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Effect of the Intensity and Duration of Light at Various Temperatures on the Germination of *Oldenlandia corymbosa* L. Seeds

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FRANÇOISE CORBINEAU AND DANIEL CÔME
Laboratoire de Physiologie des Organes Végétaux après Récolte, Centre National de la Recherche Scientifique, 92190 Meudon, France

ABSTRACT

At temperatures below 35 to 40°C, fairly intense continuous white light (13 watts per square meter) inhibits germination of *Oldenlandia corymbosa* L. seeds, and the lower the temperature, the greater the inhibition. However, such lighting may enable seeds to germinate later in the dark; their degree of germinability depends both on the duration of lighting and on the temperature during lighting and after transfer to the dark.

Seeds of *Oldenlandia corymbosa* L. (tropical Rubiaceae) have the peculiarity of germinating only in the light and at very high temperatures (1, 4, 5). Moreover, unlike many other photosensitive seeds (2, 7–9), the absolute need for light is not eliminated by previous cold treatment (4, 5). To define more precisely the effects of light on the germination of *Oldenlandia corymbosa* seeds, we studied the effect of light intensity and duration at various temperatures, since earlier investigations all had been conducted under fairly intense continuous white light.

MATERIALS AND METHODS

Oldenlandia corymbosa L. produces two types of seed (1). One type germinates rapidly in continuous white light at 35 to 40°C and is considered as nondormant; the other is dormant, because under the same conditions it can only germinate after several days' exposure to fairly low temperature in a wet medium. The present study has been confined to nondormant seeds harvested from plants selected to produce only this type of seed (1). They were grown in the Phytotron at Gif-sur-Yvette (France) under conditions defined previously (4). Since the germinability of *Oldenlandia corymbosa* seeds is a function of plant age (3, 6), the seeds used came from plants about 6 months old. They had been stored at 20°C in the open air for 10 d (batch 1), 2 months (batch 2), or 1 year (batch 3). Although their ability to germinate varied during storage, this caused no fundamental change in their behavior (3).

Germination experiments were carried out with 100 to 200 seeds/assay placed on filter-paper over a layer of wet cotton wool in Petri dishes. Seeds were placed under light or in the dark at temperatures ranging from 17 to 40°C.

Maximal light of about 13 $w \cdot m^{-2}$ was provided by two 16-w Mazdafluor tubes (warm white). Lower light intensities were obtained by use of Wratten filters (Kodak) transmitting 0.01, 0.1, 1, 20, 32, 50, or 80% of the maximal light without spectrum modification. Seeds were either left continuously under one of these different light intensities or placed under maximal light for various periods before transfer to the dark. In the first case, germinated seeds were counted after 7 d, which sufficed to obtain the maximal percentage of germination observed. In the second case, germinated seeds were counted at the time of their transfer to the dark and 7 d later. A seed was considered to have germinated when its radicle had pierced the seed-coat.

RESULTS

Effect of Continuous Light. Whatever the temperature, *Oldenlandia corymbosa* seeds never germinated in total darkness, but were extremely sensitive to light (Fig. 1). Very low light (0.01% of the maximal lighting: 1.3 10^{-3} $w \cdot m^{-2}$) was sufficient to ensure germination of about half the seeds at temperatures between 32 and 40°C. At 35 and 40°C, all seeds germinated at light intensities between 0.13 and 13 $w \cdot m^{-2}$. At lower temperatures, germination was all the more difficult as the temperature dropped, but the highest proportion of seeds observed at such temperatures germinated in between 1% and 30% of maximal light. More intense light inhibited germination. These experiments were carried out with all three batches of seed and always gave similar results.

