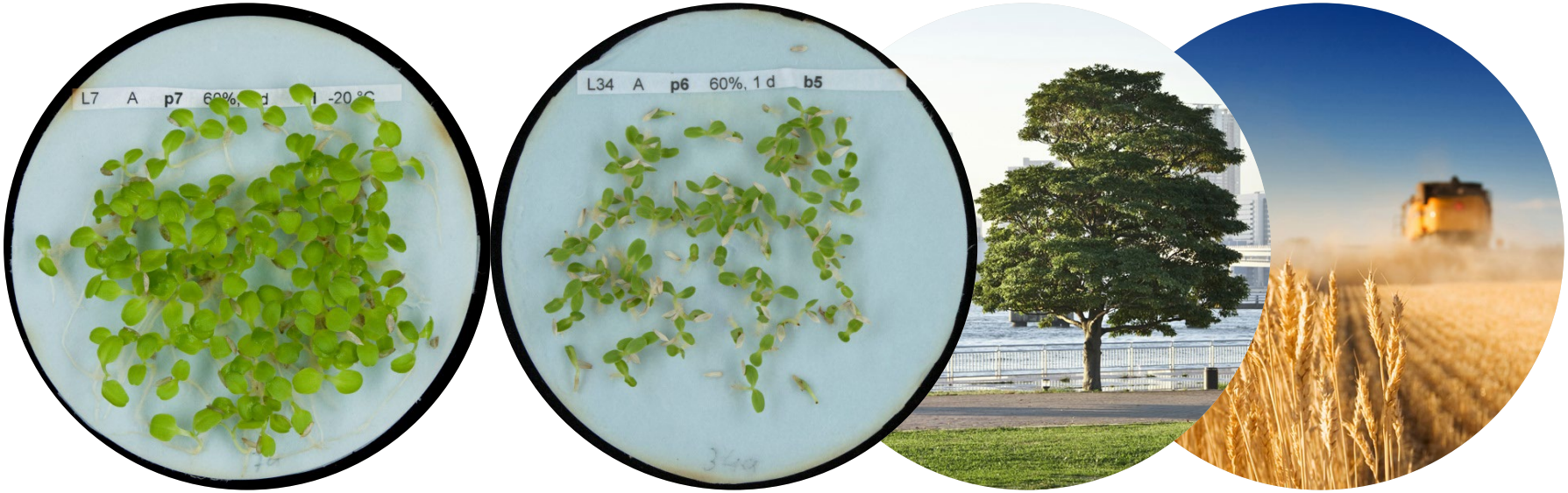
Seed storage and the relative effects of temperature, moisture and oxygen

ISTA Annual meeting 2024, Seminar 'Seed quality assurance a critical component of food and nutritional security' - Cambridge

Steven P.C. Groot



WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Seed longevity varies with storage

Thailand rice seed warehouse
± 80% RH, ± 30 °C

NL seed company
warehouse 30% RH, 20 °C

Genebank storage
15% RH, -20 °C

Seed moisture content

Storage temperature

WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Dry seed storage for food and farming

Trends in Food Science & Technology 71 (2018) 84–93

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: www.elsevier.com/locate/tifs

The dry chain: Reducing postharvest losses and improving food safety in humid climates

Kent J. Bradford[a,*], Peetambar Dahal[a], Johan Van Asbrouck[b], Keshavulu Kunusoth[c], Pedro Bello[a], James Thompson[d], Felicia Wu[e]

[a] Department of Plant Sciences, Seed Biotechnology Center, University of California, Davis, CA 95616, USA
[b] Rhino Research, Moo Baan Sai Samphan 66/17, 66000 Phichit, Thailand
[c] Department of Seed Science & Technology, Professor Jayashankar Telangana State Agriculture University, Rajendra Nagar, Hyderabad 500030, India
[d] Department of Biological and Agricultural Engineering, University of California, Davis, CA 95616, USA
[e] Department of Food Science and Human Nutrition, Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing, MI 48824, USA

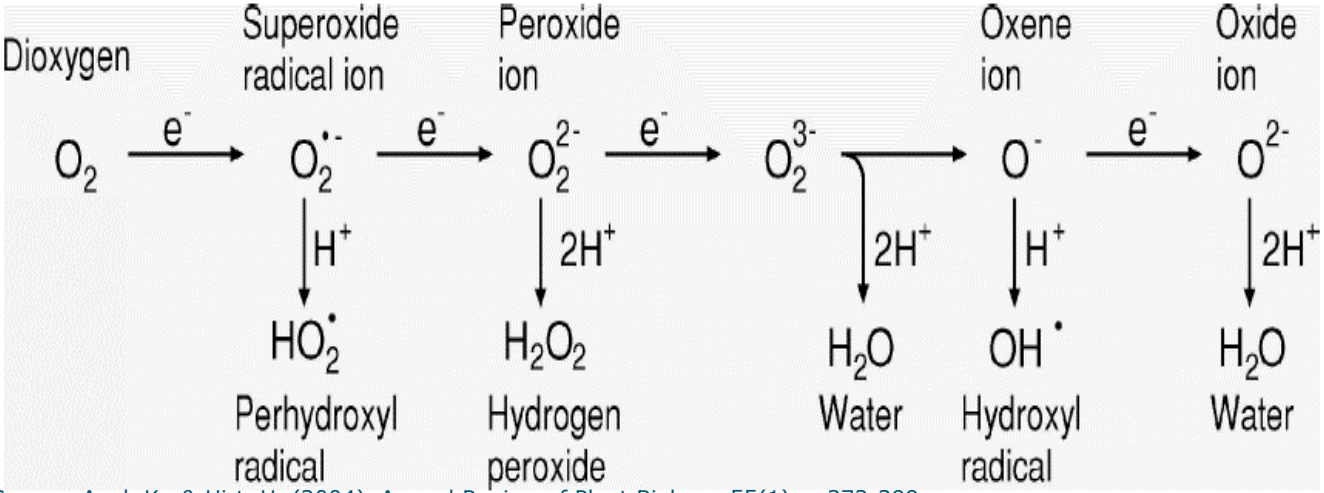
WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Deterioration during seed ageing

- DNA damage,
- Protein oxidation,
- Lipid peroxidation
- Cell membrane damage
- Mitochondrial membrane damage
-

