THE LIGHT PROMOTED GERMINATION OF THE SEEDS OF CHENOPODIUM ALBUM L. I. THE INFLUENCE OF THE INCUBATION TIME ON QUANTITY AND RATE OF THE RESPONSE TO RED LIGHT

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SUMMARY

At progressively later moments after the beginning of the imbibition a single red irradiation(R) has been given to the positive photoblastic seeds of *Chenopodium album*. It could be demonstrated that not only the final germination percentage, but also the period between R and the visible germination, are dependent on the irradiation moment.

1. INTRODUCTION

The seeds of *Chenopodium album* show the light promoted (positive photoblastic) germination pattern, as described for several other species (CUMMING 1959; WENTLAND 1965). The red/far-red reversal effects, which are similar to those reported for lettuce seeds, indicate the participation of the phytochrome system in the photocontrol of this germination.

Since the papers of EVENARI & NEUMANN (1953) and BORTHWICK c.s. (1954) it is known that the response of positive photoblastic seeds to a single red irradiation depends on the period of dark incubation before it.

The present paper deals with the influence of the irradiation moment on both the final germination percentage and the length of the post-irradiation time.

2. MATERIALS AND METHODS

The seeds (code number: K 1964) were harvested from a group of plants on a waste lot near Utrecht. They were stored in dry conditions, at room temperature, in environmental light conditions.

The conventional filter-paper-method was used. Lots of 100 seeds were spread on 3 layers of filter paper (Schleicher & Schull, no. 595) in petri dishes (⌀ 9 cm) and wetted with 5 ml of de-ionised water. Two dishes were generally used for one treatment. Immediately after wetting the dishes were placed in dark containers, at a constant temperature of 23 °C.

The source of the red light was an incandescent lamp, with an appropriate system of lenses and a 5 cm layer of water, in combination with a 659 nm "Depal" double band line filter (Schott & Gen., Mainz, W. Germany) plus a Calflex-C filter (Balzer, Liechtenstein). The intensity at seed level was approximately 250 μWatt. cm^{-2}. In all the experiments the irradiation time of red light was 200 sec.

In several experiments the germination-time course was determined. For that purpose the dishes were viewed in green light, obtained from the same light source, in this case in combination with a 560 nm Filtraflex-B line filter (Balzer) and a 560 nm Depal filter. This radiation had an intensity of 100 μWatt. cm^{-2} at seed level. To test a possible influence of the green light on the germination of the seeds, "green controls" were viewed at the same time as the red irradiated ones. Never did the final germination percentage show any difference with that of the dark controls. So the time course of the green controls was considered to be identical with that of the dark germinators and was used as such.

As the seeds never showed incomplete germination (CUMMING 1963), the protrusion of the fruitwall by the rootlet was taken as the criterion for germination. If the time course was not determined the germination was counted 6 days after the last irradiation.

3. RESULTS

When the seeds of *C. album* are given a short red light irradiation (R) after progressively longer periods of incubation in darkness, their responsiveness to light increases during the first 16 hours, stays constant till about 48 hours and decreases afterwards (*fig. 1*). After 96 hours the seeds are in a state of imposed or secondary dormancy (EVENARI 1965).

Fig. 1 shows the effect of a longer pre-irradiation time on the final germination percentage only. A second effect was detected when the time course of the germination was determined. *Fig. 2* shows the course of the summed up germination percentages, after the start of the imbibition, of seeds irradiated respectively after 16 or 40 hours of dark incubation. Whereas the first visible effect of the irradiation appears after 3 days, the germination of the light-independent fraction is already at its maximum after about 30 hours. So it is easy to differentiate between these two fractions of the samples.

As both curves have the same slope the differences between the moments of visible germination of the individual seeds in both groups must be the same. The final germination percentages of both groups are also nearly the same, but the time between R and the germination response (post-irradiation time) differs by

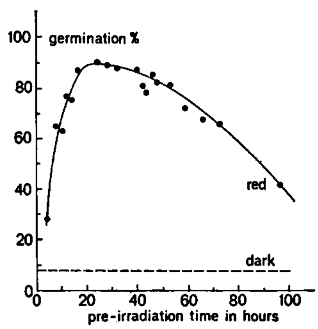

Fig. 1. The responsiveness of dark incubated seeds for a single red irradiation (5.10^4μ Wattsec.cm^{-2}) after progressively longer pre-irradiation time.

