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PETIOLE LENGTH REACTION IN *HYOSCYAMUS NIGER* UPON DAYLENGTH EXTENSION WITH LIGHT OF NARROW SPECTRAL REGIONS AS CORRELATED WITH THE LENGTH OF THE BASIC LIGHT PERIOD, AND UPON NIGHT INTERRUPTION WITH RED AND INFRARED RADIATIONS

by

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1. INTRODUCTION

Some experiments are described which were part of a more extensive investigation on light effects in *Hyoscyamus niger*. The present paper is especially concerned with reactions of the petiole length to several combinations of basic and supplementary illuminations, and to night interruptions. Generally, a daily high intensity period was given in artificial, white light, supplemented by periods (or night interruptions) in light of narrow spectral regions, and low intensity.

2. MATERIAL AND METHODS

The plants used were of the annual strain of *Hyoscyamus niger*, var. *pallidus* which has been employed before in work of this laboratory (1, 2, 3, 4, 5). The seeds have originally been obtained from Professor A. LANG, Los Angeles, Cal., U.S.A.

The plants were raised in the greenhouse on a 9 hour day in natural light. During the experiments the plants were kept in the laboratory at controlled temperature and under artificial light. White light at an intensity of 11.000–15.000 ergs/cm^2 sec was obtained from a bench of 40 W-daylight fluorescent tubes. Different daylengths in this light were applied.

The coloured light was provided by the low light intensity equipment as described in (6) and (7), using the improved blue filter, mentioned in (2) and (3), transmitting no measurable trace of near infrared. The intensity applied was 1000 ergs/cm^{2}sec in each spectral region; the maxima were at 400 mμ (violet), 460 mμ (blue), 550 mμ (green), 590 mμ (yellow), 660 mμ (red), 760 mμ (near

32752

infrared). The temperature was 18–20°C during the white light period, 20 ± 1°C in the coloured light cabinets, and 17–18°C during the dark period.

Each treatment covered 4 plants.

3. Results and their discussion

In the first experiment the plants received 8, 11 or 14 hours white light of high intensity per day, supplemented with 4 hours coloured light of low intensity. The petioles were measured after 24 days; these data are given in Table 1 (columns headed A), and figure 1 (of also plate 1).

TABLE 1. Petiole length of *Hyoscyamus niger* after various durations of a basic daily illumination with white light (daylight fluorescent tubes), intensity 11.000–15.000 ergs/cm²sec., supplemented by 1000 ergs/cm²sec coloured light during 4 hours per day

Spectral region of supplementary light (4 h/day) \ Hours white light per day	8			11			14		
	A	B	C	A	B	C	A	B	C
Infrared	74	190	238	53	136	183	39	**100**	140
Red	33	165	106	23	115	80	20	**100**	72
Yellow	30	167	97	20	111	68	18	**100**	65
Green	29	160	93	23	128	80	18	**100**	65
Blue	31	148	100	27	128	92	21	**100**	75
Violet	33	150	106	27	123	92	22	**100**	79
Dark	31	110	**100**	29	104	**100**	28	**100**	**100**

A = petiole length as measured after 24 days, in mm.
B = relative petiole length in the 8 and 11 h. series with reference to the 14 h. series.
C = relative petiole length in the various spectral regions with reference to darkness.

In the 14 h. white light series the petioles were longest when the 4 h. supplementary irradiation was (near) infrared, next was the dark control (14 h. white light only). In the plants in which the supplementary light was any of the other

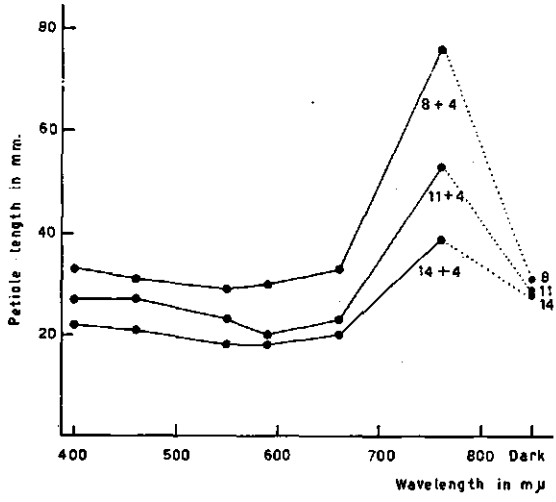

FIG. 1.
Petiole length of *Hyoscyamus niger* after various duration (8, 11 and 14 hours) of a basic daily illumination with white light (daylight fluorescent tubes), intensity 11.000–15.000 ergs/cm²-sec., supplemented by 1000 ergs/cm²sec. coloured light during 4 hours per day. Measured after 24 days