Oxidation! induced by ROS

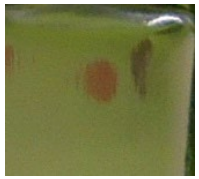


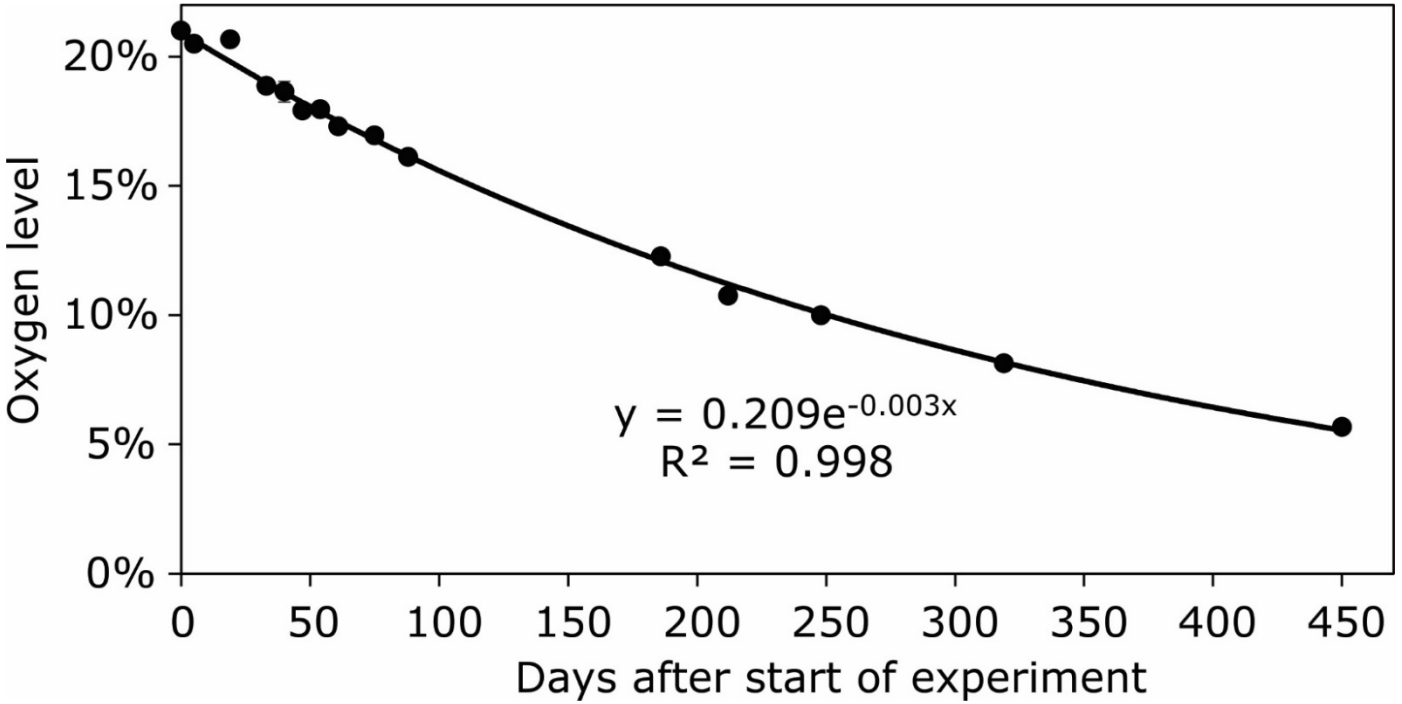
Source: Apel, K., & Hirt, H. (2004). Annual Review of Plant Biology, 55(1), p 373-399

WAGENINGEN UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Oxygen uptake by dry seeds





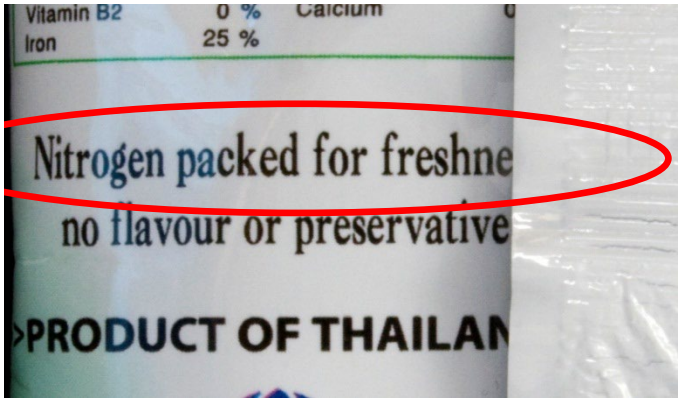
- 10 g lettuce seeds (approx. 18 ml) after equilibration at 39% RH
- Stored in closed 47 ml glass jar at 20 °C (dark)

WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Can storage under anoxia improve shelf life?

- The food industry packs seeds under anoxia



WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Can seeds survive longer under anoxia?

- Roberts E.H. (1961) Ann Bot 25, 381-390.

The Viability of Rice Seed in relation to Temperature, Moisture Content, and Gaseous Environment

BY

E. H. ROBERTS

West African Rice Research Station, Rokupr, Sierra Leone

With three Figures in the Text

ABSTRACT

The seed viability of a tropical variety of rice has been investigated in hermetic storage under a range of conditions of temperature and moisture content. The results confirm a previous suggestion, which was made on the basis of data from temperate cereals, that the relationship between these factors and viability can be described in simple mathematical terms. In addition, a comparison has been made of the effects on viability of hermetic storage in air, oxygen, nitrogen, and carbon dioxide.