At any temperature, if n and N denote the percentages of

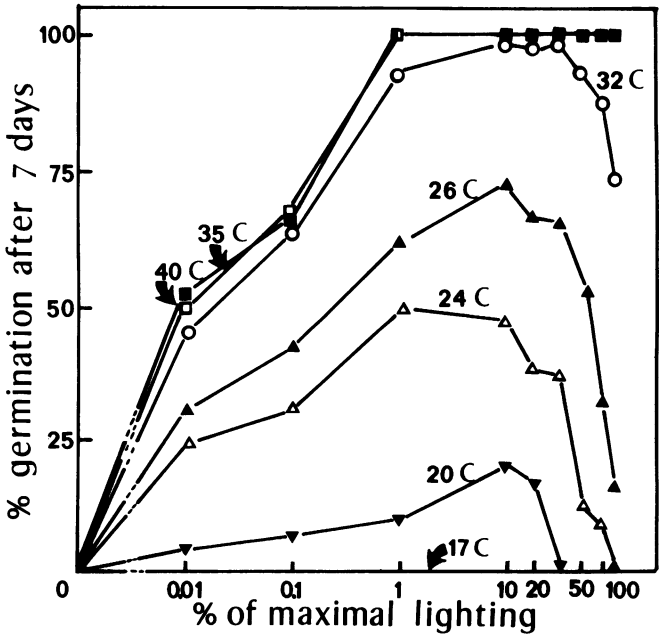

FIG. 1. Effect of light intensity on the germination of batch 2 seeds at 17, 20, 24, 26, 32, 35, and 40°C. Maximal lighting was about 13 $w \cdot m^{-2}$.

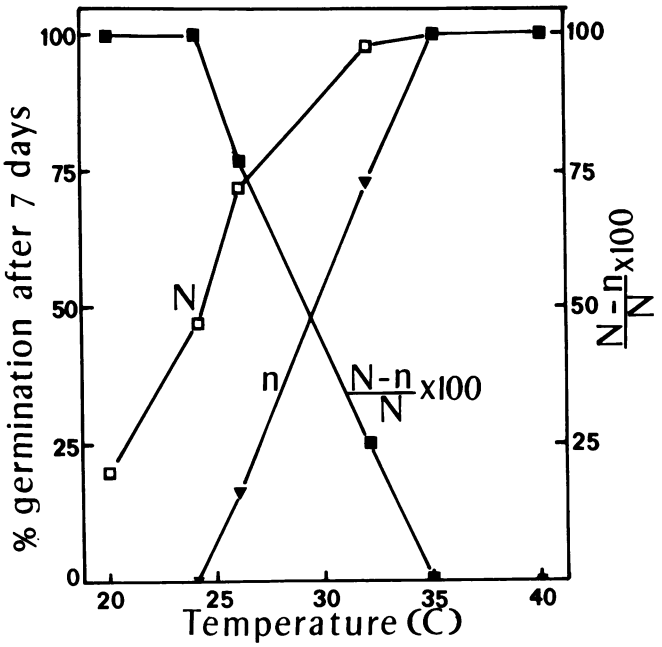

FIG. 2. Effect of temperature on the percentage of batch 2 seeds germinating after 7 d under maximal lighting (n) or under 10% of this maximum (N), and on the ratio $N - n/N \times 100$.

germination obtained after 7 d under maximal and 10% of maximal light, respectively, the ratio $\frac{N-n}{N} \times 100$ gives the percentage of seeds the germination of which is inhibited by maximal light (Fig. 2). At 20 and 24°C, inhibition was total but decreased as the temperature rose and fell to zero at 35 and 40°C.

Effect of the Duration of Light on Subsequent Germination in the Dark. In a first experiment, the seeds in batch 1 were placed for various periods under maximal light at 17, 20, 26, 31, 35, and 40°C, and then transferred to the dark at the same temperature (Fig. 3). In light, germination was total within 3 d at 40 and 35°C, but some seeds germinated after transfer to the dark. Germination of the latter no doubt had advanced sufficiently in the light for them to develop further in the dark. At 31°C only 90% of the seeds germinated in continuous light; here again, some seeds germinated subsequently in the dark, but the total percent germination never exceeded the 90% obtained in continuous light. At 26°C, and to a lesser extent at 20°C (two temperatures very unfavorable to germination in the light) many seeds germinated in the dark when exposed previously to light less than 2 d. At 17°C, no germination was observed.

The same experiment was performed with batch 3, but after exposure to light at various temperatures, all seeds were transferred to the dark at 40°C. The seeds placed in the light at 40, 35, or 31°C and then in the dark at 40°C germinated as previously (Fig. 4), but a little more slowly, because the batch was not the same. Relatively brief exposure to light at 26°C enabled many seeds to germinate subsequently in the dark at 40°C. Prolongation of lighting to 8 to 12 d had no further effect, but exposure to light for more than 12 d again allowed subsequent germination in the dark. At 20 and 17°C, no seed germinated in continuous light. The percentage of seeds germinating in the dark at 40°C varied, depending on the length of time to the preceding period of light; first it rose, then diminished, and then rose again.

