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STEM FORMATION IN *HYOSCYAMUS NIGER* UNDER SHORT DAYS INCLUDING SUPPLEMENTARY IRRADIATION WITH NEAR INFRARED

by

P. J. A. L. DE LINT

Laboratory of Plant Physiological Research, Agricultural University, Wageningen, Netherlands, 186th Communication

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1. INTRODUCTION

Some years ago, WASSINK and STOLWIJK (10), in discussing effects of light quality on plant growth, have made the statement that the term "critical daylength" is to a high degree senseless in view of recent photoperiodicity research. According to their opinion, the idea that the critical daylength is a rather fixed property for a special plant, is no more in agreement with the continually growing pile of experimental evidence.

Factually, the critical daylength has been reported to depend on *e.g.* temperature (12), chemicals (4), sugar supply (5), and very strongly on the light regime. The disturbing capacity of different light treatments upon daylength reactions may be mainly due to two principally different qualities of light, *viz.* irradiation pattern and composition. Each of these two can be sub-divided into three possibilities, as follows:

A. Pattern: 1. Ratio daylength/nightlength. Almost immediately from the beginning of daylength experimentation the influence of the relation day/night length has been studied. Again recently BLANEY and HAMNER (1) have reported a large series of results on this topic.

2. Night interruption. Already in 1943 HARDER and BODE (3) have demonstrated that it was possible to change the daylength dependence of plants by supplying short light periods of sufficient intensity at about the middle of a too long night; since then many more results have been reported on this phenoenon.

3. Light intensity. Also of highest interest seems to be the light intensity during the day. The results reported by DE ZEEUW (13) for instance are an example of this feature.

B. Composition: 1. The wavelength region with which the night interruption has been given has turned out to be of primary importance. Much work in this field was reported by HENDRICKS, BORTHWICK, *et al.* Some figures reporting the reaction in *Hyoscyamus* to different coloured night breaks are published by STOLWIJK and ZEEVAART (7).

2. Equally important seems to be the quality of light following a day as supplementary irradiation.

Furthermore, it seems to be more or less important whether this supplementary radiation is given at higher or lower intensities. Results about strong supplementary radiation are from BORTHWICK *et al.* (2) with respect to the reaction of the short-day plant *Xanthium pensylvanicum*. Weak supplementary radiation has been studied by STOLWIJK (6) and recently by WASSINK *c.s.* (8).

3. Finally, the colour of the main light period seems to be important. This possibility has been the object of experiments reported by STOLWIJK and ZEEVAART (7) on the reaction of *Hyoscyamus niger*.

For the short-day plant *Xanthium pensylvanicum*, BORTHWICK *et.al.* (2) have demonstrated that this plant can be brought to flower in too long days, as compared with white light treatment under the same conditions, by supplying half an hour of near infrared at the end of a white day. Also the reverse phenomenon could be observed by the same authors, *i.e.* vegetative growth in short enough a day for flowering if the last half hour of this day (in white light) was composed of the wavelength band in the red region only.

STOLWIJK and ZEEVAART (7) have reported about vegetative growth of the long-day plant *Hyoscyamus niger* in 10-hour days of white light (25,000 ergs/sec. cm^2, daylight fluorescent light), extended with 4 or 8 hours of red radiation at 1000 ergs/sec.cm^2 intensity, and also in 24 hours/day red radiation of high intensity (18,800 ergs/sec. cm^2 ø sphere).

In this report figures will be presented showing that stem formation[2]) in *Hyoscyamus niger* may happen in short days, which feature was up to now, as far as we know, the missing one of the four possibilities of coloured-light-induced surpassing of the more or less fixed critical daylength limits. These 4 possibilities being:

short-day plants	vegetative	in short day
short-day plants	flowering	in long day
long-day plants	vegetative	in long day
long-day plants	flowering	in short day

It must be clear from this that it is gradually growing more difficult to formulate the exact meaning of the term "critical daylength" in describing photoperiodic results from experiments dealing with the effects of special light treatments and treatments with special light colours.

2. MATERIAL AND METHODS

An annual strain of *Hyoscyamus niger* var. *pallidus*[1]) was used throughout this investigation (see also STOLWIJK and ZEEVAART [7]). The plants had developed more than 20 leaves before they were used in the experiments. Up to the start

[1]) The first seeds of this strain were obtained from DR A. LANG, Los Angeles.
[2]) (Introducing flowering)

of the experiment they were kept in 9-hour days, in a greenhouse. Each treatment was applied to 4 plants.

