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THE INFLUENCE OF LIGHT AND OF GROWTH REGULATORS ON THE ELONGATION OF GHERKIN SEEDLINGS

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Introduction

In a previous paper results were given of the elongation of gherkin seedlings in light of different colours (Meijer, G., 1958).

If the seedlings were germinated in white light and afterwards placed in light of different spectral regions, strong elongation of the hypocotyls occurred only in blue, blue + near infra-red or in green + near infra-red radiation. In green and in red light the plants remained short. These light germinated seedlings also remained short if they were placed in darkness.

If, however, the seedlings were germinated in darkness or directly in the coloured light the growth response was completely different. In darkness the seedlings produced an extremely long hypocotyl; all colours including near infra-red caused an inhibition of this elongation. It was found that a combination of blue and red light, whether given simultaneously ("white light") or red light after an exposure to blue light, had a much stronger inhibiting effect than each of the two components separately or blue light after an exposure to red. These results are schematically given in Fig. 1.

It was suspected that the elongation of light germinated plants in blue or in green + infra-red might be caused by an increase of the auxin activity.

In this paper experiments are described about the influence of growth regulators on the elongation of gherkin seedlings in light of different spectral regions.

Methods and material

The conditions in which the experiments were carried out are the same as described before (Meijer, G., 1958).

As growth regulators were used tryptophan, tryptamine, tryptophol (= indole-aethanol), indole-pyruvic acid, indole-acetic acid (IAA), indole-aldehyde, indole-carboxylic acid and penta-chloro-phenoxy-acetic acid. All substances were applied to the plants in a lanolin paste.

Experimental data

The first indication that near infra-red radiation increased the auxin activity was observed with young tomato plants ("Victory").

When such plants, grown in white light, were transferred to green + infra-red, a strong epinastic curvature of the leaves occurred within a few hours and lasted for about 48 hrs. This epinasty was of exactly the same type as obtained by spraying the plants with an aqueous IAA solution. Quantitatively the degree of curvature after

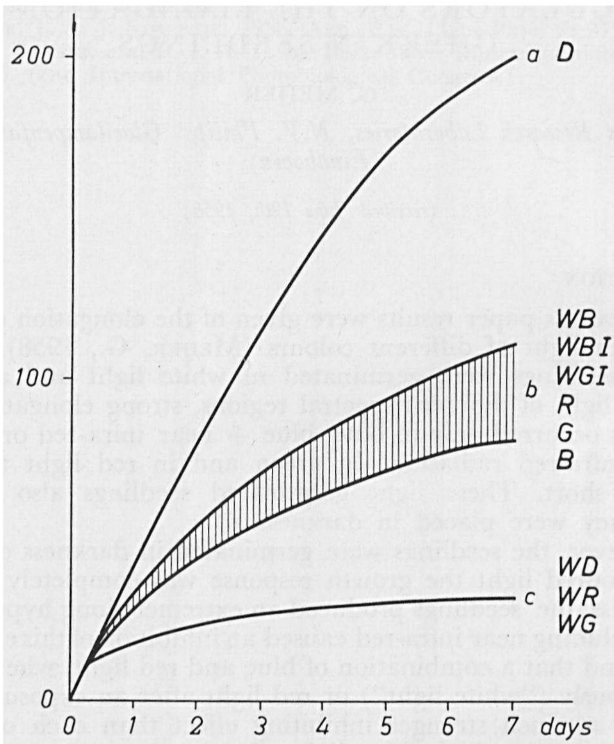

Fig. 1. Scheme of the growth response of the hypocotyl of gherkin seedlings to coloured light. *a:* plants germinated and grown in darkness (D); *b:* plants germinated in white light and afterwards grown in blue (WB), blue + infra-red (WBI) or green + infra-red (WGI), or germinated and grown in red (R), green (G) or blue light (B); *c:* plants germinated in white light and afterwards grown in darkness (WD), red (WR) or green (WG) light. Ordinate: length in mm. Abscissa: number of days.

24 hrs of green + infra-red was as strong as the maximal curvature occurring in plants grown in white light and sprayed with 40 ppm IAA (Fig. 2).

