Temperature During Seed Development Affects Size, Germinability and Storability of Lettuce Seeds

S. Contreras*[1], D. Tay[2] and M.A. Bennett[1]
[1]Dept. of Horticulture and Crop Science, [2]Ornamental Plant Germplasm Center
The Ohio State University, Columbus, Ohio 43210-1086
*contreras.19@osu.edu

Introduction

•Seed germinability and storability are important aspects of seed quality determined by the genotype and environment of seed development.
•Lettuce is one of the most important vegetables in the USA and the world. The establishment of this species requires high quality seed, which may germinate at sub-optimal conditions (e.g. high temperature).
•The main objective of this study was to determine how temperature of the mother environment affects lettuce seed quality.

Materials and Methods

Two experiments were performed to determine: i) effects of temperature on lettuce seed quality, and ii) critical moments during lettuce seed development for temperature effects.

Experiment 1, effects of temperature: Seeds of cv. Tango were produced in growth chambers under one of two treatments: a) high temperature (HT), with day/night temperatures of 30/20°C, respectively, and b) low temperature (LT), with temperatures of 20/10°C. The experiment was replicated four times using plants from different sowing dates. Each replication was considered a block and consisted of 10 plants randomly assigned to each treatment. Several flower heads per plant were labeled during anthesis and harvested periodically to determine seed weight accumulation curves for each treatment. Final seed harvest was performed manually extracting only fully matured flower heads of each plant.
Seed evaluation. Seed dry weight, standard germination (normal seedlings after 7 days at 20C-light), and germination (radicle protrusion) at different conditions of temperature, light and water potential (PEG solutions) were evaluated on at least 100 seeds per replication. The germination index (GI) was calculated as the algebraic sum of the ratio of germinated seeds and days after sowing at the count moment. The accelerated aging (AA) test consisted on evaluate seed standard germination after 72 h of aging at 41°C and ~100%RH. Seed standard germination was also evaluated after 1, 2 and 3 months of storage at 30°C and 74% RH.

Experiment 2, critical moment determination. Flower heads of four plants of each temperature treatment were labeled the day of anthesis. Labeling of flower heads at 30/20°C was performed 0, 4, 8 and 12 days before movement of the plants to 20/10°C, and plants at 20/10°C were labeled 0, 5, 10, and 15 days before being moved to 30/20°C. According with the moment of labeling and combination of temperatures, there were eight treatments: a) LOW (all the time at LT), b) 3/4 LOW- 1/4 HIGH (15 days at LT, then HT), c) 2/4 LOW- 2/4 HIGH (10 days at LT, then HT), d) 1/4 LOW- 3/4 HIGH (5 days at LT, then HT), e) HIGH (all the time at HT), f) 3/4 HIGH- 1/4 LOW (12 days at HT, then LT), g) 2/4 HIGH- 2/4 LOW (8 days at HT, then LT), and h) 1/4 HIGH- 3/4 LOW (4 days at HT, then LT). Fully matured flower heads from each labeling moment were harvested manually.
Seed evaluation. Seed dry weight, dark germination at 30°C, germination at -5 bar, and percentage of normal seedlings after AA were evaluated on 4 sub-samples of 50 seeds per treatment.

Results and Discussion

Experiment 1. At 30/20°C seeds reached physiological maturity (PM), or max dry weight, 11 days after flowering (DAF), while seeds at 20/10°C did at 15 DAF (Fig. 1). After PM seed desiccation was three times faster in seeds at 30/20°C than in those at 20/10°C (Fig. 1). Seeds from 20/10°C were heavier than seeds from 30/20°C (Fig. 1, Table 1), however the seed standard germination was similar for both treatments (Table 1).

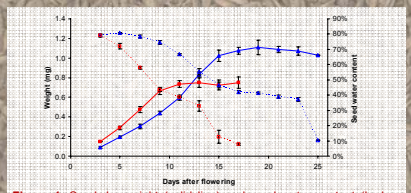

Figure 1. Seed dry weight (solid line) and seed water content (broken line) during development of seeds produced at 30/20°C (red) and 20/10°C (blue). Data are average ±SE from four replications.

Table 1. Parameters of quality for lettuce seed produced under high (30/20°C) and low (20/10°C) temperatures.

Parameter	Treatment		*p*-value[(1)]
	30/20°C	20/10°C	
Seed dry weight (mg/seed)	0.76	1.04	0.024
Normal seedlings at 20°C (%)	99.8	99.8	1.000
Normal seedlings after AA[(2)] (%)	59.5	1.8	0.001
Dark germination at 13C (%)	97.0	87.0	0.086
Dark germination at 18C (%)	100.0	86.0	0.006
Dark germination at 24C (%)	97.0	68.0	0.004
Dark germination at 29C (%)	50.0	14.5	0.022

(1): calculated from analysis of variance.
(2): Accelerated aging for 72 h at 41°C and ~100%RH. Normal seedling percentages 11 days after planting are reported.