The radiation equipment in which the plants were treated with light of restricted spectral regions has been described earlier (6, 9). The maxima of radiation in the different wavelength bands are as follows: 400 mμ (violet), 460 mμ (blue), 550 mμ (green), 590 mμ (yellow), 660 mμ (red), 760 mμ (near infrared), and darkness as a control. All colours were set at the same intensity of 1000 ergs/sec.cm^2. Photosynthetic light was supplied by white (daylight) fluorescent tubes, at an intensity of 11,000–15,000 ergs/sec. cm^2.

3. Description and discussion of results

Hyoscyamus plants selected for uniformity were subjected to three daylengths of strong white irradiation, *viz*, 8, 11, and 14 hours. The white radiation was immediately followed by a series of radiations in coloured light during 4 hours. The supplementary regions used were: violet, blue, green, yellow, red, near infrared, and dark. The results on the leaf petiole elongation reaction in the different supplements of this experiment recently have been published by Wassink and Sytsema (11). The leaf petiole results are quite equal to the stem formation observations.

The results on stem elongation (always resulting in flower bud initiation) are presented in Table 1. Representative plants from the shortest day treatment are presented in figure 1.

TABLE 1. *Hyoscyamus niger*. Stem formation as influenced by daylength (14, 11 and 8 hours) in artificial white (daylight fluorescent) light (intensity 11,000–15,000 ergs/sec. cm^2) in combination with 4 hours supplementary radiation of narrow wave length bands (as indicated) at 1000 ergs/sec. cm^2 intensities (+ is stem formation; — is rosette state). Observation after 69 days of treatment.

Hours in white + colours	Supplementary radiation						
	near infrared	red	yellow	green	blue	violet	dark
14 + 4	+	+	+	+	+	+	+
11 + 4	+	—	—	—	—	—	—
8 + 4	+	—	—	—	—	—	—

From Table 1 it can be seen that all plants in the 14-hours white light series have produced stems (+). The plants of the near infrared group were ahead of all others, while the red and violet groups were the slowest ones.

In the series with 11 and 8 hours of white light, only the near infrared sets of plants showed stem elongation.

These observations can be summarised in the statement that in near infrared radiation stem formation happens easily.

However, the shortest treatment is still 8 + 4, being 12 hours, which is above "critical". So a treatment had to be tried in which a total radiation period of 11 hours per day was not surpassed. This was done in the experiment presented next; the shortest treatment in this series consisting of 8 hours of strong white light immediately followed by 2 hours of low intensity near infrared radiation. As is obvious from Table 2, this treatment really produces stem formation, indicating a break through the "critical" daylength requirement for stem production of the long-day plant *Hyoscyamus niger* (fig. 2).

TABLE 2. *Hyoscyamus niger*. Stem formation as influenced by radiation combinations of 8 hours strong white fluorescent light (intensity 11,000–15,000 ergs/sec. cm² of "daylight" type tubes) followed by 0, 2, 4, 6, or 8 hours red (660 mμ) radiation and 0, 2, or 8 hours of near infrared (760 mμ) at 1000 ergs/sec. cm² intensities. The plus numbers, last column, elongated within 50 days from the beginning of the experiment, which was ended after 78 days.

Hours per day of radiation					Stem formation
white		red		near infrared	
8	+	0	+	0	—
8	+	0	+	2	+ [1])
8	+	2	+	2	+
8	+	4	+	2	+
8	+	6	+	2	+
8	+	8	+	2	+
8	+	8	+	0	—
8	+	0	+	8	+

This experiment was arranged to test a broad range of daylengths, together with the necessary controls. All sets of plants obtained 8 hours of strong white light (for photosynthesis); one set getting these 8 hours only (0 + 0, fig. 2). For the others, the white day was supplemented with a series of weak red irradiations (0, 2, 4, 6, and 8 hours) to obtain a series of daylengths. One set of plants receiving 8 hours supplementary red got only darkness for the remaining 8 hours of the day (8 + 0). The others were, immediately after the red, irradiated for 2 hours with near infrared (0 + 2, 2 + 2, 4 + 2, 6 + 2, and 8 + 2). One set was treated each day with the sequence: 8 hours white, 8 hours near infrared and 8 hours darkness (0 + 8). All these indications refer to fig. 2.

