.9
b	15.1	17.6	5.5
c	16.7	19.7	5.8
d	17.1	17.8	5.4
Control	13.5	12.7	3.5
Significance	**	***	***
LSD	1.5	3.3	1.2
c) Experiment 3			
a	15.3	17.7	5.2
b	13.9	14.2	5.2
c	14.6	16.8	4.6
d	15.8	17.6	5.0
Control	14.7	18.7	5.0
Significance	N.S.	N.S.	N.S.
LSD	–	–	–

Table 2. *Schefflera arboricola.* Plant height, number of leaves with the level of significance.

Lighting regime	Plant height (cm)	Number of leaves
a) Experiment 1		
a	15.2	7.5
b	15.2	7.6
c	14.4	7.8
d	15.1	8.6
Control	10.4	6.4
Significance	***	***
LSD	2.8	2.0
b) Experiment 2		
a	14.2	8.4
b	13.8	7.8
c	13.4	8.3
d	14.5	8.2
Control	6.9	6.0
Significance	***	***
LSD	2.5	1.0
c) Experiment 3		
a	9.7	6.4
b	9.9	5.5
c	9.6	5.7
d	9.6	6.0
Control	6.3	4.7
Significance	***	***
LSD	2.1	1.5

In the third experiment there were no effects of artificial light (Table 1c). In treatment b the number of leaves were significantly fewer than in the other treatments but it may not have originated from the light treatment.

Schefflera arboricola

The experiments with *Schefflera arboricola* showed a significant effect of artificial light (Table 2). Even though the growth rate was significantly increased by artificial light there was no difference between the lighting regimes.

Hedera helix

In all three experiments the growth rate was increased by artificial light. In the first (Fig. 2) and the third (Fig. 4) experiment there was a difference between two of the lighting regimes but the effect was inconclusive.

Discussion

The present experiments show a seasonal variation in the effect of artificial light. But artificial light given at different times during the diurnal cycle gave the same plant growth and development.

None of the artificial lighting regimes seems to be more favourable than the others.

Hibiscus rosa-sinensis

The breaking of sideshoots is depending on the light quality (spectral distribution) (4), daylength

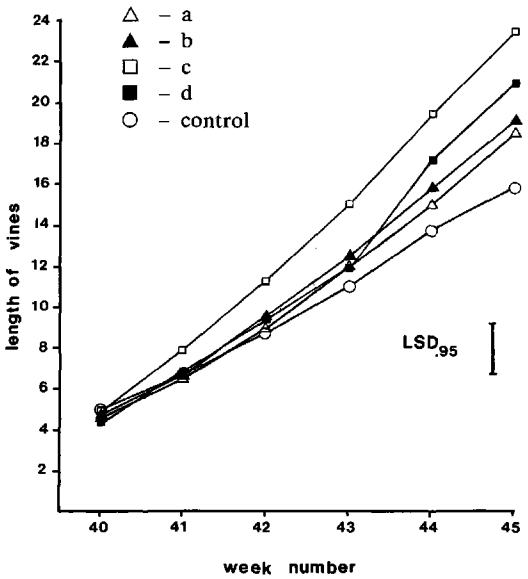

Fig. 2. In exp. 1 the growth rate of *Hedera helix* is nearly the same in all treatments.

(3), and the quantity of light (2). The high pressure sodium lamps is promoting breaking of sideshoots because of its high ratio between red and far-red. However, the breaking of lateral sideshoots is very complex. An increase in cutting production has been found in chrysanthemum if

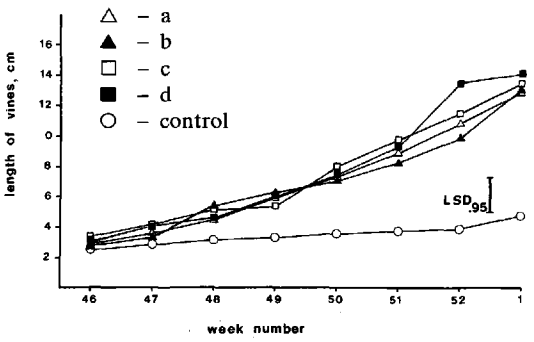

Fig. 3. *Hedera helix.* In exp. 2 artificial light is increasing the growth rate and is playing an important role in plant production.

they received red light just prior to the dark period (4). In *Hibiscus rosa-sinensis* the breaking and growth of sideshoots was not affected by the lighting regimes. The breaking of lateral sideshoots seems in this experiments only to depend on the amount of irradiance.

Schefflera arboricola

Schefflera is responding very well to artificial light probably because it has a very high ability of acclimatization to low light levels. The accilimatization period is very short and results in a low light compensation point (8).

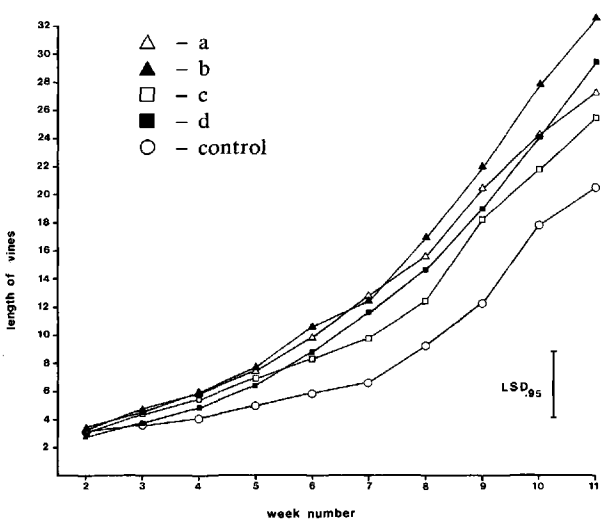

Fig. 4. *Hedera helix.* In exp. 3 there is a strong increase in the growth rate of the unlit control after week number 7.

Hedra helix

In exp. 1 the growth rate was nearly the same in the lighting regimes and the control (Fig. 2). But at the termination of the experiment there was a significant difference between the lighted and the unlighted plants. In this experiment there was a significant difference between regime c and a.

In exp. 2 the artificial light is dominating and the unlighted plants (control) are growing very slowly. There is no difference between the lighting regimes (Fig. 3).

Exp. 3 is very interesting because of the change in the growth rate of the plants. Until week number 7 the growth rate is analogous to the growth rate in exp. 2. After week 7 there is a strong increase in the growth rate in all regimes even in the unlit control (Fig. 4). This indicates that artificial light not any longer is a major factor in plant production. In this experiment there was a significant difference between regimes b and c.

The results from these experiments show that plant growth and development are unaffected by the lighting regime, if the duration of light is over a critical value. Changes in leaf area, dry matter content, and in the ratio between root and top have been found under very short duration of lighting (6, 10).

The results open up the opportunity to use electricity during the night time for lighting plants and at the same time heat an insulated greenhouse.

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