Bewaring van zaaizaad

1 December 2015,
Steven P.C. Groot

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Seed longevity

- Most seeds are desiccation tolerant and can survive storage in a dry state, called orthodox seeds
- Some seeds are not desiccation tolerant, these are called recalcitrant seeds (e.g. *Quercus robur*)
- Longevity of desiccation tolerant seeds may vary, but there is evidence of survival for about 2000 years

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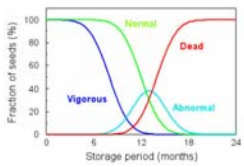
Seed longevity

- Seeds eventually deteriorate during storage
  - Germination rate drops
  - Less vigorous seedlings
  - Total germination drops



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The period for which seeds can remain viable is greatly affected by:

- Quality at the time of collection
- Treatment between collection and storage
- Conditions of storage
  - Moisture content
  - Temperature
  - Oxygen
- Genetics (crop, variety)

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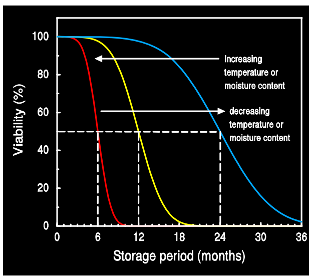
Rules for Seed Storage



James' Rule:
Temp (°F) + eRH (%) < 100
Temp (°C) + eRH (%) < 60

Harrington's Rule:
Seed longevity decreases by one-half for every 1% increase in moisture content or every 10°F (6°C) increase in temperature.

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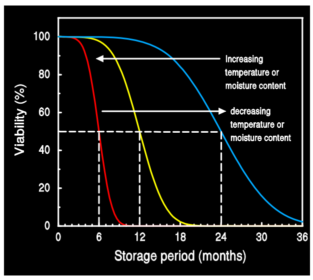
Rules for Seed Storage



Car rule
"The distance your car can drive depends on the amount of fuel and the economy in its use"

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Seed Moisture Content

Oven method: weigh seeds, dry in oven, weigh again. The difference is the weight of water in the original sample.

Fresh weight basis (%): $\frac{\text{weight of water} \times 100}{\text{initial total weight}}$

Dry weight basis (%): $\frac{\text{weight of water} \times 100}{\text{final dry weight}}$

Low constant temperature method: 103 ºC for 17 h

High constant temperature method: 130 ºC for 1 h (small seeds), 2 h for cereals, 4 h for maize

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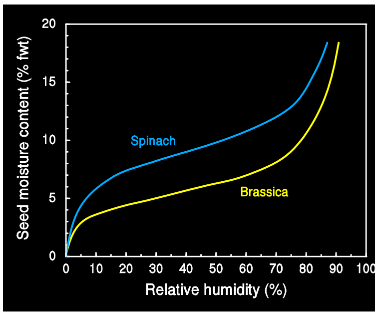
Seed Moisture Isotherms



The relationship between seed MC and ambient RH at a given temperature is called a moisture isotherm.

Seed composition, particularly oil content, results in different seed MCs at the same RH.

Volume in the seed occupied by lipids excludes water, so seed MC decreases as lipid content increases.

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Seed Moisture Content vs. Relative Humidity at 20 °C

Crop	Relative Humidity (%)				
	15	30	45	60	75
	Seed moisture content, fresh weight basis (%)				
Pea	6.0	8.6	10.8	13.1	15,.6
Rice	5.9	8.5	10.7	12.9	15.4
Onion	4,.9	7.0	8.9	10.8	13.0
Lettuce	4.1	5.9	7.5	9.1	11.0

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Water Activity (a_w) is related to MC in non-oil part

www.rotronic.com/

- Water activity (a_w) (= RH/100)
- Seeds with different composition store more similarly when at the same equilibrium a_w than when at the same MC.