When germinability was evaluated at sub-optimal conditions seeds produced at 30/20°C outperformed those from 20/10°C. For example, seeds from 30/20°C presented significantly higher dark germination at 18, 24 and 29°C (Table 1). Germination under light was similar for both treatments between 20 and 30°C, however between 30 and 40°C germination percentage and rates (expressed as germination index) were higher for seeds from 30/20°C (Fig. 2A). When germinated at osmotic potentials below -1.5 bar, seeds from 30/20°C also performed better (Fig. 2B).

The production of normal seedlings after accelerated aging (AA) was significantly higher for seeds from 30/20°C (Table 1). The AA test has been used to evaluate both vigor and storability of seeds. On this case the lower ability for seeds from 20/10°C to be stored was confirmed by the production of normal seedlings after different periods of seed storage at 30C and 74%RH (Fig. 3).

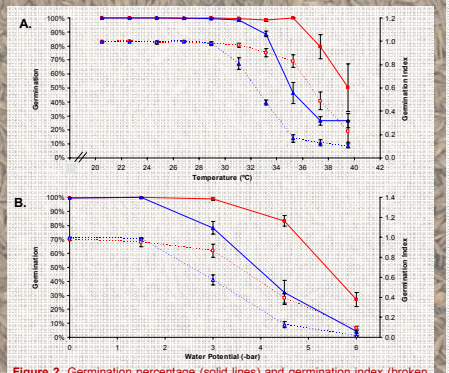

Figure 2. Germination percentage (solid lines) and germination index (broken lines) at different temperatures (A) and at 20°C and different water potentials (B) of seeds produced at 30/20°C (red) and 20/10°C (blue). Data are average ±SE from four replications.

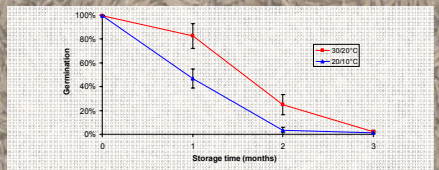

Figure 3. Germination of normal seedlings after storage of seeds produced at 30/20°C (red) and 20/10°C (blue). Data are average ±SE from four replications.

Experiment 2. When the critical moment for temperature effects were studied, seed dry weight, dark germination at 30°C, and germination at low osmotic potential showed to be determined earlier during seed development, before 5 and 4 DAF for seeds from 30/20°C and 20/10°C seeds, respectively (Fig. 4). On the other hand, seed storability was determined at the end of seed development, after physiological maturity.

According with our results, lettuce seed germinability is affected by the environmental temperature of the mother plant during the first days of lettuce seed development. Seeds that developed at higher temperatures presented better germinability. The physiological mechanism governing this effect remains unclear and probably is related with some event happening early on seed development, as for example ABA accumulation on the seed.
On this study seed germinability was not correlated with seed storability (Fig. 4). The effect of temperature on seed storability was produced at the end of seed development, after physiological maturity. The time required for seed desiccation on seeds at 30/20°C was markedly lower than on seeds at 20/10°C (Fig. 1), and this could be a factor affecting seed performance after storage.

Because the importance of lettuce seed germinability for proper establishment of the crop and storability for seed conservation and management of seed stocks, the mechanisms by which temperature affects these two aspects of seed quality should be further studied.

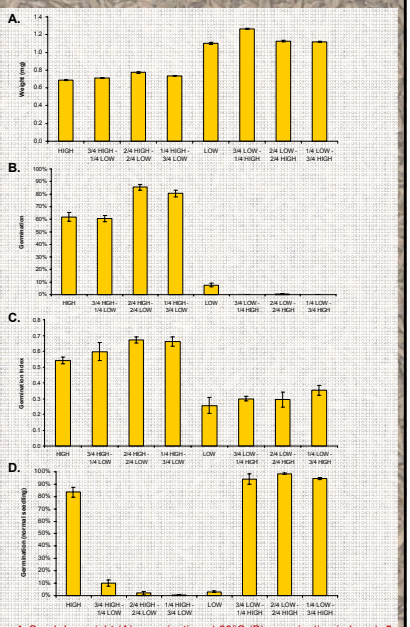

Figure 4. Seed dry weight (A), germination at 30°C (B), germination index at -5 bar (C), and normal seedlings after accelerated aging (D) of seeds produced at **LOW** (all the time at LT=20/10°C), **HIGH** (all the time at HT=30/20°C), **3/4 LOW- 1/4 HIGH** (15 days at LT, then HT), **2/4 LOW- 2/4 HIGH** (10 days at LT, then HT), **1/4 LOW- 3/4 HIGH** (5 days at LT, then HT), **3/4 HIGH- 1/4 LOW** (12 days at HT, then LT), **2/4 HIGH- 2/4 LOW** (8 days at HT, then LT), and **1/4 HIGH- 3/4 LOW** (4 days at HT, then LT). Data are average ±SE from four sub-samples of 50 seeds.

Acknowledges

Salaries and research support provided by state and federal funds appropriated to The Ohio State University, Ohio Agricultural Research and Development Center, and PhD Fulbright Scholarship to S. Contreras.