

# A SHIFT OF THE RESPONSE THRESHOLD TO RED IRRADIATION IN DORMANT LETTUCE SEEDS

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## SUMMARY

Seeds of lettuce of the cultivars Noran and Meikoningin germinate readily in darkness, but a requirement for red light can be induced by long exposure to far-red irradiation or by exposure to temperatures above 30°C. After the first treatment the response threshold to red irradiation is several orders of magnitude higher than after the second treatment.

## 1. INTRODUCTION

Seeds of lettuce of the cultivars Noran and Meikoningin (= May Queen) germinate in darkness as well as in light. Germination can be inhibited by exposure to far-red light during 22 hours or to temperatures above 30°C. A short red exposure will induce germination again with reversion of the effect by a short far-red exposure. Preliminary experiments suggested a dependence of the sensitivity to red light on the dormancy inducing treatment: either exposure to far-red light or exposure to 37°C. The purpose of the present investigation was to examine this dependence.

## 2. MATERIAL AND METHODS

*Lactuca sativa* L. seeds of cv. Noran were obtained from Rijk Zwaan's Zaadteelt en Zaadhandel N.V., de Lier, Holland; seeds of cv. Meikoningin from firma Hulleman, Utrecht, Holland. The seeds were stored in a cold room at 4°C.

For germination tests lots of 100 seeds were imbibed in 9-cm petri dishes in 4.5 ml tapwater. The dishes were placed in light-tight bags at 37°C during 72 hours ('Noran') or during 24 hours ('May Queen'). 'Noran' seeds require 72 hours at 37°C and 'May Queen' seeds 24 hours at 37°C to be induced to dormancy. In other experiments dormancy was induced by placing the petri dishes under far-red light during 22 hours at 22°C. The far-red source for inducing dormancy was a set of 5 25W incandescent lamps filtered through one layer of red (Röhm und Haas no 501) and two layers of blue (Röhm und Haas no 627) plexiglass, illuminating an area of 25 dm<sup>2</sup>, with an intensity of about 10 μW cm<sup>-2</sup>.

After completion of the pretreatments the seeds were irradiated and placed in darkness at 22°C. 48 hours after the experimental irradiations germination

percentages were determined. The experimental irradiations were performed with a iodine incandescent lamp with an appropriate system of lenses and a 5 cm water filter. The beam was filtered through a precision double-band filter ("DEPAL", Scott u. Gen., Mainz;  $\lambda = 660$  nm) in combination with a Calflex filter (Balzer, Liechtenstein). The light intensity was  $40 \mu\text{W cm}^{-2}$ . The range of light doses required was too large to be covered with one light intensity. As the reciprocity law could be demonstrated to hold large red doses could be applied with higher intensity than small doses. The intensity was varied between  $0.1 \mu\text{W cm}^{-2}$  and  $40 \mu\text{W cm}^{-2}$ . by introducing NG (type neutral) filters (Schott u. Gen.), the duration of irradiation never exceeded 120 sec.

### 3. RESULTS AND DISCUSSION

As is shown in *fig. 1* dormant lettuce seeds 'Noran' are far more sensitive to red irradiation when dormancy is induced by high temperature than when dormancy is induced by far-red treatment. For  $37^\circ\text{C}$ -dormant seeds the response threshold lies at  $10^{-2} \mu\text{W sec cm}^{-2}$  of red light, for far-red-dormant seeds at ca  $10^2 \mu\text{W sec cm}^{-2}$ . Moreover the shapes of the dose-response curves are different, which was confirmed in more than 20 experiments. TAYLORSON & HENDRICKS (1971) reported that the responsiveness of *Amaranthus* seeds to a given non-saturating irradiation of red light increases as dark imbibition at  $35^\circ\text{C}$  continues from 24 to 96 hours. The authors interpret their results as a synthesis of phytochrome. The  $P_{fr}$  level resulting from a given red irradiation would accordingly increase.

Synthesis of P might explain the shift in threshold dose for red induced germination demonstrated in *fig. 1*, but not the effect of long exposure to far-red compared to the effect of high temperature on 'May Queen' seeds. In *fig. 2* the dose-response curves for red irradiation are given for far-red-dormant and  $37^\circ\text{C}$ -dormant 'May Queen' seeds. It appears that the dose-response curve for

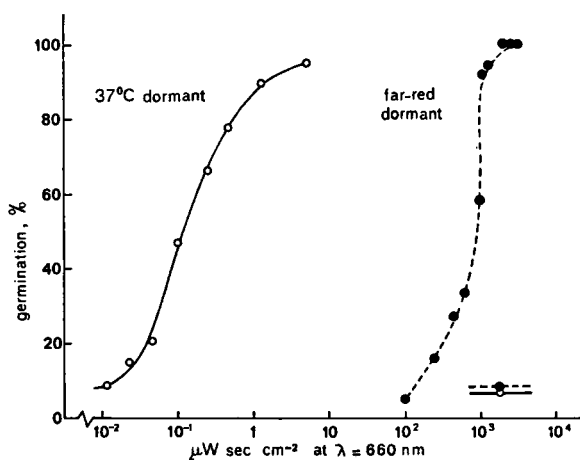


Fig. 1. Dose-response curves for induction of germination of lettuce seeds ("Noran"). Dormancy was induced either by long exposure to far-red light or by exposure to  $37^\circ\text{C}$ . Horizontal lines indicate germination percentages of the dark controls.