DISCUSSION AND CONCLUSION

In continuous white light, seeds of *Oldenlandia corymbosa* germinate at temperatures distinctly below 35 to 40°C, provided

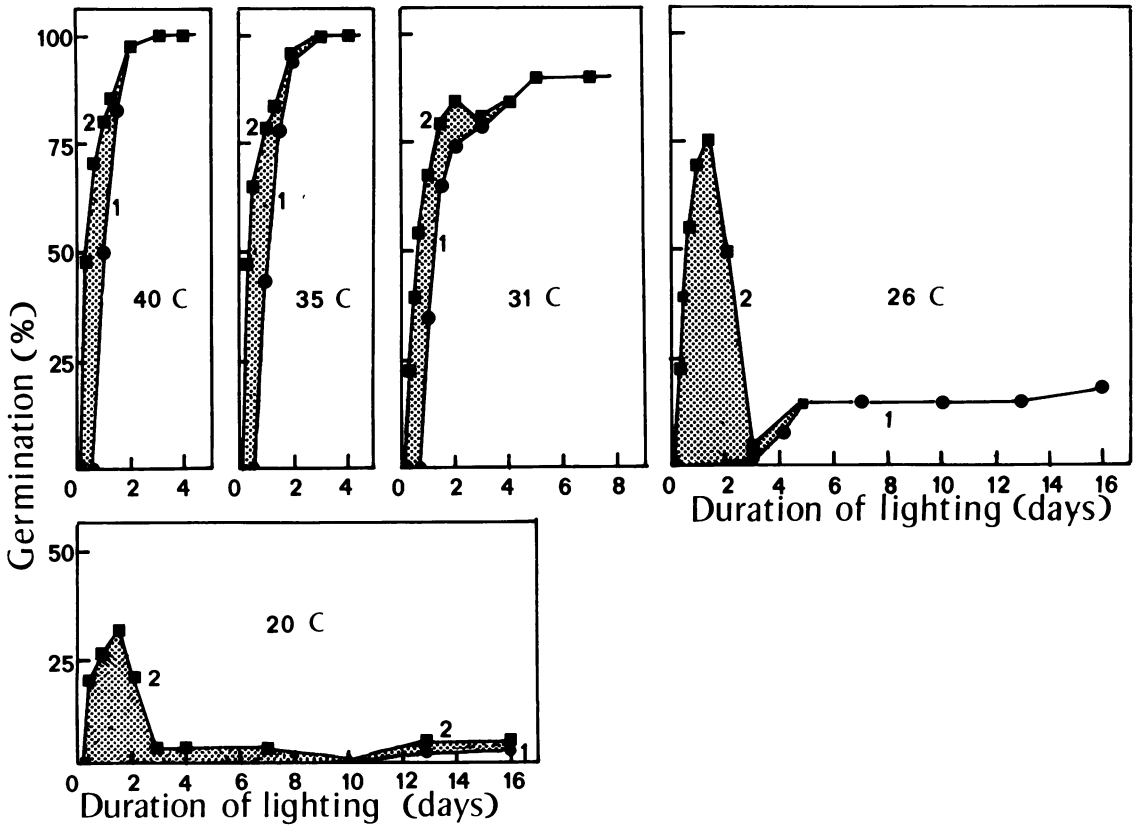

FIG. 3. Effect of the duration of maximal lighting (13 w· m^{-2}) on the germination of batch 1 seeds, at 40, 35, 31, 26, or 20°C. 1, (●): % germination in the light at the time transfer to the dark; 2, (■): % germination 7 d after transfer to the dark. The distance between the two curves represents the fraction of the seeds which germinated in the dark.

