Light and temperature interactions in promoting lettuce seed germination

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Introduction

Lettuce is one of the most important vegetables grown in North America. Its establishment in the field is performed mainly by direct sowing, and uniform seedling emergence is critical to achieve high yield. However, there are two properties of lettuce seeds that affect germination uniformity: i) germination inhibition in dark, and ii) sensitivity to high temperatures (thermodormancy) (Wien, 1997). The objective of this work was to determine the effects of temperature, light and their interaction in promoting lettuce seed germination.

Materials and Methods

Lettuce seed (*Lactuca sativa* L. cv. 'Tango'), produced under greenhouse conditions at Columbus, OH, during summer 2004, was used. Seed germination (radicle emergence 5 days after sowing) was evaluated under different treatments which are grouped in two experiments.

Experiment 1. Treatments consisted of germination under dark conditions, with or without a light break (red light, 28.8 mmol·m^{-2}) 48 h after sowing (Fig. 1), and of different combinations of temperatures pre- (soaking temperature, ST) and post- (germination temperature, GT) light break. In addition, germination with continuous light at 20 and 30ºC was also evaluated. Each treatment was repeated 3 times. Each replication consisted of 4 petri dishes, each one with 50 seeds placed over 2 blotters saturated with distilled water.

Experiment 2. Treatments were similar to those in experiment 1 but with different combinations of temperatures (ST and GT). With the use of a thermogradient table, temperatures between 12 and 30ºC were incorporated to the treatments (Fig. 2). Each treatment was repeated 4 times. Each replication consisted of a petri dish with 50 seeds placed over 3 blotters saturated with distilled water.

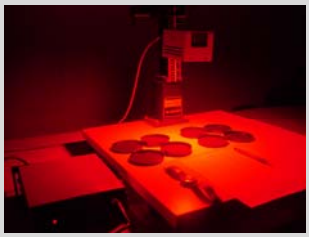

Figure 1. Red light (28.8 mmol·m^{-2}) break of lettuce seeds after soaking for 48 h.

Figure 2. Dark germination treatments on the thermogradient table.

Results and Discussion

Under continuous light, lettuce seed presented 100 and 96% germination at 20 and 30°C, respectively (Fig. 3). However, when no light was supplied, germination decreased drastically to less than 5% (Fig. 3; Fig. 4a, e) unless seeds were soaked at cold (2 or 10°C) temperatures (Fig. 3; Fig. 4f, g). The efficiency of cold soaking in promoting lettuce germination was dependent of ST (2°C was more effective than 10°C) and GT (temperatures around 21.8°C presented the best response) (Fig. 4f, g).

The germination promotion of a red light break after 48 h of soaking was dependent of the ST and GT. When GT was 20°C, germination after light at any of the ST treatments was improved significantly in relation to the same combination of temperatures without light break (Fig. 3; Fig. 4c, e); germination values close to 100% were observed when ST was 14°C or lower. When GT was 30°C, germination was significantly higher than 0% only when ST was lower than 21.8°C (Fig. 3; Fig. 4d); germination was over 95% only with a ST of 10°C (Fig. 3; Fig. 4h).

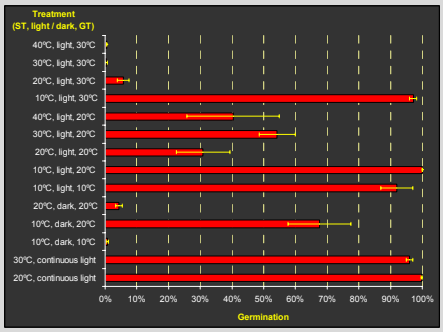

Figure 3. Lettuce seed germination after 5 days under different conditions of light and temperature. Unless otherwise stated, treatments consisted of 48 h in dark at soaking temperature (ST), a light break that could be present ("light") or not ("dark"), and 72 h in dark at germination temperature (GT). In treatments with "continuous light", seeds were evaluated after 5 days at constant temperature and constant light. Data are means ± SE.

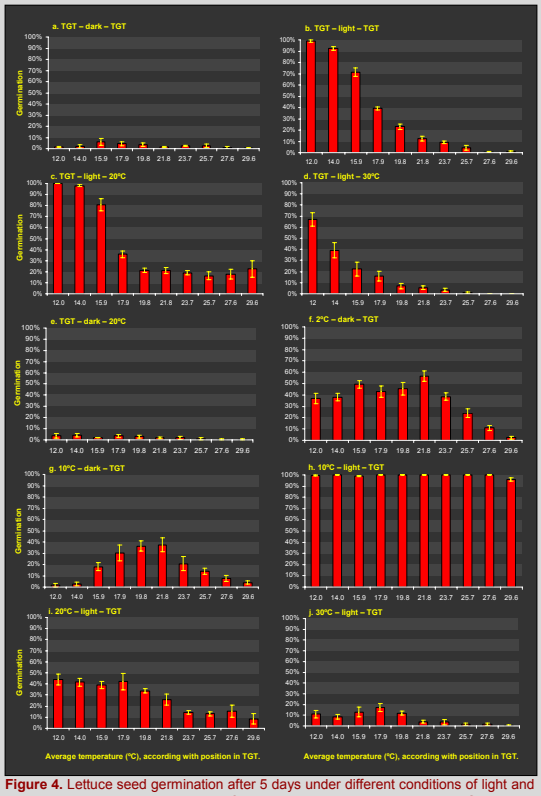

Figure 4. Lettuce seed germination after 5 days under different conditions of light and temperature. Treatments consisted of 48 h in dark at soaking temperature (ST), a light break that could be present ("light") or not ("dark"), and 72 h in dark at germination temperature (GT). In all cases, at least one of the temperatures (ST, GT, or both) was determined by the position of the seeds in a thermogradient table (TGT), which presented temperatures between 12.0 and 29.6°C. Data are means ± SE.

Germination after a combination of cold soaking and light break was close to 100% independent of the GT (Fig. 3; Fig. 4h). Seed germination responded synergistically to cold soaking and a light break, especially at extreme GT (Fig. 4g, h, i).

In contrast to what has been observed previously with lettuce seed of other cultivars, the seed that we used exhibited a marked light requirement for germination at any of the temperatures tested (Fig. 3a). On the other hand, thermodormancy was also observed, but it was dependent of ST, GT and the amount of light. According to Saini et al. (1989), the increased light requirement at higher temperatures could be explained either by higher instability of the activated form of phytochrome (Pfr), or by decreasing sensitivity to Pfr. Because of the high germination observed after a light break applied to cold-soaked seeds (Fig. 3; Fig. 4h), our results support the idea that low soaking temperatures may increase sensitivity to Pfr, reversing effects of high GT. Additionally, Hallet and Bewley (2002) suggested that a component of the phytochrome signal transduction pathway would be membrane linked, and temperature would modulate this pathway by affecting membrane fluidity. Higher membrane fluidity by increased acyl chain saturation of membrane lipids could partially explain the improved germination observed after cold soaking of seeds.

References

Hallet, B.P. and J.D. Bewley. 2002. Membranes and seed dormancy: beyond the anaesthetic hypothesis. Seed Science Research 12: 69- 82.

Saini, H.S., E.D. Consolación, P.K Bassi, and M.S. Spencer. 1989. Control processes in the induction and relief of thermoinhibition of lettuce seed germination. Plant Physiology 90: 311- 315.

Wien, H.C. 1997. Lettuce. In: The physiology of vegetable crops. H.C. Wien (Ed). CABI Publishing. p. 479- 509.