All plants receiving near infrared, be it 8 or 2 hours, were bringing out stems. In the treatments without near infrared at the end of the daily radiation period all plants were strictly in the rosette state.

The data from this experiment are in agreement with all results obtained in this laboratory with *Hyoscyamus niger*, and earlier work. First of all it could be confirmed that this long-day plant is not able to form a stem in a short day in white light. Secondly, it must be mentioned that the observation by STOLWIJK and ZEEVAART (7) could be repeated, *viz.*, that in the long-day treatment of 8 hours white light plus 8 hours red radiation rosettes are produced. In the third place, the results of the first experiment described in this paper, that *Hyoscyamus* can raise stems if 4 hours of near infrared follow directly after white light radiations of 8, 11, or 14 hours, is confirmed in this series.

It seems, that a few hours of near infrared radiation following a white day in *Hyoscyamus* plants generate the possibility to produce stems in daylengths in which white light only does not allow elongation. This statement then leads to the further supposition that near infrared and blue radiations, at least for one effect in *Hyoscyamus*, act differently, because (contrary to near infrared) a short-day blue treatment is not allowing stem formation, according to STOLWIJK and ZEEVAART's data. It should be stated, however, that in their experiments leaf petioles were strongly elongated in the short-day blue treatment.

[1]) The long-day reaction upon this short-day treatment can be reversed by short red night interruptions, as normally observed in short-day plants (added in proof, communication in preparation).

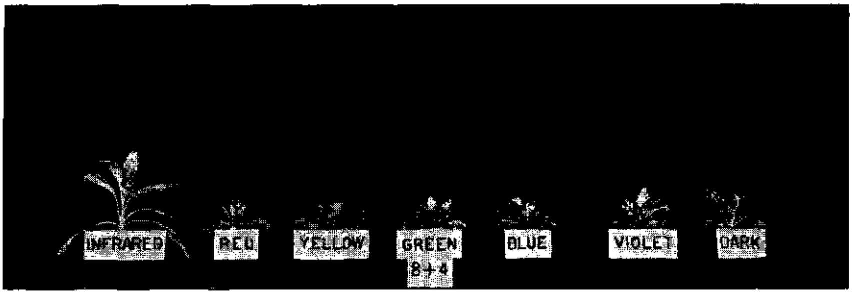

FIGURE 1. *Hyoscyamus niger.* Stem formation under 8 hours white fluorescent light followed by 4 hours low intensity coloured light (1000 ergs/sec. cm^2). (From ref. 11).

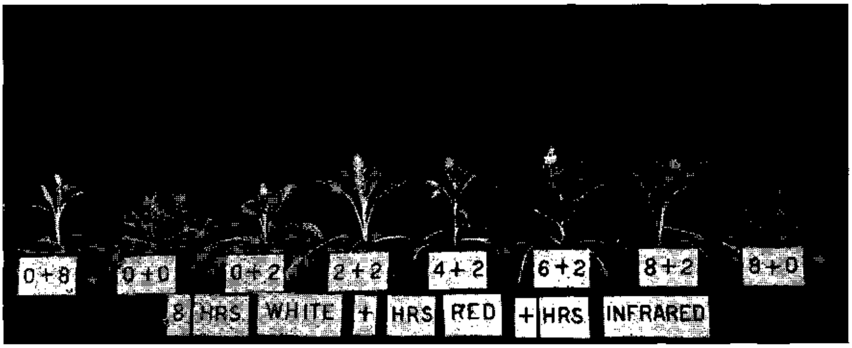

FIGURE 2. *Hyoscyamus niger.* Stem formation as influenced by radiation combinations of 8 hours strong white fluorescent light (intensity 11,000–15,000 ergs/sec. cm^2, of "daylight" tubes) followed by 0, 2, 4, 6, or 8 hours red radiation and 0, 2, or 8 hours of near infrared at 1000 ergs/sec. cm^2 intensities. Photographed at 11-12-1957, after 56 days of treatment.

4. SUMMARY

Results are presented, demonstrating stem formation in the long-day plant *Hyoscyamus niger* under short-day conditions.

Irrespective of daylength stem elongation was observable if 2, or more, hours of near infrared radiation were the last light treatment before night darkness.

Now examples are available showing the uselessness of the term "critical daylength" both for long-day and short-day plants when coloured light effects are considered. It is shown that both can be brought to flower in their inhibitive daylengths and kept vegetative in days allowing flowering under normal-white light conditions.

Other results will be published soon in a more extensive paper.

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