spectral regions tested, the petioles were about equally long, but shorter than in the dark control.

In the 11 h. white light series all petioles were somewhat longer than in the 14 h. series, and especially so with supplementary (near) infrared. The relations between the various spectral regions and darkness were the same as above.

Again the same remarks can be made about the 8 h. white light series. All petioles again are longer than in the previous series, and most so in (near) infrared. In this series the plants supplemented with light of the other spectral regions had petioles about as long as the dark controls.

Thus, in all colour supplement series the petioles are longer, the shorter the basic white light period has been. The differences are – at least absolutely – largest in the infrared.

There seems to be a tendency for petioles being slightly longer with violet and blue than with green, yellow, and red supplementary light.

It should be observed that in the 8 and 11 h. series only the (near) infrared supplementary irradiation ultimately led to stem elongation and flowering whereas in the 14 h. series this happened in all supplements including darkness. This stage was reached, however, only much later. It will not be discussed here, and was not yet obvious when the petiole measurements were made.

A clearer idea of the effect of white light daylength and that of coloured supplement may be obtained from columns B and C in Table 1. The data of columns B have been computed in putting the A-data in the 14 h. series all equal to 100, those of the columns C by putting the A data in all dark controls = 100. Thus, the data of the B columns represent the white daylength effects and those of columns C the spectral region effects.

Considering columns B, it is clear that white daylength abbreviation increases the petiole lengths also in a relative measure, and, in each daylength much the same so for all coloured supplements with the exception of the (near) infrared. The latter produced a distinctly stronger elongation.

Considering columns C, it is shown that for 14 and 11 hours the relative petiole length is distinctly reduced for all spectral regions except (near) infrared, in which a distinct elongation is observed. The percentage reduction in the visible colour extensions is slightly smaller in the 11 h. series than in the 14 h. series, while the increase in infrared is larger, and much more definitely so. In the 8 h. series, the relative petiole length is about the same for all visible colour supplements as with dark supplement, but much greater for infrared supplement. In this way, the excessive position of the near infrared, with respect both to the relevant dark control and to the white daylength is brought out clearly.

Similar, but less regular results were obtained in a second experiment in which only red and infrared were given supplementary, aside of darkness (basic white light only). These results are given in Table 2.

It should be mentioned that the computed infrared values in columns B and C (*cf.* above) are more nearly the same as in Table 1, so that the relative effects of daylength and of coloured supplement are about equal in magnitude for this spectral region. There seems no obvious reason why these effects should be equal, and their relative magnitude may well vary in different experiments, according to conditions still unknown. The main deviation between Table 1 and 2 is that in Table 1 the B values for the 11 and 8 h. series are all definitely higher with all coloured supplements than for dark supplement (last horizontal

line). In Table 2 this does not seem so, on the contrary there the dark B-values are about the same height as the infrared ones while the red values appear strongly suppressed. In general, however, this does not disturb the overall picture. (It should be definitely stressed that such apparent differences in the general reaction level often occur. They may be due to slight differences in the physiological structure of the plants in successive experiments owing to the fact that especially during the initial greenhouse period, conditions can not be rigorously controlled).

TABLE 2. Same legend as Table 1, but 2 h. supplementary light per day, measured after 20 days.

	8			11			14		
	A	B	C	A	B	C	A	B	C
Infrared	58	170	166	47	138	138	34	**100**	148
Red	25	108	72	27	117	79	23	**100**	100
Dark	35	152	**100**	34	148	**100**	23	**100**	**100**

In addition to this, Mr. DE LINT remarks that these results deviate from his figures on internode inhibition in *Cosmos bipinnatus*. In his experiment supplementary radiation in red and yellow light produced slight internode inhibition but in green, blue and violet no change in length could be detected as compared with darkness (personal comm., see also [3]).

