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# INFLUENCE OF LIGHT ON THE ELONGATION OF GHERKIN SEEDLINGS

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## INTRODUCTION

It has been reported that plants grown in red and green light show a marked elongation, whereas the blue-violet part of the spectrum has an inhibiting effect on internode length (WASSINK *e.a.*, 1956, review). STOLWIJK (1954) and VINCE (1956), however, described experiments in which it was shown that blue light has also an elongating effect.

It has been found that a contamination of the blue light with near infra-red irradiation ($\lambda > 7000$ Å)—emitted by the blue fluorescent lamp and transmitted by the filter—has a promotive effect on the elongation of internodes as compared with plants treated with pure blue light (WASSINK *e.a.*, 1957, MEIJER 1957). So it seems plausible that the elongating effect of blue light must be ascribed to the use of blue filters which also transmit near infra-red.

The elongating effect of near infra-red irradiation has already been reported by ROODENBURG (1940) and was confirmed by WASSINK *e.a.* (1950).

HENDRICKS *e.a.* (1956) and DOWNS *e.a.* (1957) have shown that the effect of an irradiation with near infra-red can be reversed by a succeeding exposure to red light. This antagonism between red and near infra-red has been found to regulate other photochemical reactions in plants also.

As for unfiltered blue fluorescent light only an inhibiting effect has been reported it may be concluded that in this "blue light" the presence of light of the red part of the spectrum counteracts the near infra-red. By filtering out only the green and red part of the blue fluorescent light the near infra-red can become effective.

In this preliminary paper experiments are described which make it clear that blue light without a contamination of near infra-red can have an elongating or an inhibiting effect, depending on the pretreatment of the plants.

## METHODS AND MATERIALS

The experiments were carried out in plant growth cabinets under the exclusion of daylight. Light of three different spectral regions was used: red, green and blue light. The characteristics of this light have been given before (MEIJER 1957). "White light" was obtained from white fluorescent lamps ("TL" 33). The light intensities were measured with a calibrated photocell.

*Cucumis sativus* (gherkin, "Venlose niet plekkers") was used in all experiments. The length of the hypocotyl was measured from the soil surface up to the insertion of the cotyledons.

Light grown plants are sown under continuous fluorescent light ("TL" 33) at a temperature of about 28° C. Four days after sowing the seedlings are potted and the next day the plants are subjected to the treatment. At that moment the length of the hypocotyl from the soil surface to the cotyledons is about 10 mm.

Dark grown plants are sown in a dark room, at a temperature of about 25° C. After some days they are selected for the same length and treated immediately afterwards.

## Experimental results

### a. *Plants germinated in white light*

In table I the results are given of an experiment with seedlings germinated in white light and afterwards grown in red green and blue light. The plants were irradiated 16 hrs per day with an intensity of 600 $\mu W/cm^2$. During the treatment the day temperature was maintained at 22° C, the night temperature at 17° C. Thirty days after the beginning of the treatment the length of the hypocotyls and of the internodes was measured. In all plants the first leaf is always inserted immediately above the cotyledons; therefore the first internode (epicotyl) has no measurable length.

As can be seen from Table I no difference in length exists between the hypocotyl and the fully grown internodes of plants irradiated with red and green light. The younger internodes develop more quickly in red light; therefore their length should not be compared with the same internodes of plants in green light. Whereas the length of the hypocotyl at the start of the treatment was about 10 mm, it doubles its length in red or green light. In blue light however elongation takes place to a much greater extent; especially the hypocotyl seems to be very sensitive.

TABLE I

The influence of red, green and blue light on the elongation of gherkins, germinated in white light. Irradiation time: 16 hrs per day. Light intensity 600 $\mu W/cm^2$. Measurements after 30 days of treatment.

Internode length in mm.

| Spectral region | hyp. | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
|---|---|---|---|---|---|---|---|---|
| red | 26 | — | 8 | 9 | 19 | 57 | 35 | 22 |
| green | 25 | — | 11 | 9 | 14 | 35 | 14 | 5 |
| blue | 105 | — | 33 | 28 | 25 | 7 | 1 | — |

Another difference is shown by the cotyledons; in red and green light a much greater size is reached than in blue light.

The question arose whether red and green light have an inhibiting effect and blue light is ineffective in this respect or whether on the contrary red and green light are ineffective and the blue light has an elongating effect.

If plants of the same group as used in Table I were placed in darkness instead of coloured light, the hypocotyl of these plants after some days reached about the same length as plants placed in red or green light. One might have expected a stronger elongation in darkness. Further development of other internodes was of course limited by lack of photosynthesis.