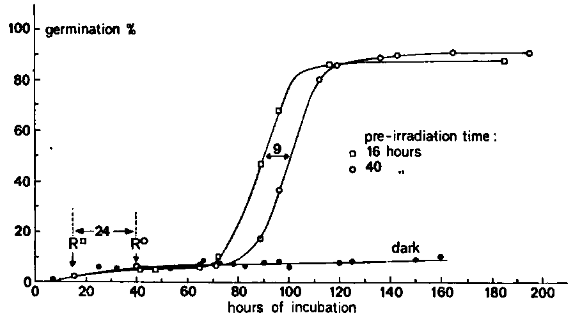

Fig. 2.
The course of the summed up germination percentages against the time after start of incubation, for two irradiation moments.
R = 5.10[4] μWattsec.cm[-2].
Germination was determined in green light.

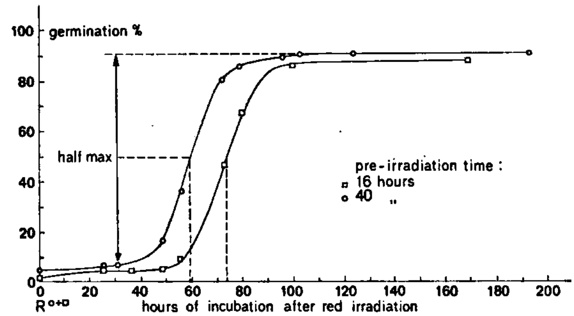

Fig. 3.
The curves of *fig. 2* plotted against the time after the red irradiation (R). The estimation of the germination half time is figured out.

several hours. This difference is more clearly shown in *fig. 3*, in which both curves are plotted against the time after irradiation.

The time-courses of a series of experiments with a progressively longer pre-irradiation time (*fig. 4*) are represented in a diagram (*fig. 5*), in which the curves are indicated by the germination-half-time ($t_{half\ max.}$), which estimation is figured out in *fig. 3*.

It is possible to discern three parts in the data presented in *fig. 5*: (1) from R after 12 hours till R after 44 hours the post-irradiation time decreases gradually; (2) from R after 44 hours till R after 59 hours it remains constant and (3) from R after 59 hours it increases.

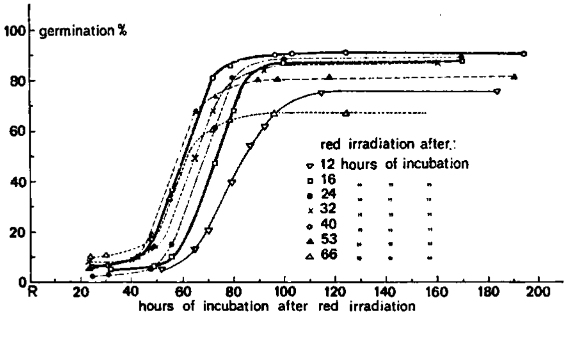

Fig. 4.
The time courses for more irradiation moments together with those of *fig. 3*.

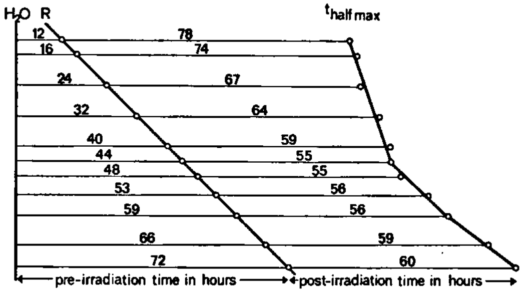

Fig. 5.
A diagrammatic representation of the experimental relation between pre- and post-irradiation time for several irradiation moments.
H_2O = start of imbibition in darkness; R = moment of irradiation with red light (5.10^4 μWattsec.cm^{-2}); $t_{half\ max.}$ = germination half time.

4. DISCUSSION

The present results show that a variation in the pre-irradiation time influences (a) the final germination percentage (*fig. 1*) and (b) the length of the post-irradiation time (*fig. 5*). So it is evident that during the incubation in darkness, some preparatory reactions take place, which, dependent on their progress, influence both quantity and rate of the response to red light.

The gradual increase in responsiveness to light has been frequently reported for lettuce seed and other positive photoblastic seeds (e.g. BORTHWICK c.s. 1954; EVENARI & NEUMANN 1953; IKUMA & THIMANN 1964) and has been attributed largely to progressive imbibition.

KOLLER c.s. (1964) show that in *Artemisia monosperma* seeds this increase must also be due to a gradual build-up of substance(s) on which the irradiation acts or with which its products interact.

Comparison of *figs. 1* and *5* reveals that whereas the final germination percentage is already maximal after 16 hours of incubation, the shortest post-irradiation time is reached at first after 44 hours of incubation. The decrease of the percentage and the increase of the time also did not show a correlation.

So the question arises whether these two effects of a variation in the pre-irradiation time depend on different preparatory reactions or on the same one.

More detailed investigations, which are in progress, are necessary to solve both this question and the nature of these reactions. Some preliminary experiments seem to indicate that the variation in the length of the post-irradiation time can be reduced to a variation in the "escape" period, during which far-red light reverses the effect of R in a gradually decreasing way.

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