It should be observed that in *Cosmos* the effect of duration of the basic light period on internode elongation as a result of supplementary light has not yet been studied.

It is, of course, tempting to qualify the elongating effect of the shorter basic light period as an expression of "etiolation". In this terminology, it then would be appropriate to state that the etiolating effect of (near) infrared supplement is stronger than that of darkness. One may do so but it does not contribute to a better understanding of the underlying phenomena.

In a third experiment an attempt was made to see whether anything could be observed of a red-infrared antagonism when using night breaks. The basic white light period was 8 h./day, supplied by the same light source as used above. The night break was given by the same sources of coloured light at the same,

TABLE 3. Petiole length of *Hyoscyamus niger* after various night interruptions. Basic illumination 8 hours per day (daylight fluorescent tubes), intensity 11.000–15.000 ergs/cm²sec. Night interruption with red and (near) infrared radiations of indicated duration, intensity 1000 ergs/cm²sec

Night interruptions		Petiole length (mm) after 23 days
Red (minutes)	Near infrared (minutes)	
15	–	28
30	–	29
60	–	28
15	30	50
30	30	43
60	30	38
–	30	52
–	–	38

fairly low intensity of ~1000 ergs/cm²sec. The interruption of the dark period was given between 45 minutes before and 45 minutes after the middle of the dark period. Red light expositions of 15, 30, and 60 minutes were or were not followed by 30 minutes of (near) infrared. Controls received either continuous darkness or an infrared interruption alone.

Obviously, the amounts of red light energy given in this way were not sufficient to induce stem elongation or flowering as was observed by DOWNS (8). After 70 days, stem elongation could nowhere be noticed. But petiole elongation had definitely reacted, aheady aerlier and, moreover clearly demonstrated a red-infrared antagonism.

Figure 2 illustrates the situation, after 23 days. In all red treatments alone (15, 30, and 60 minutes) the petioles reached about the same length. They were definitely shorter than those receiving uninterrupted darkness. Infrared (30 minutes) supplied subsequent to red made the petiole length increase to the value reached in uninterrupted darkness, or to an even higher value. A definite relationship with the duration of the preceding red treatment is obvious. Infrared applied alone yields a greater petiole length than continuous darkness. About the same value as in dark is reached when the infrared treatment is preceded by 15 minutes red. As already remarked, longer preceding red radiations are less fully compensated by the subsequent application of infrared for 30 minutes (so also Table 3, and Plate 2).

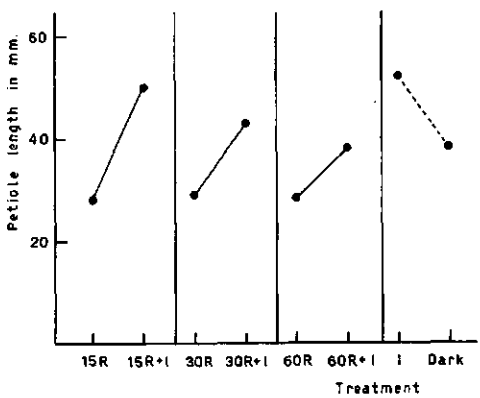

FIG. 2.
Petiole length of *Hyoscyamus niger* after various night interruptions. Basic illumination 8 hours per day (daylight fluorescent tubes), intensity 11.000–15.000 ergs/cm²sec. Night interruptions with red and (near) infrared radiations of indicated duration, intensity 1000 ergs/cm²sec.
(R = minutes red light, I = 30 min (near) infrared).

4. SUMMARY

The petiole lengths of *Hyoscyamus niger* plants were measured after about 20 days of specific light treatments. Three different durations of the basic white light period (8, 11, 14 hours) were supplemented with 4 h. low light intensity radiation in several spectral regions with a dark control.