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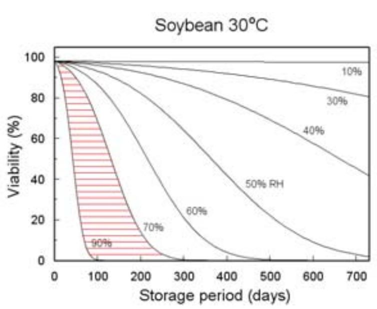
Relative Humidity and Seed Longevity



Seed longevity is dramatically affected by RH (MC), particularly as RH increases above about 40%.

http://data.kew.org/sid/viability/

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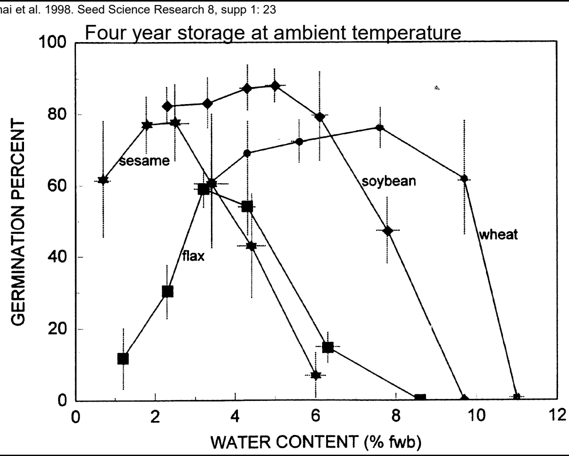
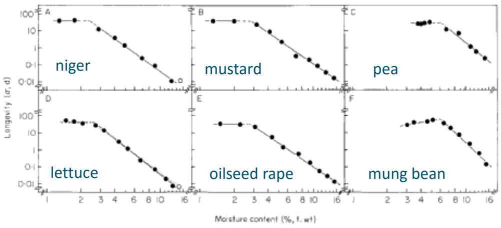
Chai et al. 1998. Seed Science Research 8, supp 1: 23



Seed Moisture Content and Seed Longevity



The relationship between lower MC and increased longevity holds for many seeds down to between 2 and 6% MC, depending upon species.

From Ellis, Hong & Roberts (1989) *Annals of Botany* **63**: 601-611.

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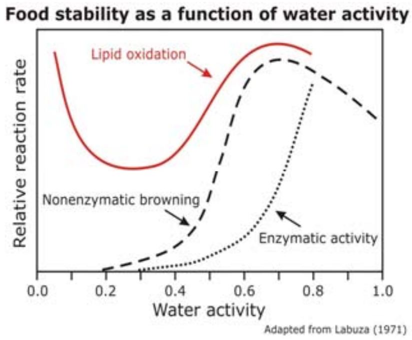
Oxidative damage in food science



At low water activities lipid oxidation is enhanced

After:
Labuza, T.P. (1971) Kinetics of lipid oxidation in foods. CRC Critical Reviews in Food Science and Technology, 2: 355-405

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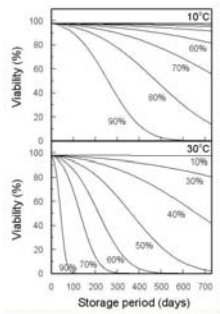
Temperature, RH and Seed Longevity



Reducing the temperature can prolong seed storage life, but is less effective at high RH.

The combination of warm temperatures and high RH (high seed MC) is particularly damaging to seeds and can result in very short storage lives.

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Packaging and Long-Term Storage

- In open storage, seed MC varies with RH
- Controlled climate ware house can maintain low MC
- Hermetic storage keeps a_w constant and oxygen limited

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Is cold storage in refrigerator or cold store room advisable?

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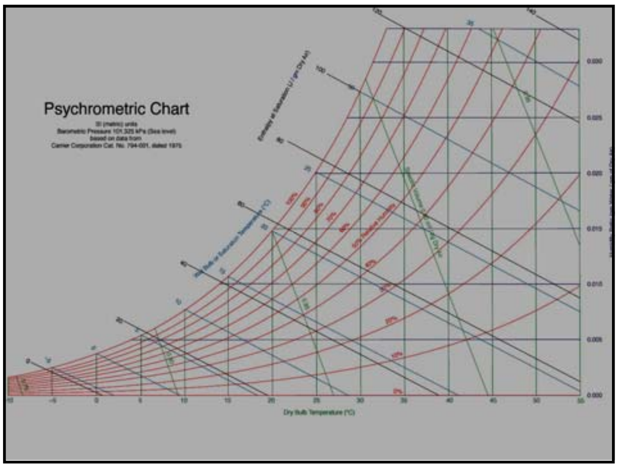
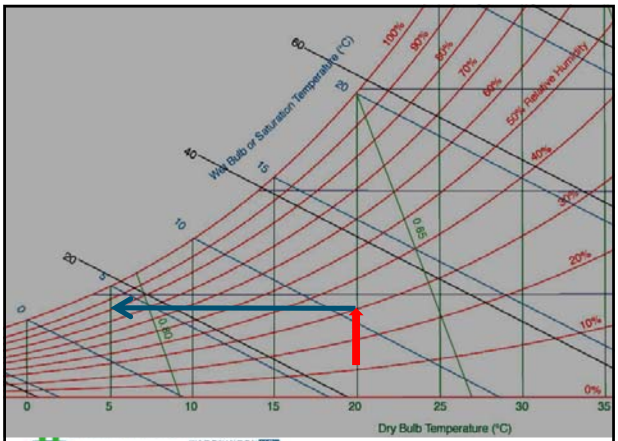
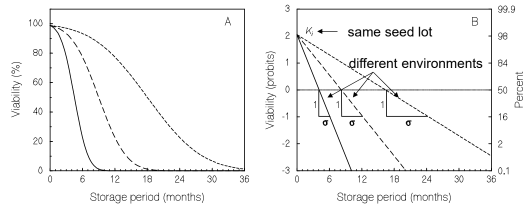


