# The role of oxygen in seed storage

DanSeed Symposium, 10 March 2015

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# Seed ageing during dry storage

Challenge for seed companies and gene banks:

- How to prolong shelf life of the seeds?

Challenge of desiccation tolerant seeds:

- How to survive the dry period?

# 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**

# What happens during seed storage?

Type of deterioration during harvest, drying and storage:

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

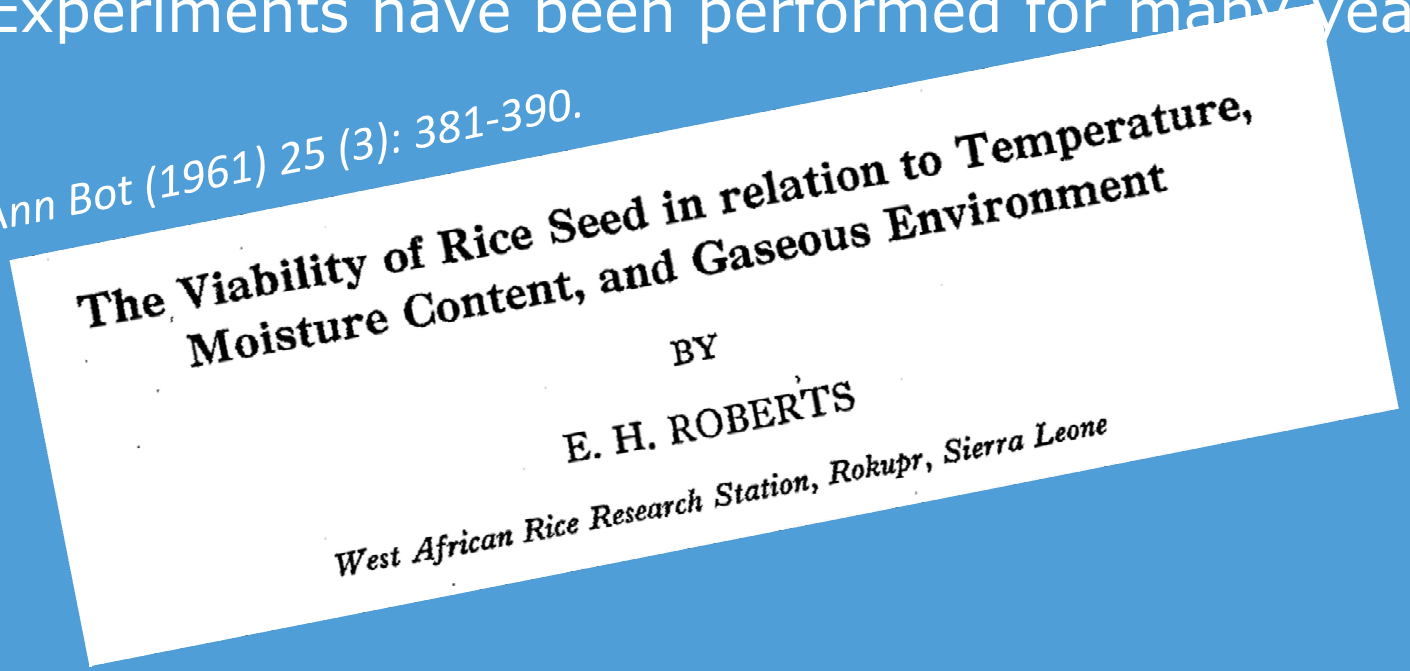
**Mostly oxidation!**

**Stimulated by high temperatures, moisture and ...**

# Can storage under anoxia improve shelf life?

- Experiments have been performed for many years

Ann Bot (1961) 25 (3): 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*

- Longevity of dry seeds is better maintained under anoxia
- However with relative moist seeds poor storage under anoxia