In blue light only a slight epinasty was found, in green or red light no epinasty occurred at all.

The epinasty in green + infra-red was followed by a strong elongation of the internodes. This elongation as well as the epinasty could be antagonized by an application of anti-auxins. In our experiments penta-chloro-phenoxy-acetic acid (PPA) and coumarin were used as anti-auxins (Fig. 2).

Another phenomenon observed was the phototropic curvature of light grown gherkin seedlings in green + infra-red radiation. In green light no phototropism occurred at all. Dark grown seedlings on the other hand show a phototropic curvature in green light. After a pretreatment of dark grown seedlings with red or green light only a slight phototropic curvature was obtained in green light; after a pretreatment with blue light the response was much stronger. If a pretreatment of red followed by blue light was given, the phototropic curvature in green light increased; after a pretreatment of blue followed by red light hardly any phototropic curvature was obtained when the plants afterwards were exposed to green light.

After these results experiments were carried out with and without an application of growth regulators.

IAA when applied in a lanolin paste to the cotyledons of light grown seedlings caused a stimulating effect on the elongation of the hypocotyl in red light. In blue light, however, hardly any extra elongation could be obtained by an IAA treatment (Table 1).

TABLE 1

Length in mm of the hypocotyls of light grown seedlings in different spectra regions treated with 0.1 % of IAA and tryptophol in lanolin paste, after 7 days

light treatment 16 hrs per day	red	blue	green + infra-red
control	25	79	84
IAA	37	82	88
tryptophol	85	105	98

Fig. 3 shows an optimum curve for different concentrations of IAA in lanolin applied to the upper surface of the cotyledons of light germinated plants in red. It seems that 0.003 % or 0.01 % causes the strongest elongation of light grown plants in red light. Strong epinasty of the cotyledons was obvious with all concentrations used. Although a fairly strong elongation was found, the IAA treated plants never reached the height of light germinated plants in blue light.

The precursors of IAA gave better results than IAA itself. Even tryptophol which usually is considered to have very weak or no auxin properties at all and might not be a precursor of IAA (MELCHIOR, 1957), gave a very strong elongating reaction of the seedlings in red (Fig. 3). Tryptamine and indole-pyruvic acid both showed a reaction like tryptophol.

There were two striking differences between the effects of IAA and tryptophol: 1st at the optimal concentration of tryptophol the plants in red reached the same length as those in blue light which was never seen with IAA; 2nd when applied on the upper surface of the cotyledons, IAA caused strong epinasty, tryptophol on the other hand caused strong hyponasty.

Tryptophan, even when applied in a very high dose, had practically no effect.

According to MEYER and POHL (1957) and MEYER, J. (1958) indole-aldehyde and indole-carboxylic acid strongly inhibit the translocation of IAA in plants. In blue light they are quickly destroyed and transformed into anthranilic acid which is inactive.

In the following experiment tryptophol 1 % was applied on the cotyledons of light grown gherkin seedlings which were transferred