Effect of different storage atmospheres

- Roberts. 1961.
  Ann Bot 25, p381-390

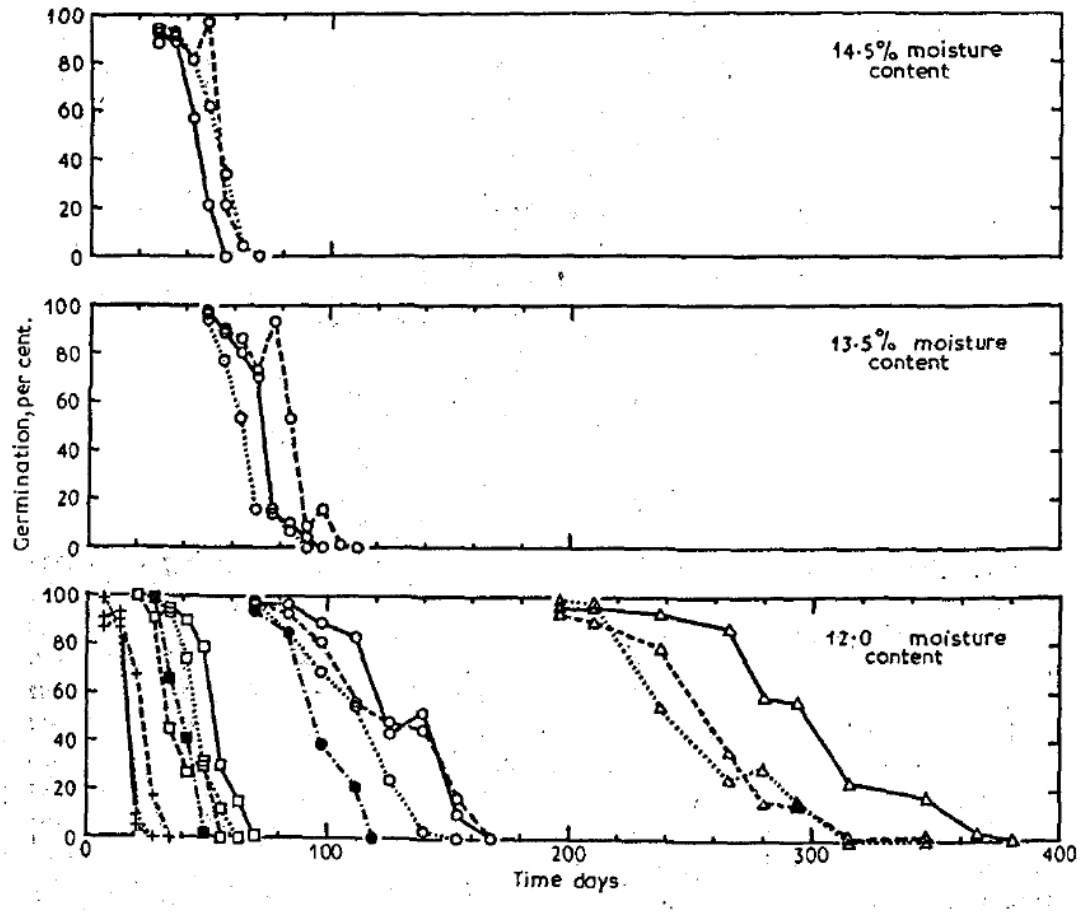
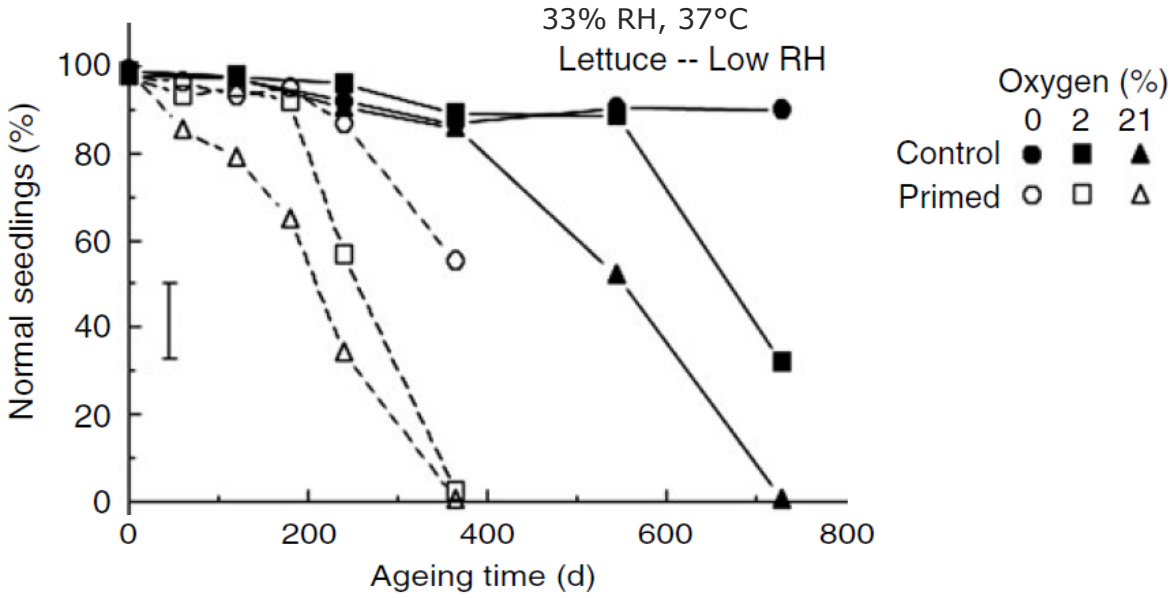


FIG. 3. Loss of viability of seed of Toma 112 hermetically sealed in various gases: nitrogen (————), air (– – – –), oxygen (·····), carbon dioxide (■ ● –·–·–·). Storage temperatures: 32° C. (Δ), 37° C. (○), 42° C. (□), 47° C. (+).

Effect of different oxygen concentrations

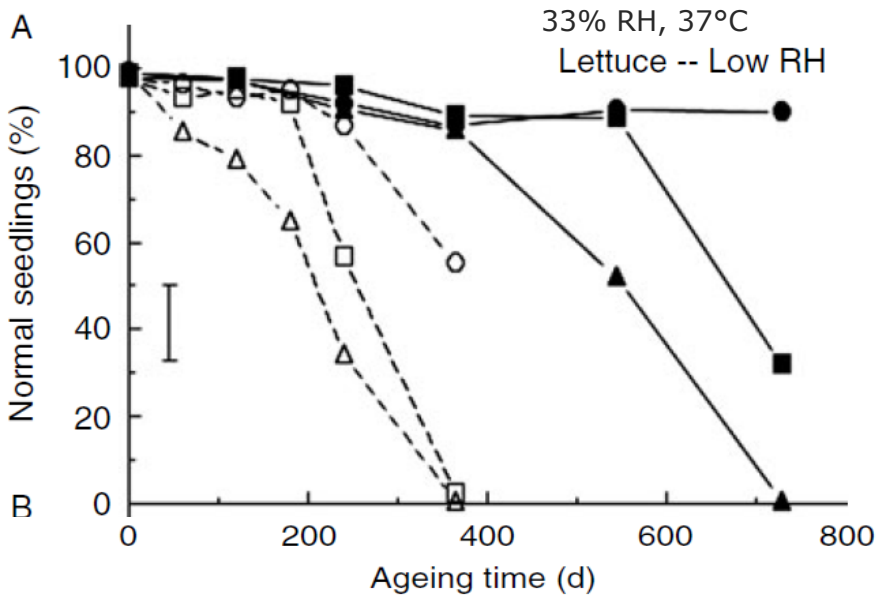


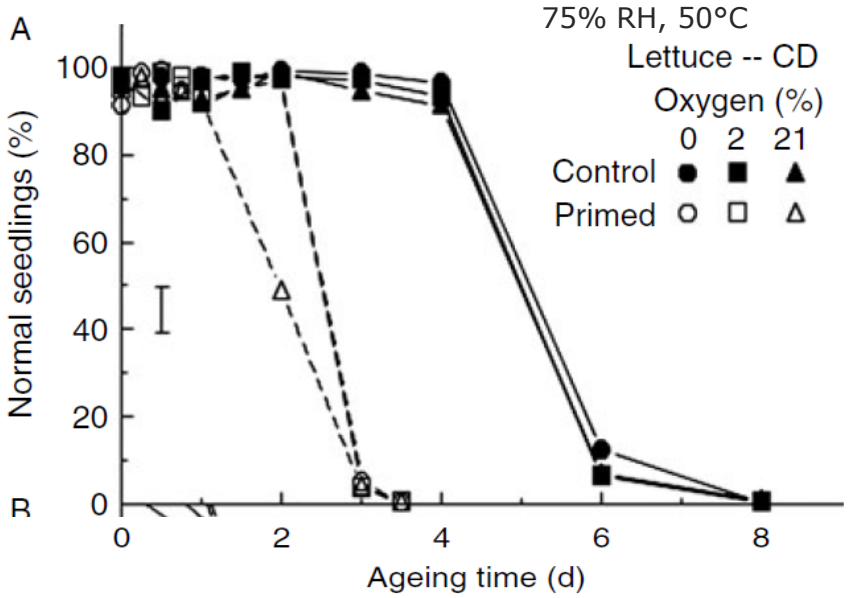
- Schwember and Bradford 2011. Seed Science Research 21: 175-185

WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Effect of different oxygen concentrations





- Schwember and Bradford 2011. Seed Science Research 21: 175-185

WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Factors affecting longevity in storage:

Seed moisture content

Storage temperature

Storage atmosphere

What is the quantitative effect of oxygen?