# Roberts EH. (1961)

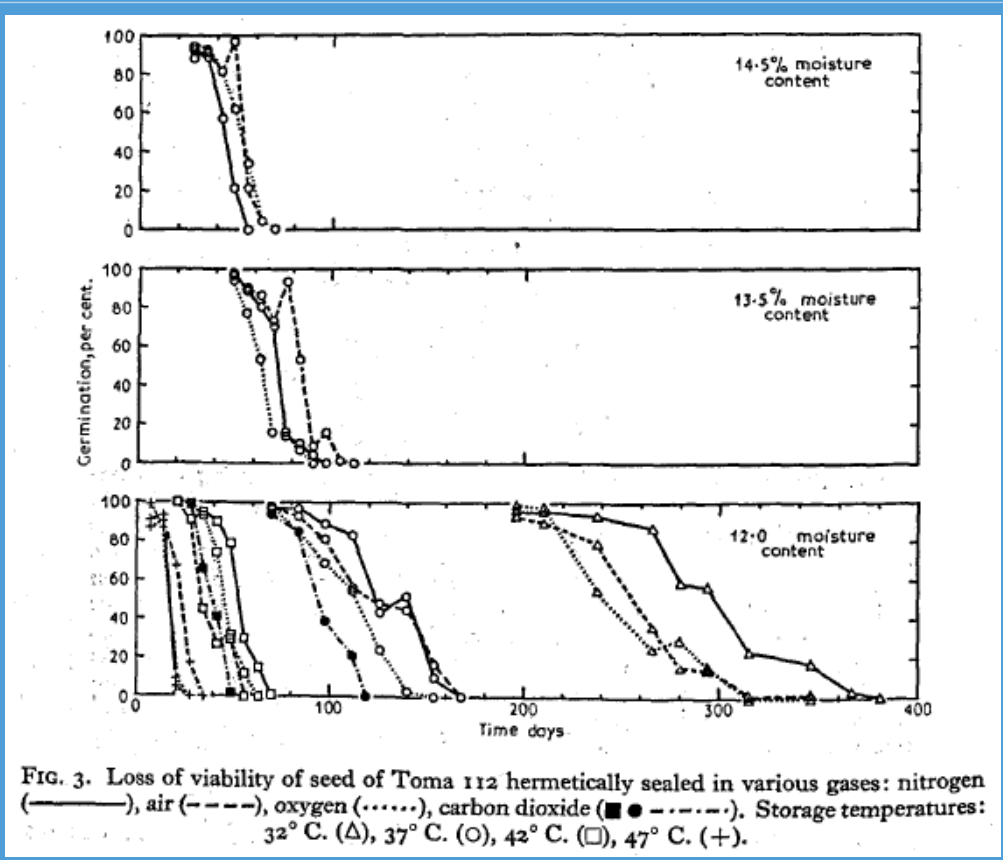
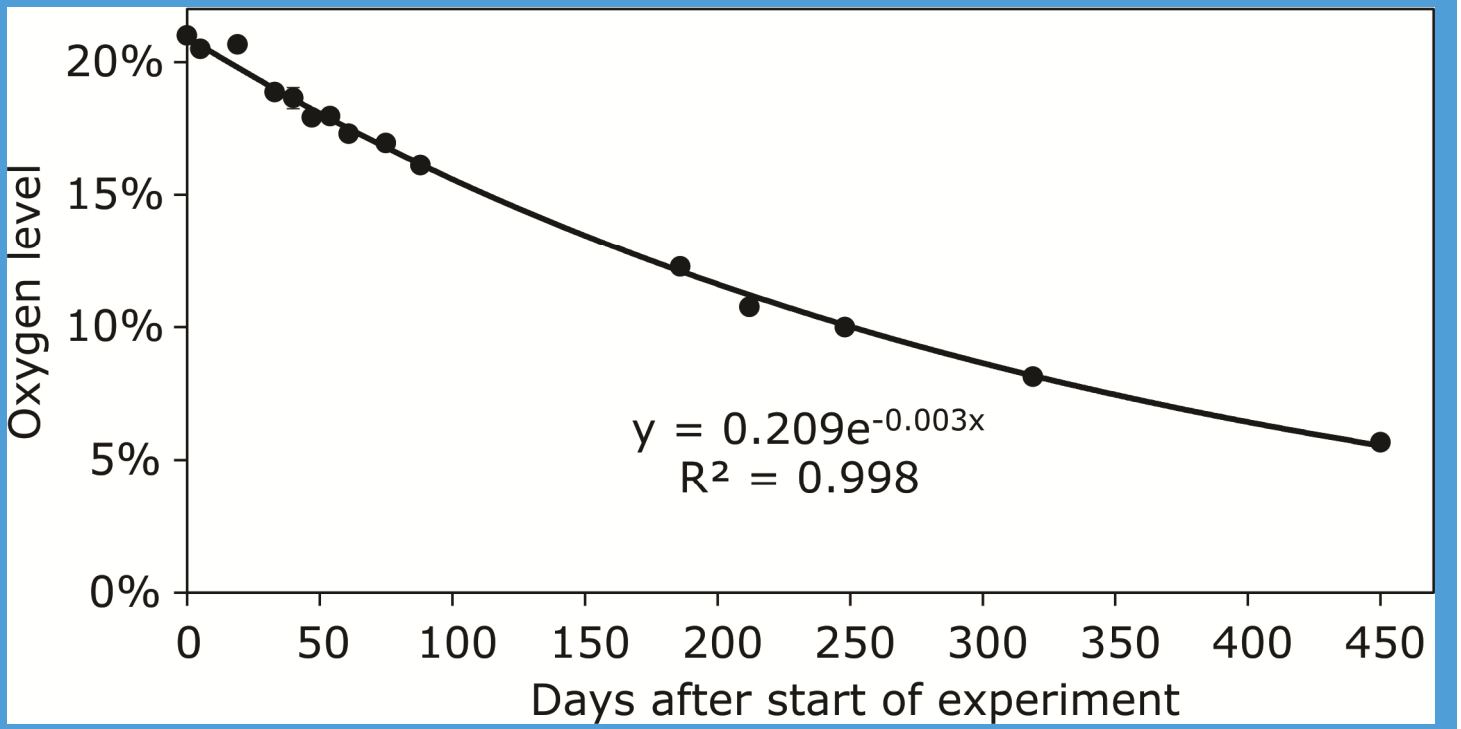