After treating plants with 8 hrs red light per day with and without a daily supplemental irradiation for another 8 hrs with blue light it was found that blue light has a promotive effect on the elongation. The results of such an experiment with three different intensities of blue light are given in Fig. 1. The 8 hrs of blue supplemental light were given after the 8 hrs of red light. The temperature during the red irradiation and the following 8 hrs blue light (or darkness) was maintained at 22° C, the temperature of the remaining 8 hrs darkness was kept 17° C. The intensity of the red light was 600 $\mu W/cm^2$ and of the blue light 0, 60, 300 and 600 $\mu W/cm^2$ respectively.

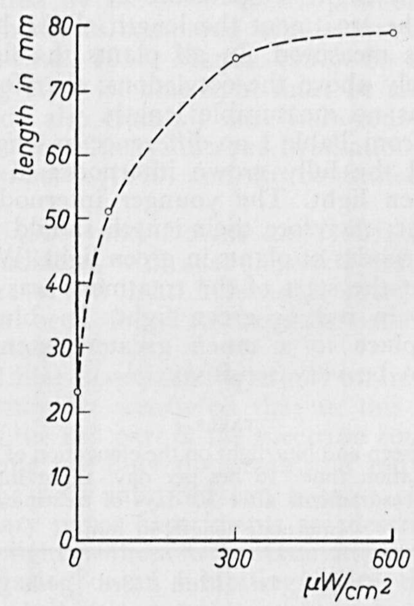


Fig. 1. Length of gherkin hypocotyls (germinated in white light) grown in 8 hrs red light per day followed by a supplemental irradiation of 8 hrs blue light, of different intensities, 7 days after the beginning of the treatment. Abscissa: intensity of the supplemental blue light in $\mu W/cm^2$. Ordinate: length in mm.

It is clear that a supplemental irradiation of low light intensity is already very effective.

These results do not exclude, however, the existence of a possible inhibiting effect of red and green light.

b. *Plants not germinated in white light*

When gherkin plants are germinated in darkness, instead of in white light, the effect of a daily irradiation with 16 hrs red green or blue light is completely different. Whereas the hypocotyls of seedlings completely grown in darkness obtained a length of about 200 mm it is obvious from the results in fig. 2*a*, that blue and red light have an inhibiting effect on the elongation of dark grown seedlings; on light grown plants blue light has on the contrary an elongating effect.

The difference in behaviour to red and blue light between light grown and dark grown plants is clearly demonstrated in the following experiment.

Gherkins were germinated in darkness and when the length of the hypocotyls was about 25–30 mm plants were selected for the same length. After an irradiation with white light (1500 $\mu$W/cm$^2$) of 0, 4, 8, 16 and 32 hrs the seedlings were irradiated with blue and red light, 16 hrs per day. The intensity of the blue and red irradiation was 310 $\mu$W/cm$^2$. The length of the hypocotyl was measured daily during the treatment. After 9 days the experiment was discontinued. The temperature during the light period was 25° C, during the dark period 22° C. The results are collected in fig. 2.

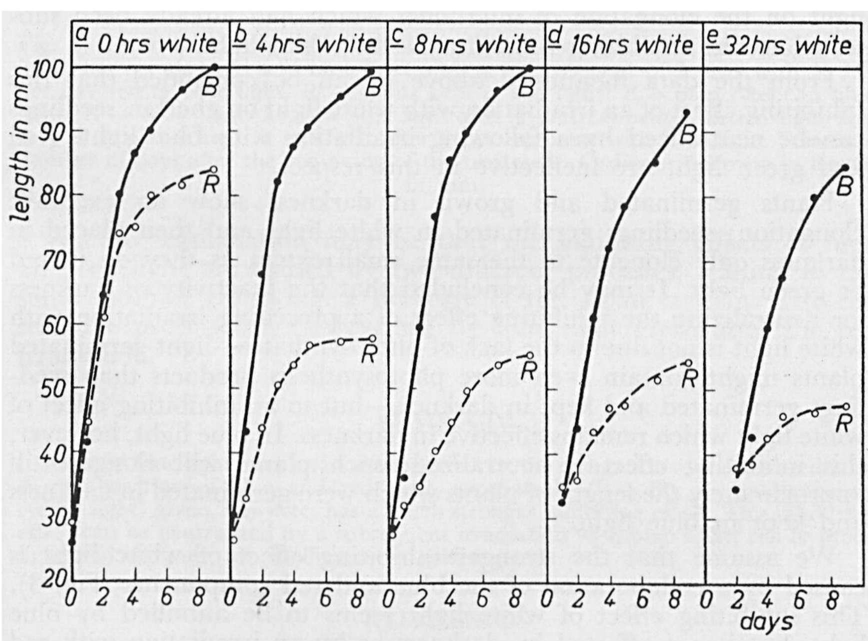


Fig. 2. Length of gherkin hypocotyls (germinated in darkness) grown in 16 hrs per day blue (B) or red light (R), after a pretreatment of 0, 4, 8, 16 and 32 hrs of white light. Abscissa: number of days after the beginning of the pretreatment. Ordinate: length in mm.