- **What is the relative effect of oxygen levels compared to temperature?**

- Project funded by government of the Netherlands and the seed companies Rijk Zwaan and Bejo

- Storage experiments lasted seven years

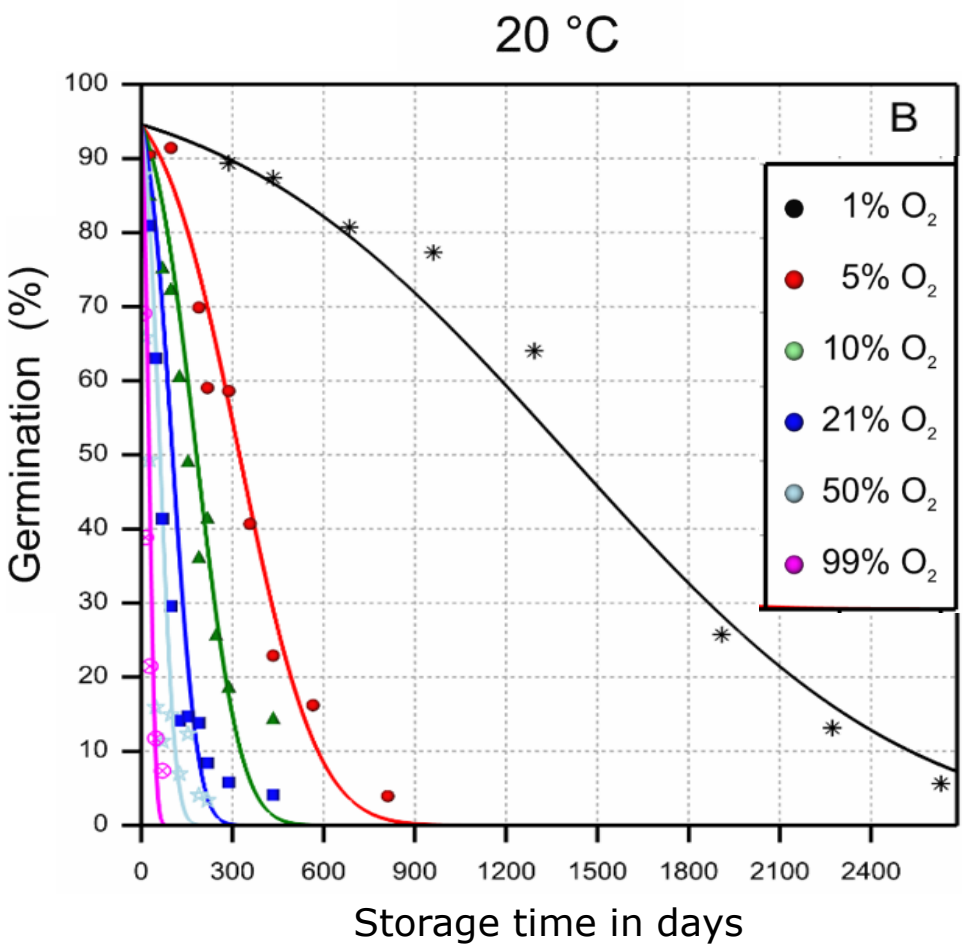
What is the quantitative effect of oxygen?

Seeds with a short shelf life were used: primed celery seeds

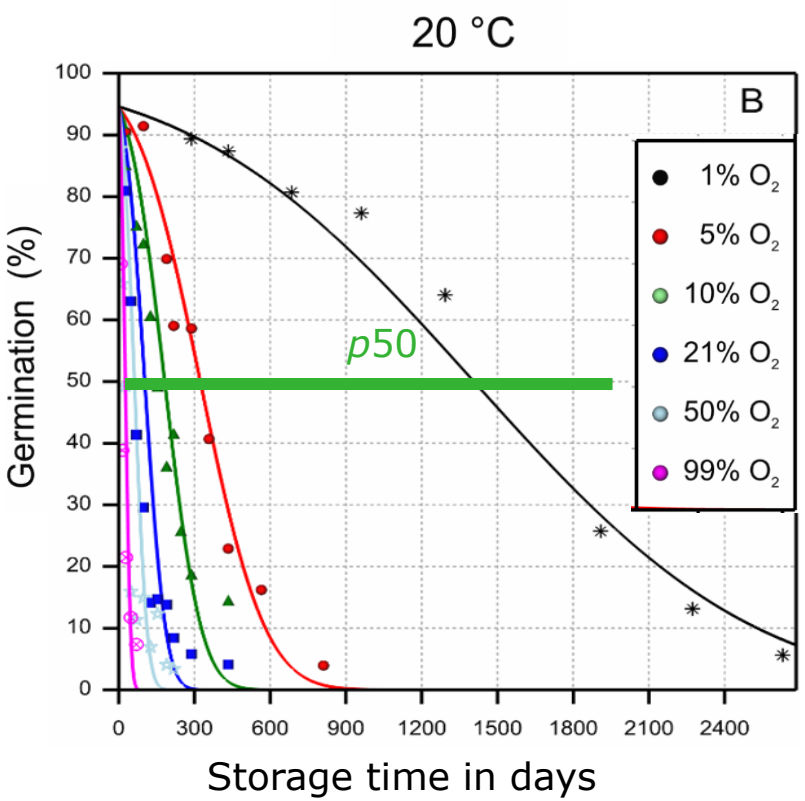
Controlled storage conditions :

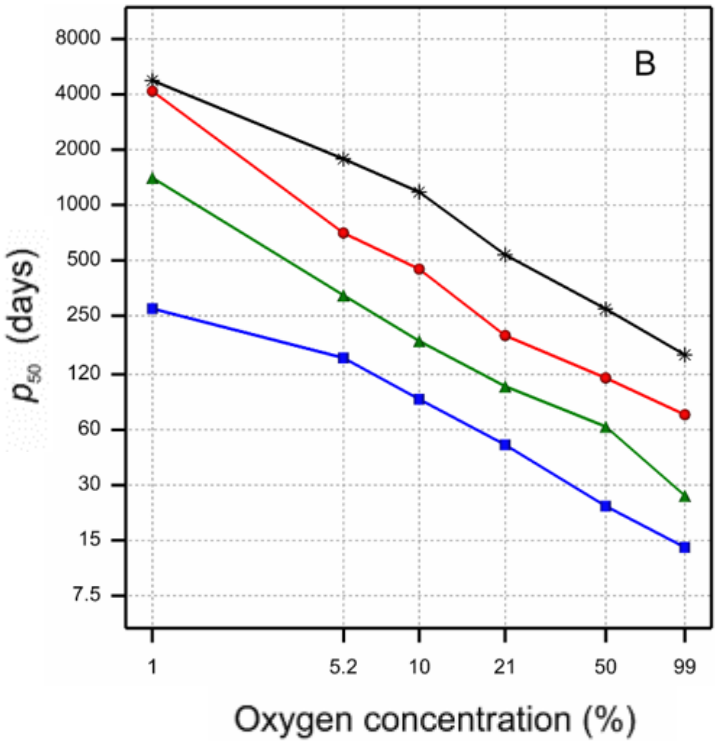
- Stable relative humidity in the container using buffering silica gel
- Stable temperature conditions using incubators
- Stable oxygen levels by flushing with mixtures of air, oxygen and nitrogen gas