FIG. 3. Loss of viability of seed of Toma 112 hermetically sealed in various gases: nitrogen (———), air (– – – –), oxygen (·····), carbon dioxide (■ ● – · – · –). Storage temperatures: 32° C. (Δ), 37° C. (○), 42° C. (□), 47° C. (+).

- Roberts E.H. (1961) The viability of rice seed in relation to temperature, moisture content, and gaseous environment. Ann Bot 25, 381-390.

# Oxygen uptake by dry seeds




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

# Can storage under anoxia improve shelf life?

- The food industry packs seeds under anoxia

# Dry seeds can survive longer under anoxia

- Roberts E.H. (1961) The viability of rice seed in relation to temperature, moisture content, and gaseous environment. Ann Bot 25, 381-390.
- Hong, T.D., Ellis, R.H., Astley, D., Pinnegar, A.E., Groot, S.P.C. and Kraak, H.L. (2005) Survival and vigour of ultry-dry seeds after ten years hermetic storage. SST 33: 449–460.
- Pérez-Garcia F. González-Benito M.E. and Gómez-Campo C. (2007) High viability recorded in ultra-dry seeds of 37 species of Brassicaceae after almost 40 years of storage. SST 35: 143-153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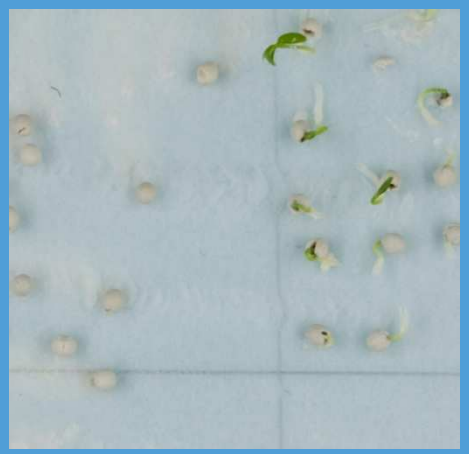
# Dry seeds can survive better under anoxia