The petiole length reached was dependent both on the duration of the basic light period and on the quality of the supplementary light. The petioles were longer in as much as the basic light period was shorter. The regions violet to red inclusive of supplementary radiation all caused only relatively slight reactions, *viz.*, some decrease in petiole length (as compared with darkness) in the 11 and 14 h. series, and virtually no change in the 8 h. series. The infrared supplement, however, always caused a strong elongation, and (in percents) progressively so in as much as the basic light period was shorter.

Low intensity red light interruptions in the middle of the dark period decreased the ultimate petiole length; this effect was subject to a red-infrared antagonism, whereas with a brief supply of infrared alone, and with excess compensatory infrared, petioles grow longer than in uninterrupted darkness.

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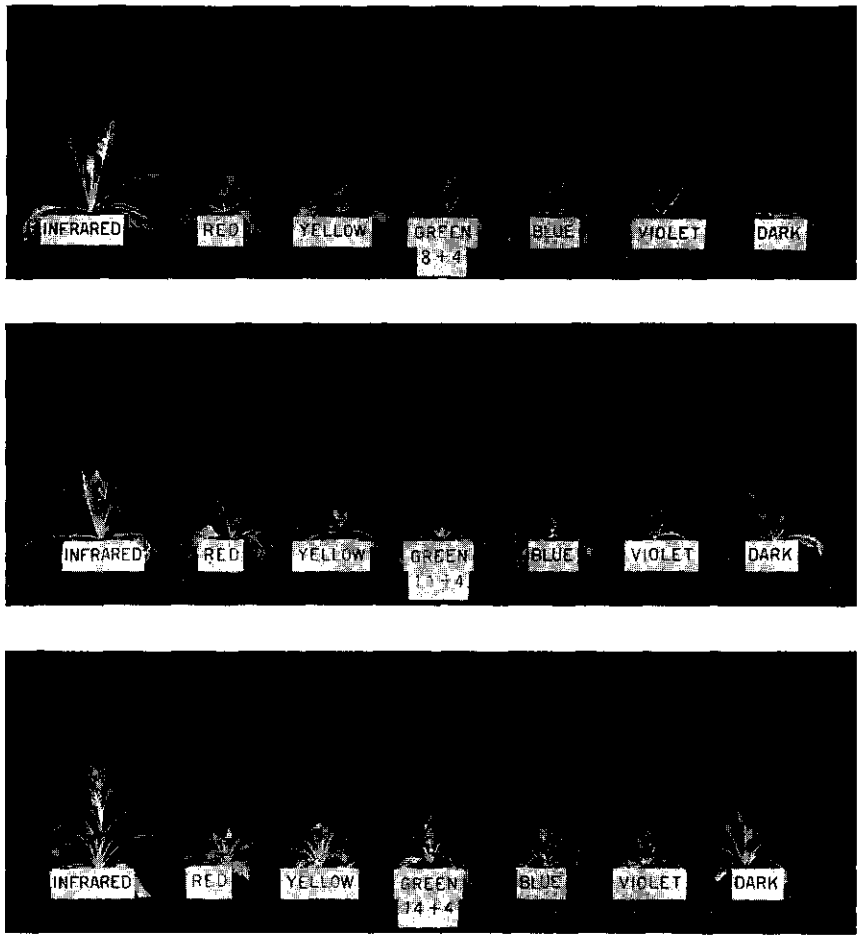

PLATE 1. *Hyoscyamus niger*. Effects of basic illumination, 8, 11 or 14 hours per day, with white light (daylight fluorescent tubes), intensity 11.000–15.000 ergs/cm²sec. in combination with supplementary irradiation in coloured light during 4 hours per day, intensity 1000 ergs/cm²sec. Photographed after 31 days, at 12.4.'57.

PLATE 2. *Hyoscyamus niger*. Effect of basic illumination with white light (daylight fluorescent tubes), 8 hours per day, intensity 11.000–15.000 ergs/cm²sec. and night interruptions with red (60, 30, 15 and 0 minutes) and (near) infrared irradiations at an intensity of 1000 ergs/cm²sec. (+ = 30 minutes (near) infrared). Photographed after 73 days, at 2.8.'57.