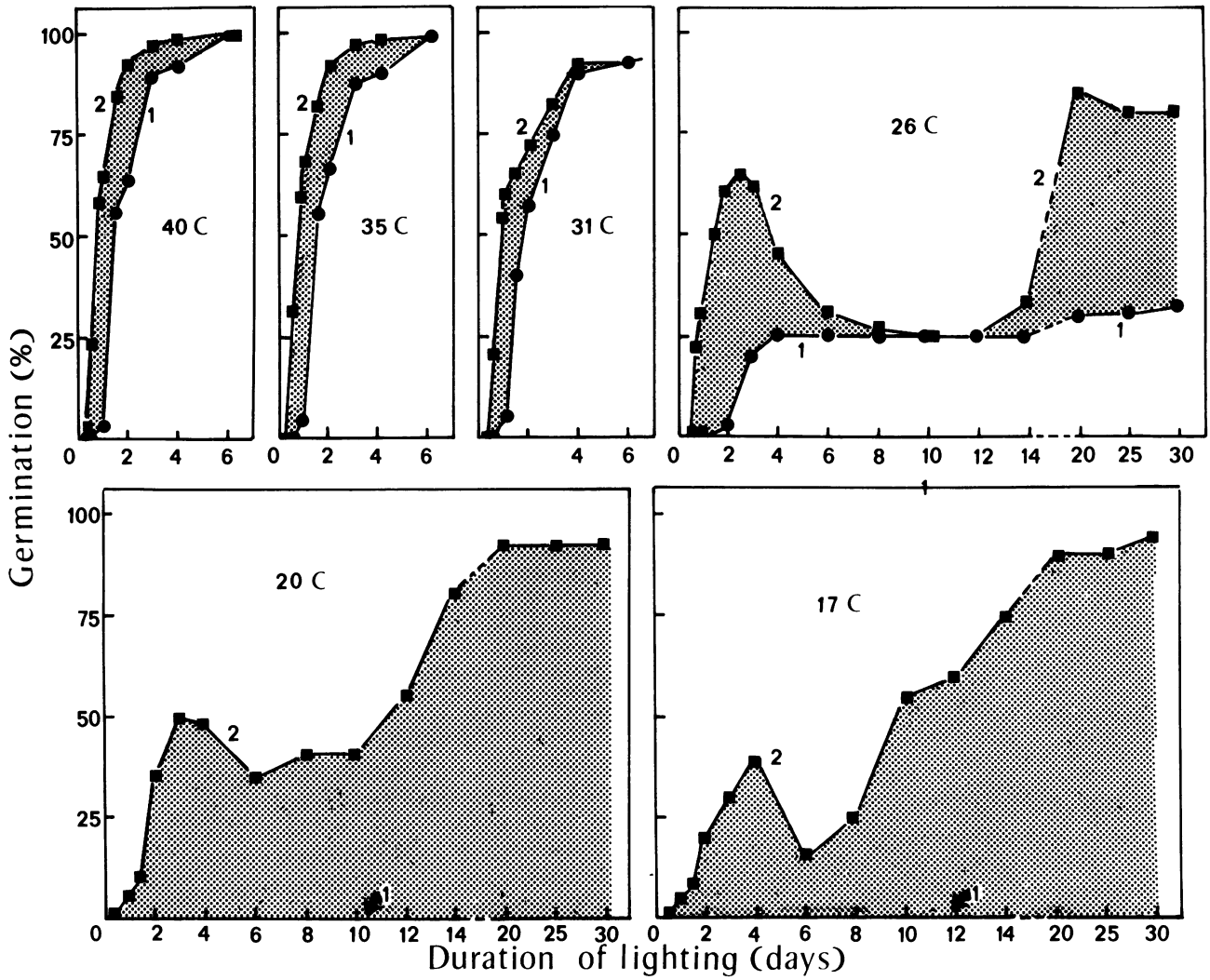

FIG. 4. Effect of the duration of maximal lighting (13 w· m^{-2}) on the germination of batch 3 seeds, at 40, 35, 31, 26, 20, or 17°C. 1, (●): % germination in the light at the time of transfer to the dark; 2, (■): % germination 7 d after transfer to the dark at 40°C. The distance between the two curves represents the fraction of the seeds which germinated in the dark.

that the light is not intense. At temperatures lower than the usual optimal ones, strong light inhibits germination, and the inhibition increases as the temperature drops. To our knowledge, no such behavior has been reported for any other seeds the germination of which requires light. It may be unique to the seeds of *Oldenlandia corymbosa* which germinate well only at very high temperatures.

At temperatures at which intense continuous light greatly inhibits germination, relatively brief exposure to light enables many seeds to germinate subsequently in the dark. Strong light, therefore, inhibits only when exposures last too long. The same behavior is observed when seeds are placed in the dark at 40°C after exposure to light at lower temperatures. However, under these conditions, very long exposures to light will still permit seeds to germinate well subsequently in the dark.

To sum up, the effect of light on the germination of *Oldenlandia corymbosa* seeds depends both on the intensity and duration of the light and on the temperatures prevailing during lighting and after transfer to the dark. These results are at present difficult to explain and require more detailed investigation of successive steps in the germination process, especially of the regulatory roles played by phytochrome, O_2, and other factors.

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