**celery**

**celeriac**

**3 w -20 °C, foil pouches**

**3 w 35 °C, jar with drying beads, air**



**3 w 35 °C, jar with drying beads, anoxia**

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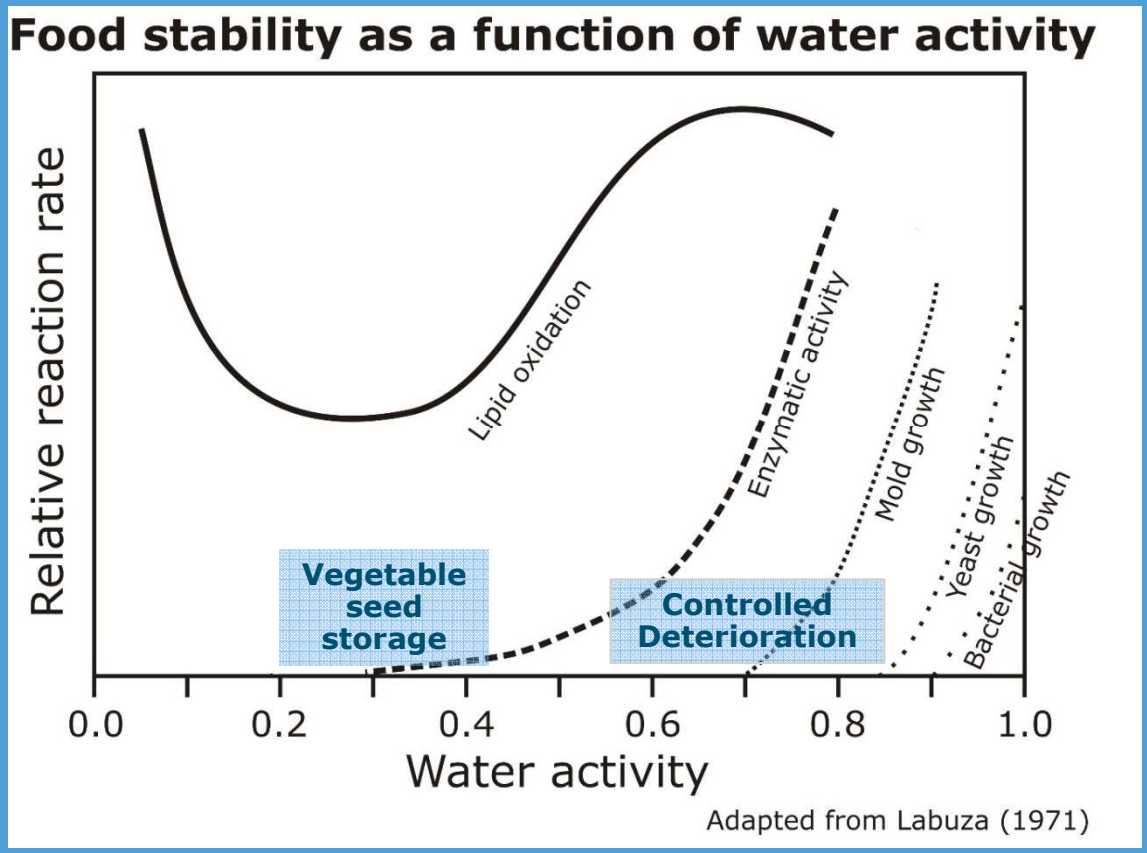
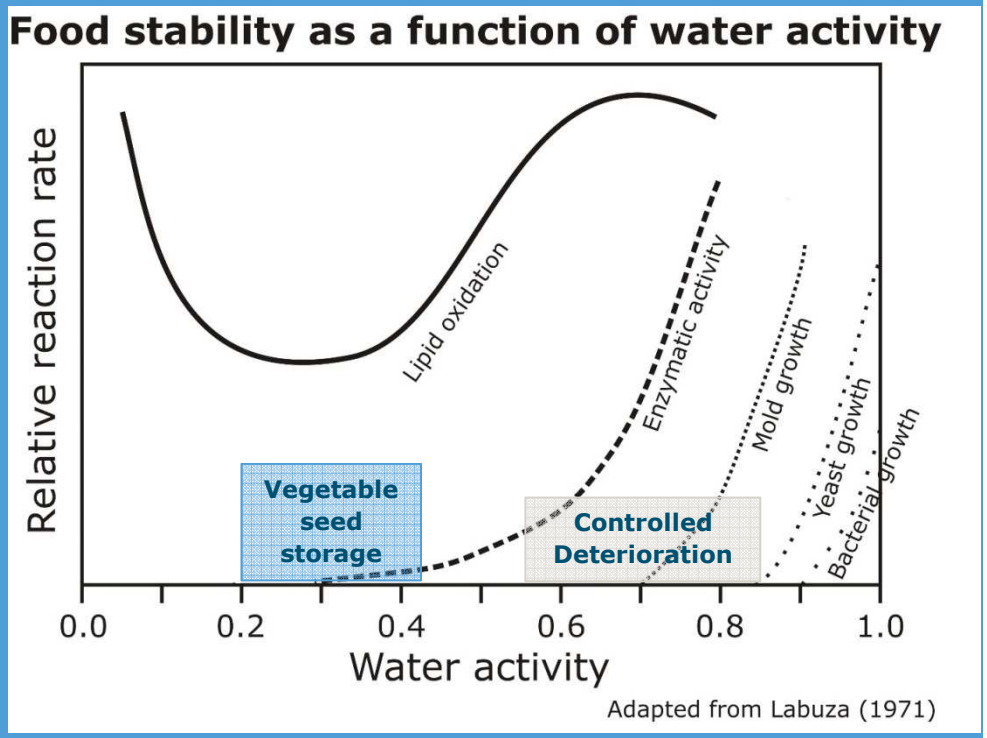
# The physiology of the seed differs with the moisture level