Results primed celery seeds at 33% eRH

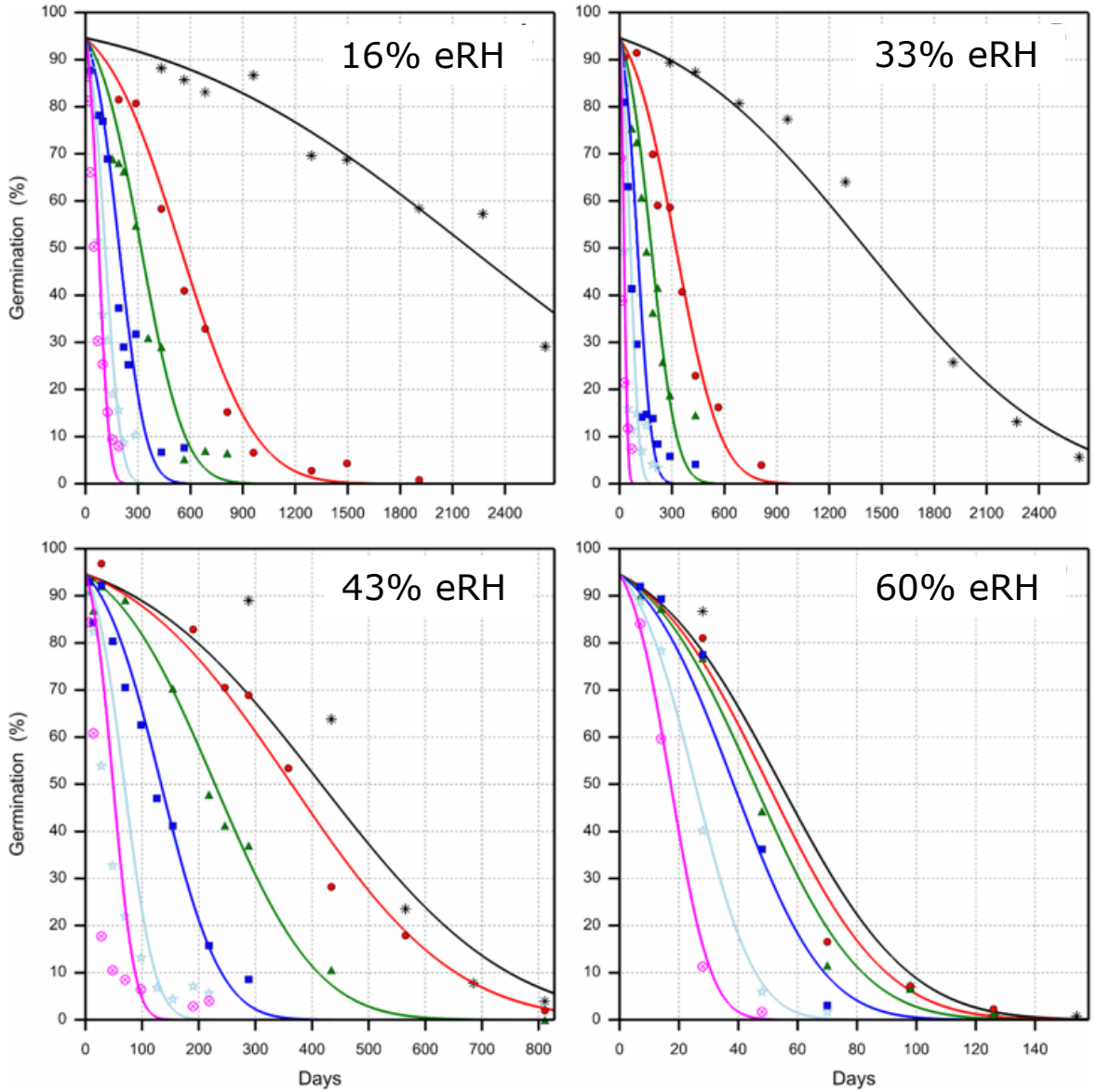


Effect oxygen on shelf life at 33% and 20°C

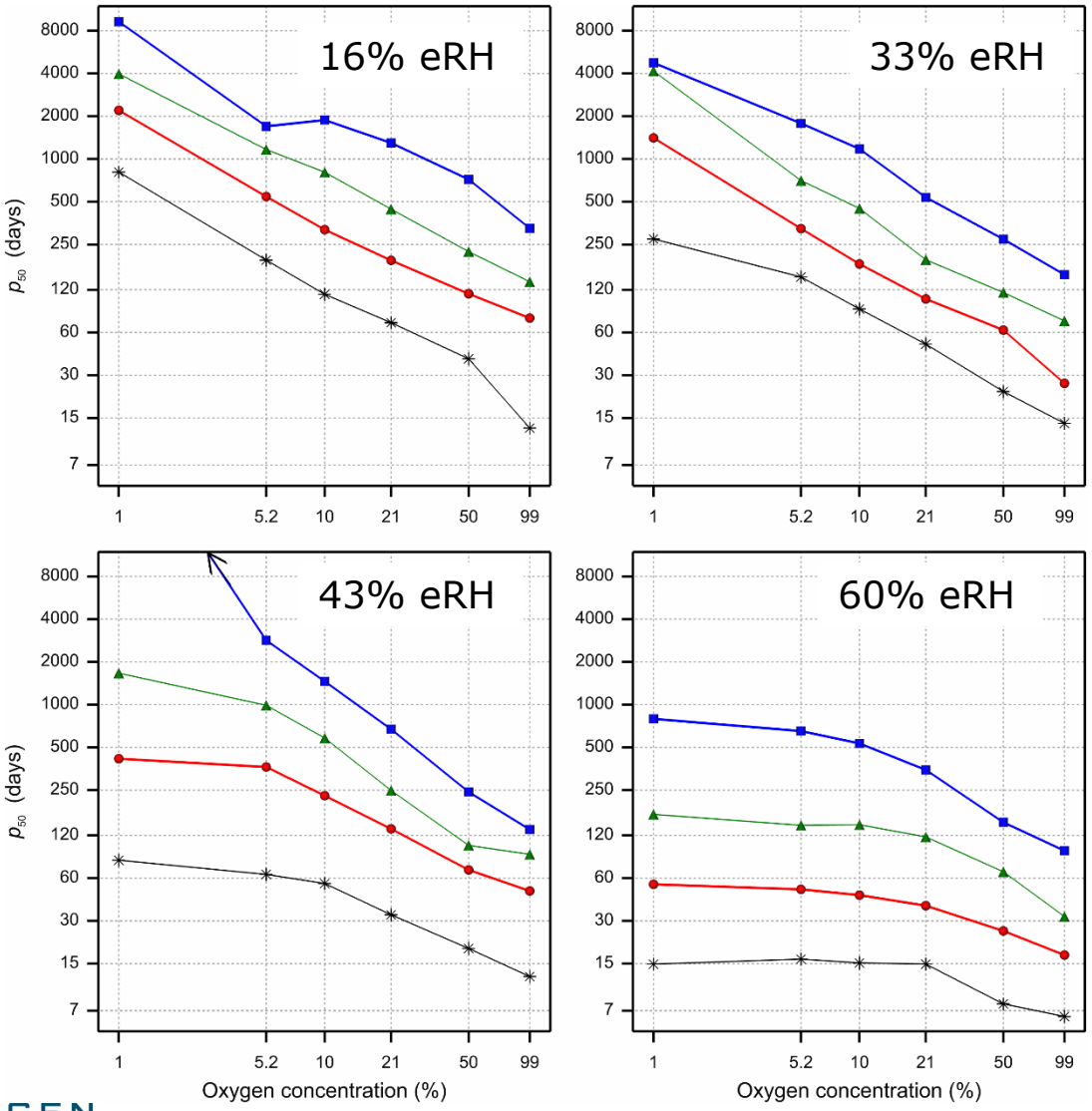




Results primed celery seeds at 20°C



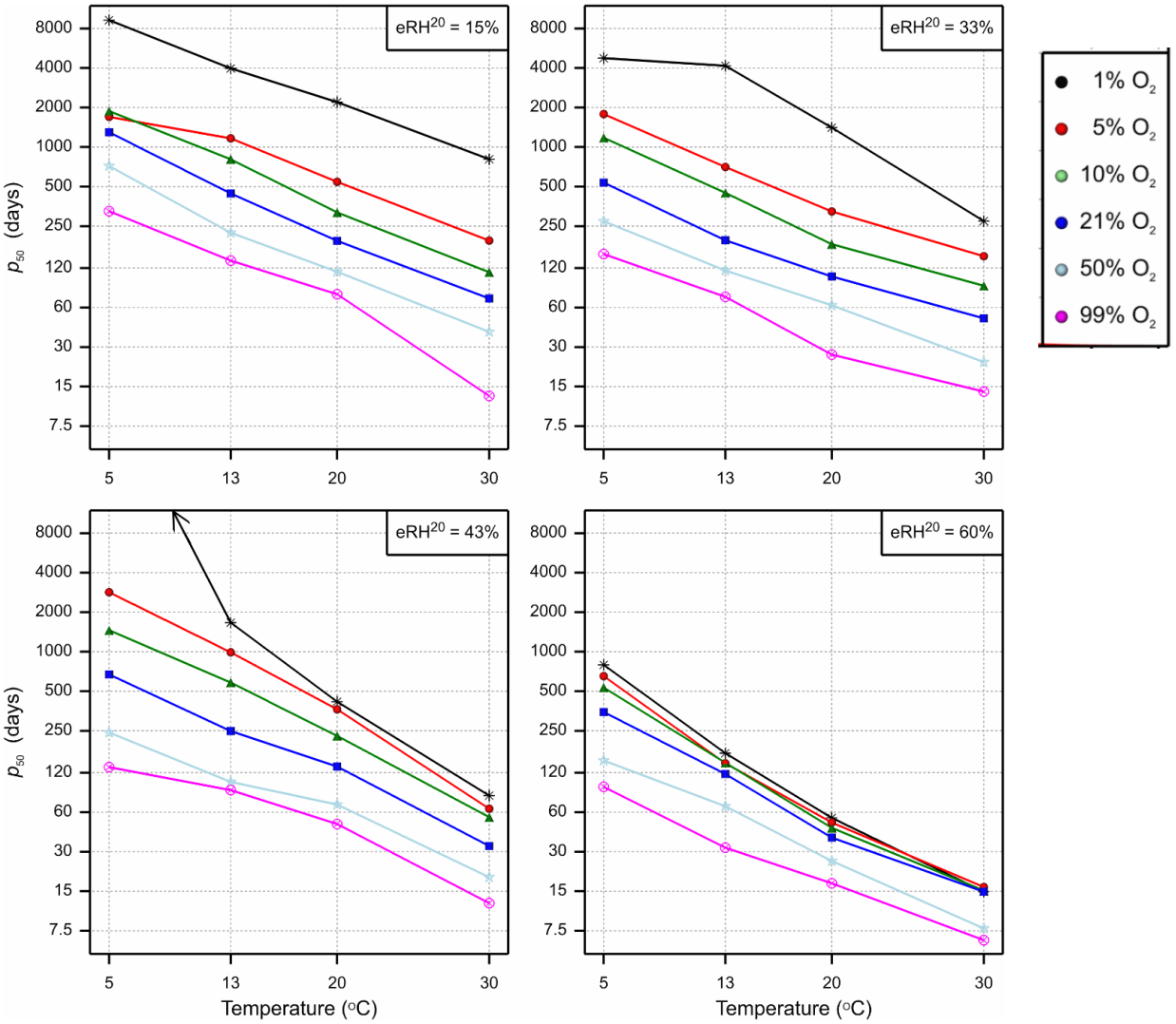
Relation oxygen and storage RH



WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

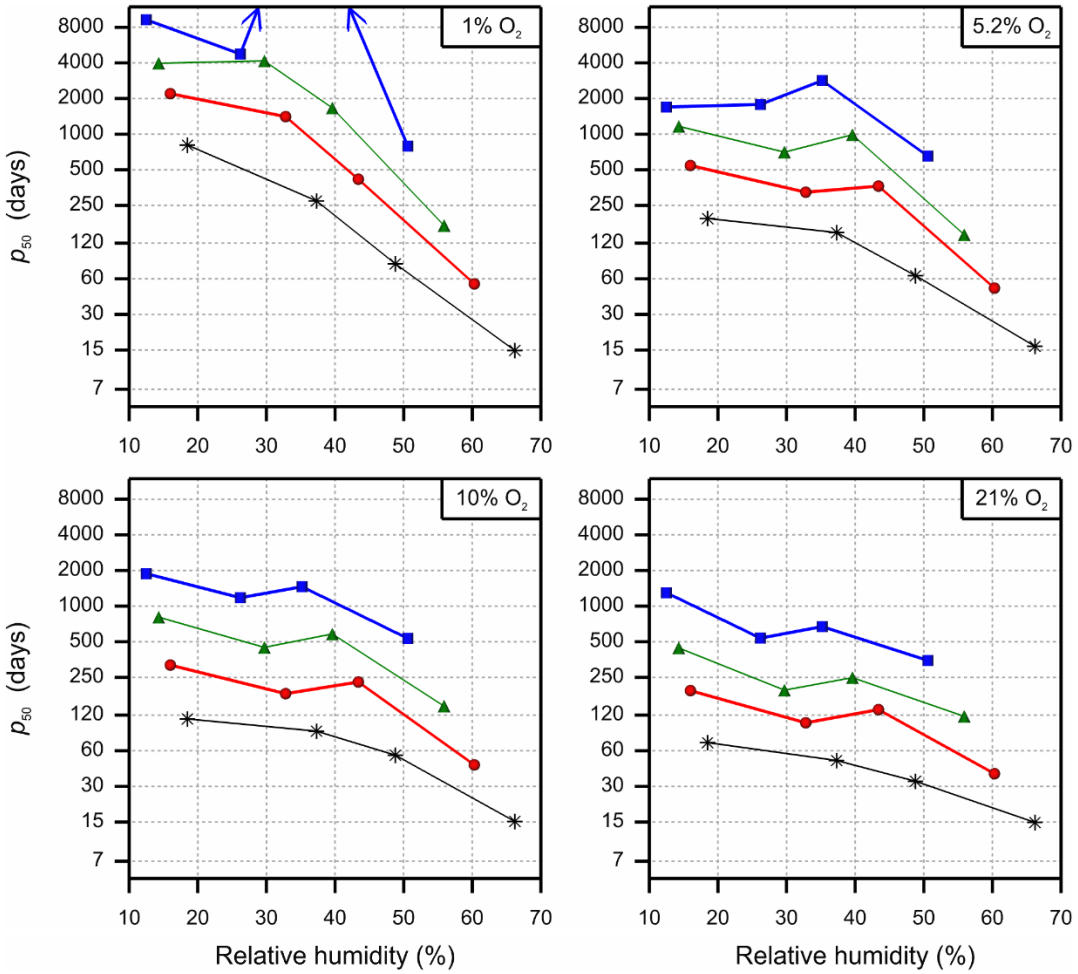
Relation oxygen and storage temperature



WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY