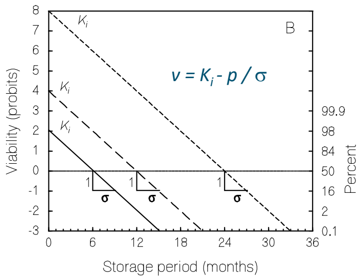


Storage Environment Affects the Rate of Seed Deterioration



The same seed lot stored in different environments will lose viability with different slopes on a probit scale. The intercept (K_i) is an index of initial seed quality, and is obviously a single value for a single seed lot.

Seed Viability Equation



The seed viability equation describes the relationship between seed longevity, the initial seed quality and the storage environment.

Ellis RH, Roberts EH (1980) *Ann. Bot.* 45: 13-30.

Temperature and Moisture Content Effects on Seed Longevity

$$\text{Log } \sigma = K_E - C_W \log m - C_H T - C_Q T^2$$

$$v = K_i - p / \sigma$$

σ = slope of the probit viability loss line
K_E = species constant
C_W = constant relating to moisture content
m = seed moisture content (fresh weight basis)
C_H = linear temperature constant
C_Q = quadratic temperature constant
T = storage temperature

Ellis RH, Roberts EH (1980) *Ann. Bot.* 45: 13-30.

Seed Viability Utility

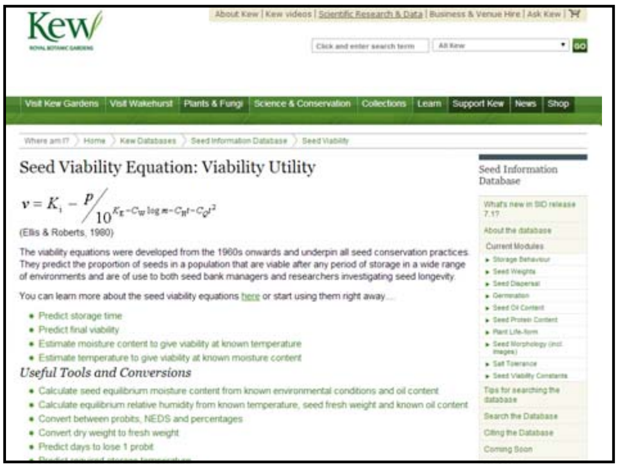
The Kew Gardens web site has compiled the viability constants for many species and can do the calculations to predict storage life under any combination of temperature and seed moisture content.

http://data.kew.org/sid/viability

The Seed Information Database at Kew in general is a good site for information about seeds.

Calculating theoretical storability

- Web site Kew Gardens UK :
  http://data.kew.org/sid/viability
- Web tools for calculating seed moisture content in relation to temperature and relative humidity
- Web tool for calculating expected loss in viability



Calculating theoretical longevity

- Web site Kew Gardens UK: http://data.kew.org/sid/viability/
- Web tool for calculating expected loss in viability: http://data.kew.org/sid/viability/final_percent.jsp
- Web tool for calculating seed moisture content in relation to temperature and relative humidity http://data.kew.org/sid/viability/mc1.jsp?constid=0

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- Hier een voorbeeld invoeren van variatie in temperatuur en van variatie in eRH
- Days to loose one probit