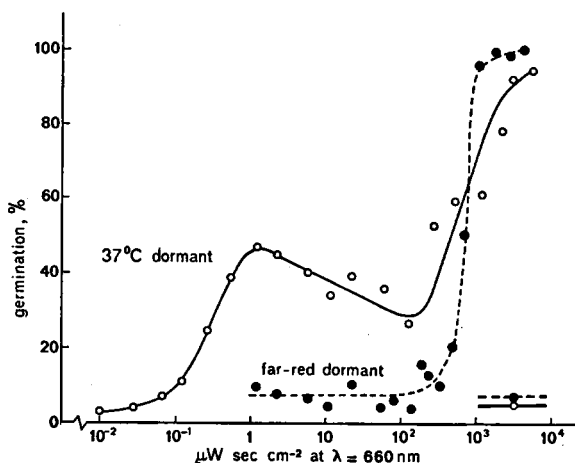


Fig. 2. Dose-response curves for induction of germination of lettuce seeds ("Meikonin-gin"). Dormancy was induced either by long exposure to far-red light or by exposure to 37°C. The experiment was performed in November. Horizontal lines indicate germination percentages of the dark controls.

far-red-dormant seeds corresponds with the right-hand curve of *fig. 1*; the 37°C-dormant seeds are like the 'Noran' seeds far more sensitive to red irradiation, but have moreover retained the response to larger doses of red light. The height of the germination maximum at small doses of red light varies with the season: *fig. 3*. The occurrence of a response to small and a response to larger doses of red light in one dose-response curve suggests formation of an alternative system responding to small red doses.

The occurrence of a minimum in the dose-response curve of *figs. 2* and *3* is another interesting feature. This cannot be explained by the dose-response curve at low red doses being an optimum curve. The dose-response curve for 37°C-dormant seeds ('Noran') reaches saturation at a red dose of about  $1 \mu\text{W sec cm}^{-2}$ . With larger energy doses up to  $5 \times 10^4 \mu\text{W sec cm}^{-2}$  this saturation level appears to be maintained. It might be assumed that the 37°C dose-response

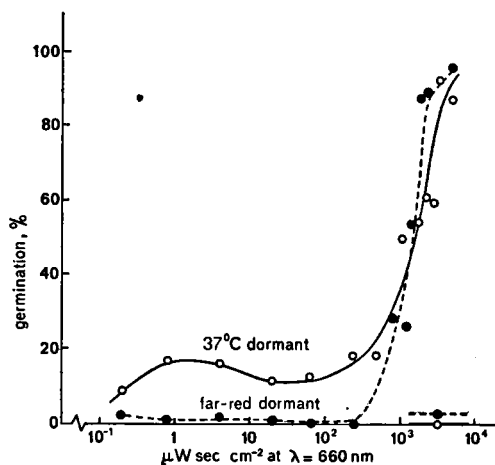


Fig. 3. As *fig. 2*. The experiment was performed in May.

curve of *fig. 2* is composed out of the two dose-response curves of *fig. 1*. In that case the minimum in the curve might be explained by assuming that we are dealing with two pigments interfering at the reaction centres.

The dose-response curves of *fig. 1* show a difference in shape. This difference resembles the difference between one-hit and more-hit Poisson probability curves. This might indicate that the far-red-dormant seeds not only require more red light for their germination but that, moreover, in the induction of germination of these seeds a more-quanta process is involved.

It is assumed that in seeds seed-phytochrome can be distinguished from seedling-phytochrome. Seed-phytochrome forms  $P_{fr}$  in complete darkness and is photostabile as contrasted to seedling-phytochrome. In *Amaranthus* seeds de novo synthesis of seedling-phytochrome is demonstrated under continuous far-red irradiation (KENDRICK et al. 1969); in lettuce seeds, however, synthesis of seedling-phytochrome is inhibited by a long exposure to far-red light (BOISARD, 1969). The absorption peaks of seed- and seedling phytochrome of *Amaranthus* coincide (KENDRICK et al. 1969), but in cucumber seeds the absorption peaks of seed phytochrome are shifted from 667 → 675 and from 730 → 735 nm compared to the absorption peaks of seedling phytochrome (SPRUIT & MANCINELLI 1969). As on the one hand nothing is known about the response thresholds of these two phytochromes to red irradiation and on the other hand we did not finish the determination of the action spectra for red-induction of 37°C- and far-red-dormant seeds, correlation of our red-absorbing systems with seed- and seedling-phytochrome is not possible for the present.

#### ACKNOWLEDGEMENT

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