Relation oxygen and storage humidity



Quantitative model

$$v = K_i - p/10^{C_0 - C_1 TEMP - C_2 logOXY}$$

- For temperatures 5 – 30 °C and RH levels 16-43%: C1 = 1.8 and C2 = 1.7
- Shelf life extends by a factor 1.8 each time the oxygen concentration is halved
  - Oxygen 21% -> 3% gives 5 times longer shelf life
  - Oxygen 21% -> 1% gives 13 times longer shelf life
- Shelf life extends by a factor 1.7 each time the temperature drops by 5°C
  - Temperature 30 °C -> 15°C gives 5 times longer shelf life
  - Temperature 30 °C -> 5°C gives 15 times longer shelf life
- Oxygen and temperature effects are additive

How to store seeds under anoxia or low oxygen levels?

- Vacuum packaging
- Use of oxygen absorbers (iron powder)
- Nitrogen gas flushing

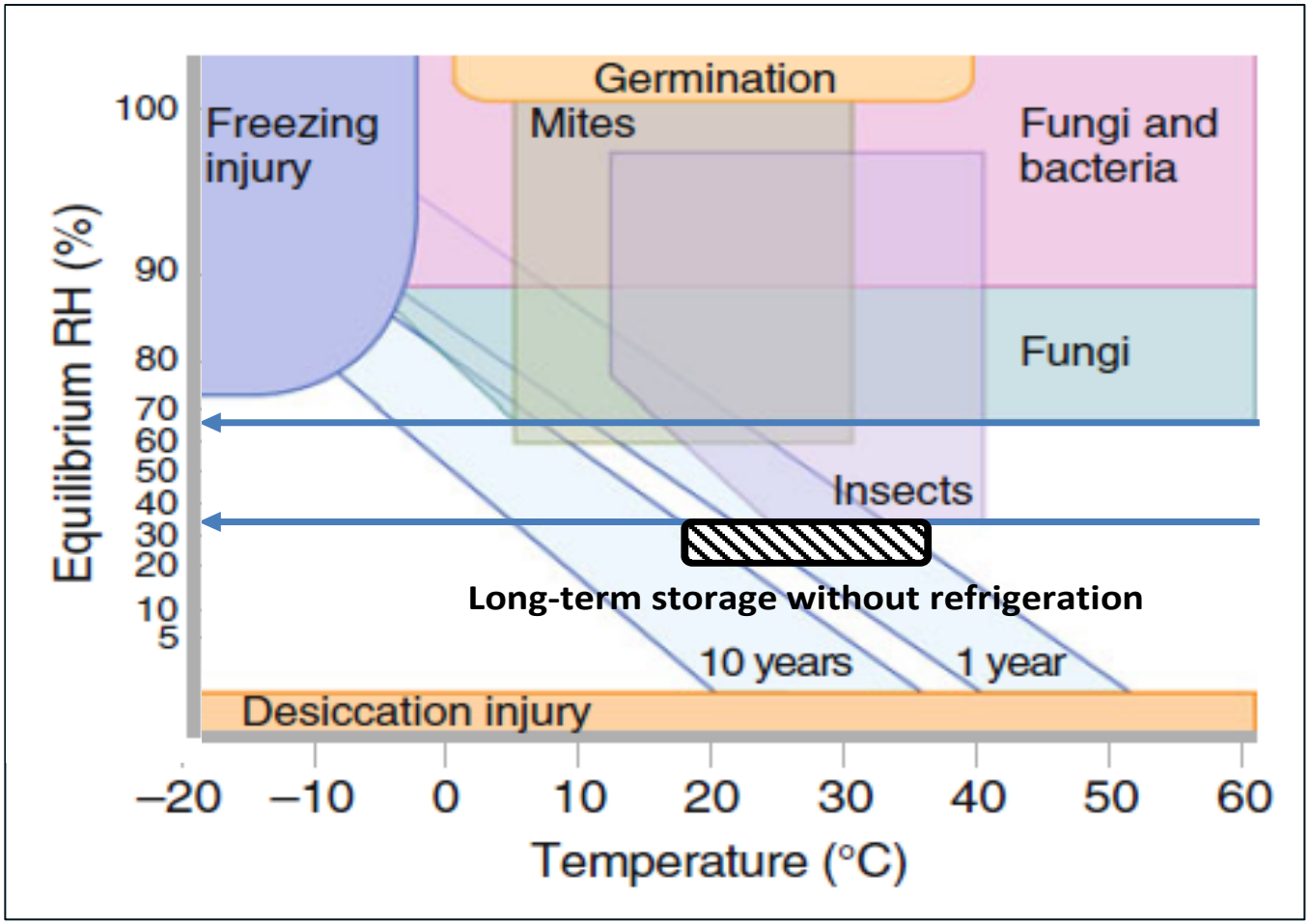
How to store seeds under anoxia or low oxygen levels

- The container should be moisture proof and air (oxygen) tight!