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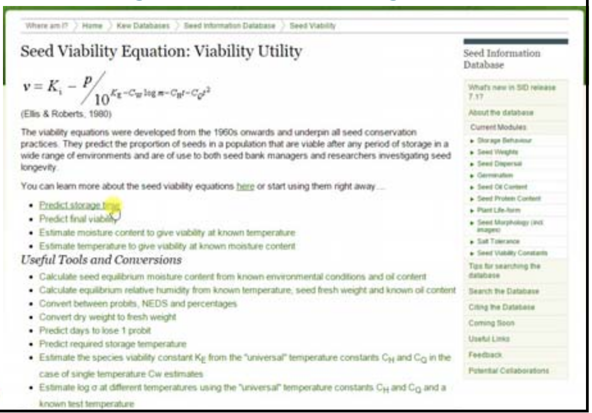
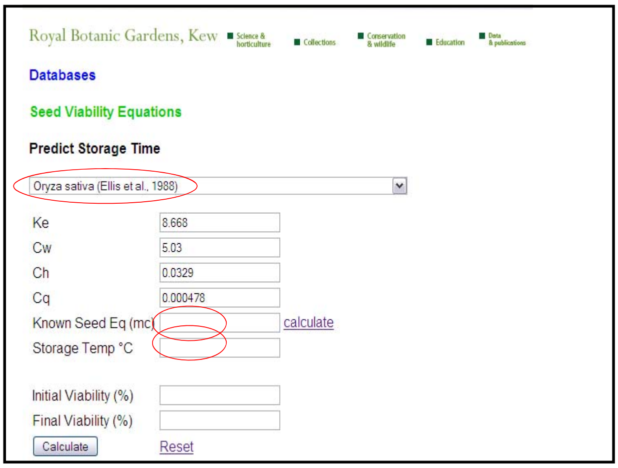
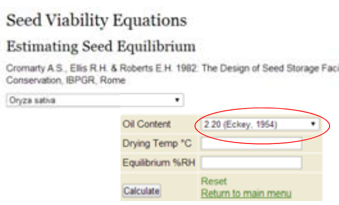
Simulating lettuce seed storage conditions





Screen shot Kew web sites



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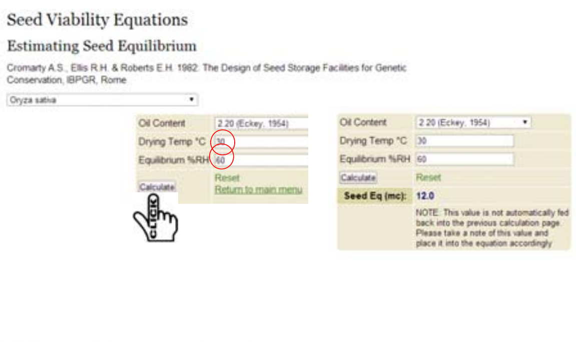

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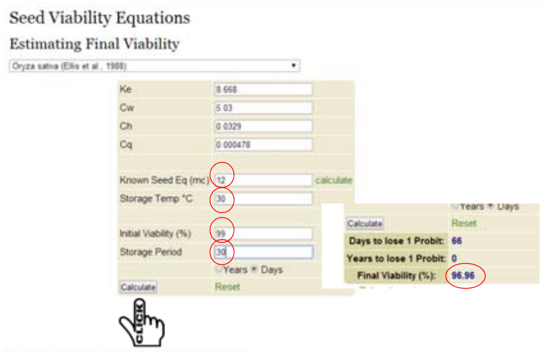
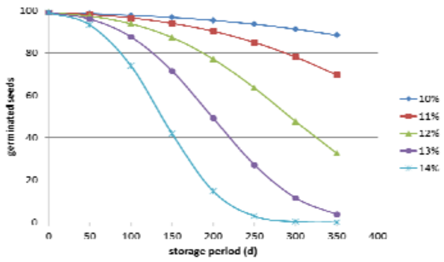
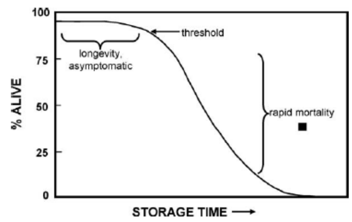


Rice seed viability loss at 30 °C (theoretical)



Seed moisture level has large effect on shelf life

Loss of Viability Shows a Threshold Pattern



Seeds tend to survive well during storage for a period of time, then die over a relatively shorter period.