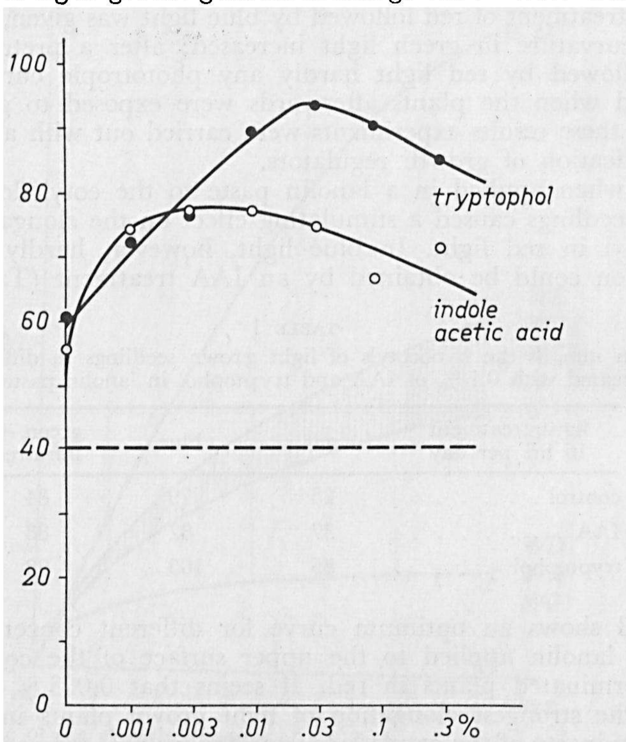

Fig. 3. The elongation of the hypocotyl of light grown gherkin seedlings treated with IAA and tryptophol in red light. Initial length 40 mm (----). Ordinated length in mm after 11 days of treatment. Abscissa: concentrations in %.

to red light. A part of these plants received, just below the insertion of the cotyledons, a ring of lanolin paste with 1 % of indole-aldehyde. Another part was treated in the same way with a ring with indole-carboxylic acid.

TABLE 2

The inhibition of tryptophol induced elongation of the hypocotyl of light grown gherkin seedlings in red light caused by indole-aldehyde. Length after 9 days.

	control	tryptophol	tryptophol + indole-aldehyde
length in mm. . .	22	106	62

In Table 2 the results of this experiment with indole-aldehyde are given. As can be seen in the plants treated with indole-aldehyde the

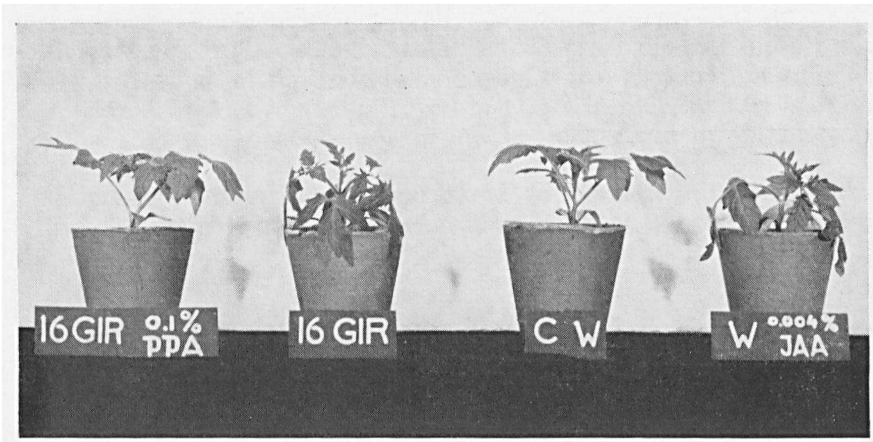

Fig. 2. Tomato plants from left to right: green + infra-red with and without PPA and in white light without and with IAA.

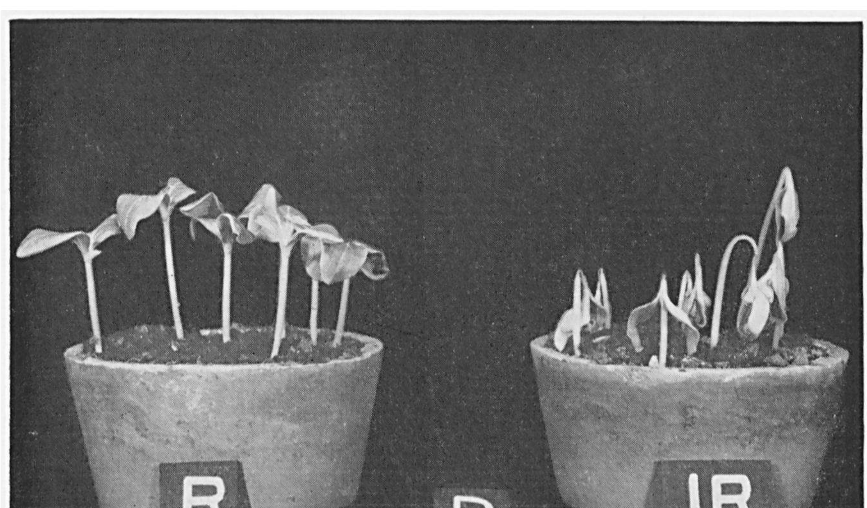

Fig. 4. The effect of a pretreatment with 16 hrs red or infra-red radiation on light grown plants, five days after the transfer to darkness.

elongating effect of tryptophol was much less. However, the hypocotyls were still longer than the control plants. Indole-carboxylic acid was without any activity.