WAGENINGEN
UNIVERSITY & RESEARCH

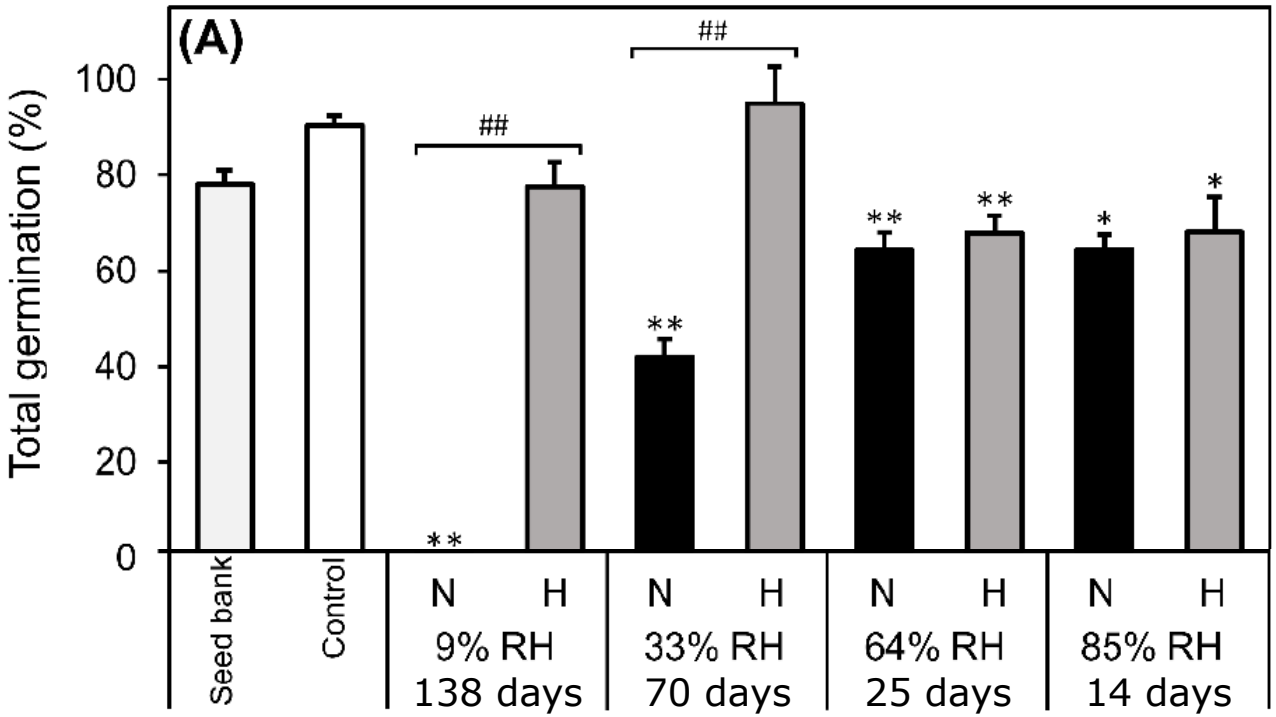
INTERNATIONAL ISA SEED ACADEMY

Oxygen interaction with Relative Humidity



Above ±70% RH seeds have respiration and need oxygen

Oxygen interaction with Relative Humidity

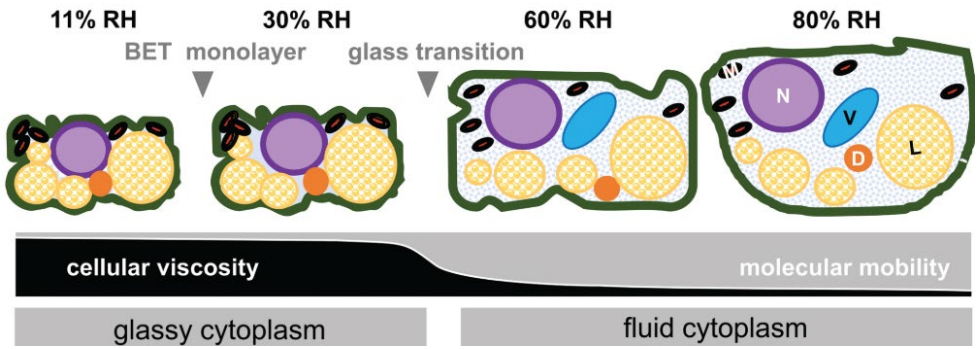


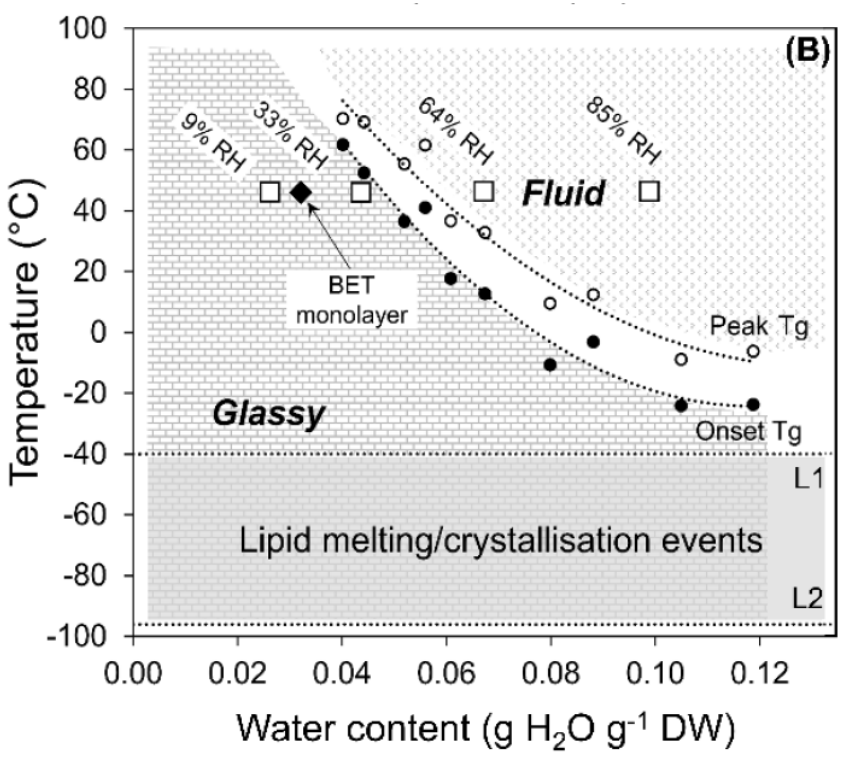
N = Normoxia (air), H = Hypoxia (± 0.5% oxygen), ageing at 45°C

Source: Gerna et al (2022) J of Exp Bot. 73(8), 2631-2649.

Anoxia does extend shelf life at 45 °C and 9 or 33% RH but not at 64 or 85% RH

Oxygen interaction with Relative Humidity



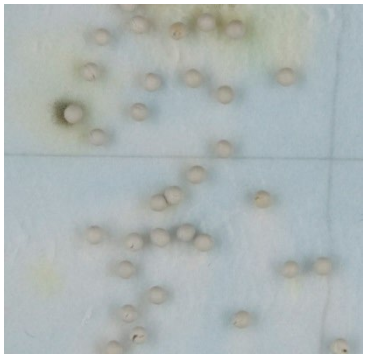


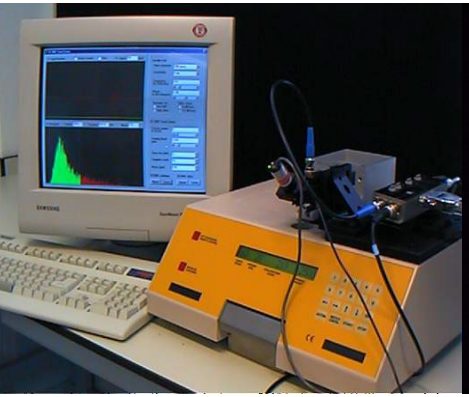
Source: Gerna et al (2022) J of Exp Bot. 73(8), 2631-2649

Conclusions

- Dry seeds to maximum in equilibrium with 50% RH, preferably to 30 or even 20% RH
- Storage at lower temperature extends shelf life with a factor of 1.7 each time temperature is 5° cooler
    - *Cooled warehouses are expensive to build and run*
- Storage with reduced oxygen levels extends shelf life with a factor 1.8 each time oxygen levels are halved
    - *Reducing oxygen levels needs cheap till expensive equipment, depending on the volume*
- Store hermetically to avoid uptake of moisture and oxygen
- For genebank storage a combination is recommended

Questions?


WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL
ISA
SEED ACADEMY

Contact

Steven P.C. Groot

International Seed Academy

E-mail: steven@seedacademy.org
Websites: https://seedacademy.org
www.researchgate.net/profile/Steven_Groot/

WAGENINGEN
UNIVERSITY & RESEARCH

INTERNATIONAL ISA SEED ACADEMY