The initial lag period is not well modeled by the Ellis-Roberts equation. It applies once viability begins to decline.

Threshold kinetics, deteriorative reactions proceed rapidly once a critical concentration of protection is lost or toxic substances accumulate. This may vary between tissues and cells within a seed.

Relative ageing rate lettuce seeds at 20 °C

Relative humidity during storage	Seed moisture content (FWB)	Days to loose 1 probit	Relative ageing rate
15%	4,1%	2966	0,22
30%	5,9%	643	1,0
45%	7,5%	235	2,7
60%	9,1%	104	6,2
75%	11,0%	47	13,7
90%	13,7%	19	33,8

In one day at 90% RH lettuce seeds age as much as in one months at 30% RH

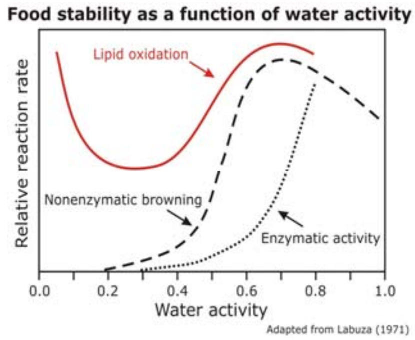
Factors affecting longevity in storage

Type of deterioration during harvest, drying and storage:

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

Oxidation!

Oxidative damage in food science



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The food industry packs seeds under anoxia

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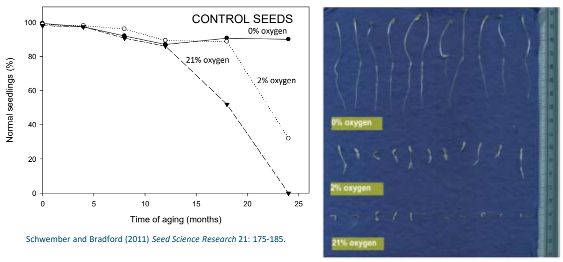
Oxygen and Seed Longevity



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

Reduced oxygen (0 or 2%) in the storage environment increased the longevity of lettuce seeds stored at 33% RH and 37°C.

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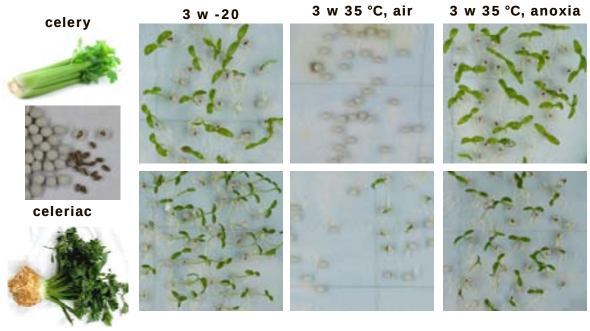
Do primed seeds survive longer under anoxia?



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Factors affecting longevity in storage:

Seed moisture content

Storage temperature

Storage atmosphere

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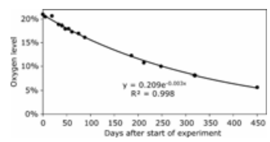
How to acquire low oxygen levels

- The container should be air (oxygen) tight
- Packaging under nitrogen or carbon dioxide gas
- Vacuum packaging
- Hermetic packaging
  - Residual oxygen levels will decline



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GrainPro bags

- GrainPro (Philippines)
- Provides bags and coverings that have a very low permeability for moisture and oxygen
- Kills also insects
- www.grainpro.com
- https://www.youtube.com/watch?v=iEb-Fs0TXC4

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Summary: Seed Drying and Longevity

- Seeds have a finite lifetime
- Seeds absorb and lose moisture in response to the humidity of their environment
- Seed longevity is very sensitive to moisture content and temperature
- Packaging to prevent moisture absorption extends storage life
- Low temperatures extend storage life
- Low oxygen level extends lifetime (with dry seeds)
- Hermetic packaging prevents moisture uptake and oxygen entry
- Seed storage behaviour can be estimated (approximately) using the seed viability equation and species specific constants
- Seeds can deteriorate via diverse mechanisms; reactive oxygen species leading to membrane, DNA and protein oxidation is a likely common mechanism

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Contact

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