In blue light indole-aldehyde had no effect; it did not inhibit the elongating effect of the blue light on light grown gherkin seedlings. But, as indole-aldehyde is destroyed in plants in blue light, it is quite possible that the concentration of indole-aldehyde in the plants was practically nil.

If light grown seedlings are treated with auxin antagonists like PPA or coumarin and transferred to blue light the hypocotyls remain short (Table 3).

TABLE 3

The inhibition of the elongation of the hypocotyl of light grown gherkin seedlings in blue and green+infra-red caused by coumarin. Length in mm after 5 days of treatment.

light treatment 16 hrs per day	red	blue	green + infra-red
control	24	55	58
coumarin 0.1 % . .	26	25	40

If dark grown plants are treated with one of the growth regulators mentioned above, the result always was a certain inhibition.

A remarkable phenomenon was observed if light grown seedlings were exposed one day (16 hrs) to coloured light and afterwards were kept in darkness. All plants which had been exposed for one day to blue or infra-red perished on the fifth day in darkness. On that day the cells in a region of the upper part of the hypocotyl very quickly lost all turgor while a few small drops appeared on the epidermis of that region (Fig. 4). As a result of this loss of turgor the upper part of the plant drooped down and the plants died. The plants treated for one day with light never showed this phenomenon but a normal appearance even on the seventh or eight day in darkness. If, however, such plants were treated with lanolin containing IAA or tryptophol, they succumbed on the fifth day in darkness, exactly in the same way as the plants which had been exposed to blue or infra-red before they were transferred to darkness.

Discussion

The experiments described in this paper indicate that auxins of the type of indole-acetic acid may be responsible for the effect of light on the elongation.

Light grown plants placed in darkness remain short; elongation can be induced either by blue or infra-red or in red light, which in itself is inactive, by an application with IAA or still better by tryptophol, tryptamine or indole-pyruvic acid.

Indole-aldehyde, which in itself has no effect on plants in red, can diminish the elongating effect of tryptophol on light grown plants in red light.

The elongation of light grown plants caused by blue light, however, was not neutralized by an application of indole-aldehyde. Penta-chloro-phenoxy-acetic acid and also coumarin (both IAA antagonists) reduced the elongation of light grown seedlings stimulated by blue light. The inactivity of indole-aldehyde in blue light can be explained by the results of MEYER, J. (1958) who showed that this substance is converted into indole-carboxylic acid which in blue light is photo-oxidized in the presence of riboflavine into anthranilic acid.

In addition to this similarity of auxin and of light influence on the elongation, it was found that a pretreatment of 16 hrs blue or infra-red radiation has the same toxic effect on light grown plants placed in darkness as IAA or tryptophol. A red light exposure does not cause this effect.

On dark grown plants both blue or red light have an inhibiting effect on the elongation of the hypocotyl. As GALSTON (1949) demonstrated IAA can be photo-oxidized by blue light in the presence of riboflavine. So the inhibiting effect of blue light can be explained by this IAA inactivation.

The inhibiting effect of red light seems to be different from that of blue light (MEIJER, G. 1958). One could suppose therefore that the IAA production is inhibited by red light. Besides the photo-oxidative effect on IAA, blue light has also a neutralizing effect on the inhibition of the IAA production caused by red light. In gherkin seedlings the antagonizing effect of blue light on the red inhibition might dominate its photo-oxidative effect at the light intensities used.

SUMMARY

The elongation of light grown gherkin seedlings in blue light can also be obtained in red light in the presence of auxins. The elongating effect of blue light on light grown seedlings can be antagonized by anti-auxins.

Light grown seedlings transferred to darkness show a toxic effect after a pre-treatment with blue or infra-red radiation. The same effect can be obtained by a pretreatment with red light when auxins were added. Plants pretreated with red light without an application of auxins do not show this typical effect.

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