As can be seen the elongation of the hypocotyls of plants pretreated with 4 and 8 hrs of white light (fig. 2*b* and *c*) is in blue light just the same as the elongation of seedlings without a pre-irradiation with white light (fig. 2*a*).

When, however, plants were irradiated with red light, a preceding irradiation with white light during 4 hrs had already a strong inhibiting effect.

In other experiments plants germinated in darkness were irradiated during 2 days with 16 hrs blue or red light per day. After this pretreatment one part of the plants in blue and red light was left in blue (B) and red light (R) respectively; the other part of each group was placed in red (B $\rightarrow$ R) and blue light (R $\rightarrow$ B) respectively and irradiated 16 hrs per day. The intensity of the red and blue light was 310 $\mu W/cm^2$. During the light period the temperature was 25° C, during the dark period 22° C. The increase in length during the treatment is given in Fig. 3. It is obvious that the inhibiting effect of red light increases by a preceding irradiation with blue light.

## Discussion

In several investigations about the influence of light of different spectral regions on the elongation of internodes, plants have been used which had been grown in white light before the experiments started. This means that one has investigated the effect of coloured light on the elongation of internodes which had already been subjected to the inhibiting influence of the white light.

From the data mentioned above it can be concluded that this inhibiting effect of an irradiation with white light on gherkin seedlings can be neutralized by a following irradiation with blue light. Red and green light are ineffective in this respect.

Plants germinated and grown in darkness show an excessive elongation; seedlings germinated in white light and then placed in darkness only elongate to the same small extent as they do in red or green light. It may be concluded that the inactivity of darkness for neutralizing the inhibiting effect of a preceding irradiation with white light is not due to the lack of photosynthates—light germinated plants might contain even more photosynthesis products than seedlings germinated and kept in darkness—but to an inhibiting effect of white light which remains effective in darkness. In blue light, however, this inhibiting effect is neutralized; such plants will elongate till approximately the length of plants which were germinated in darkness and kept in blue light.

We assume that the stronger inhibiting effect of white light is caused by a collaboration of the blue and red components (Fig. 3). This inhibiting effect of white light seems to be annulled by blue light, but is not affected by darkness or by an irradiation with red or green light. This might be explained by the hypothesis that in blue light a precursor is formed which is transformed into an inhibitor by red irradiation, given simultaneously with (white light) or successively (Fig. 3) to the blue irradiation. This inhibitor might be inactivated by blue light.

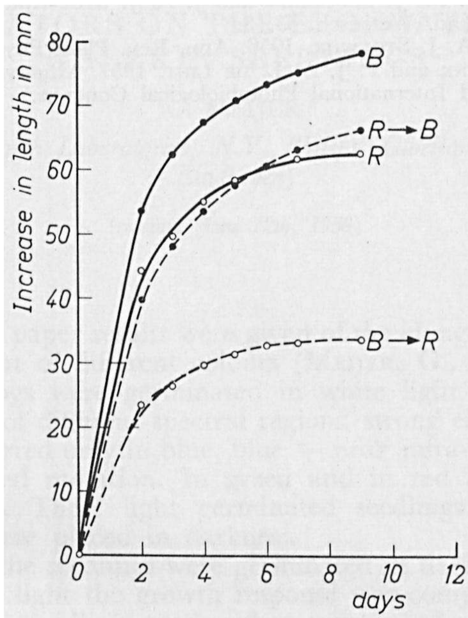


Fig. 3. Increase in length of gherkin hypocotyls (germinated in darkness) grown in 16 hrs per day red and blue light after a pretreatment of 2 days with 16 hrs per day red or blue light. R = plants kept in red light; B = plants kept in blue light; R → B = plants kept in blue light after a pretreatment with red light and B → R = plants kept in red light after a pretreatment with blue light. Abscissa: number of days after the beginning of the treatment. Ordinate: increase in length in mm.

Another explanation may be that the inhibiting effects of blue and red light are caused by two different processes, leading to the same ultimate result e.g. a decrease of the auxin content. The red sensitive process can be reversed by blue light given after the red irradiation.

## SUMMARY

Red and blue light have an inhibiting effect on the elongation of gherkin seedlings. A collaboration of blue and red light, successively (B → R) or simultaneously (white light) given, however, has a much stronger inhibiting effect. This inhibiting effect can be neutralized by a subsequent irradiation with blue light; red or green light and darkness are ineffective in this respect.

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