- Molecular mobility low at low eRH
- Under dry conditions < ±40% eRH no enzyme activity
- Under relative moist conditions > ±60% eRH enzyme activity



# Prediction of longevity

- Do CD conditions predict seed longevity under commercial storage conditions?
- Not very well for primed lettuce seeds
- Is there an alternative artificial seed ageing method?



# Oxygen and seed ageing in dry conditions

If low oxygen prolongs seed longevity with dry seeds, can increased oxygen levels accelerate the aging with dry seeds?

**Nitrogen**

**Air = 21% oxygen**

**100 % oxygen**

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# Storage under elevated partial pressure of oxygen $P_{O_2}$

- In atmospheric air:
  $P_{O_2}$ air = 21% x 1 bar
  = 0.21 bar

# Storage under elevated partial pressure of oxygen $P_{O_2}$

| | $P_{O_2}$ |
|---|---|
| Air at sea level | 0.21 bar |
| Pure oxygen at sea level | 1.0 bar |
| Air in SCUBA tank (200 bar) | 42 bar |
| Pure oxygen in SCUBA tank | 200 bar |

# Storage under elevated partial pressure of oxygen (EPPO)

- 18 Mpa (180 bar) air or pure oxygen
- 1 bar air and 18 Mpa (180 bar) nitrogen and helium as controls
- RH controlled (5-85%)
- Temperature 20 °C
- Storage 1 / 7 weeks

Groot et al. (2012) Ann Bot 110:1149-1159

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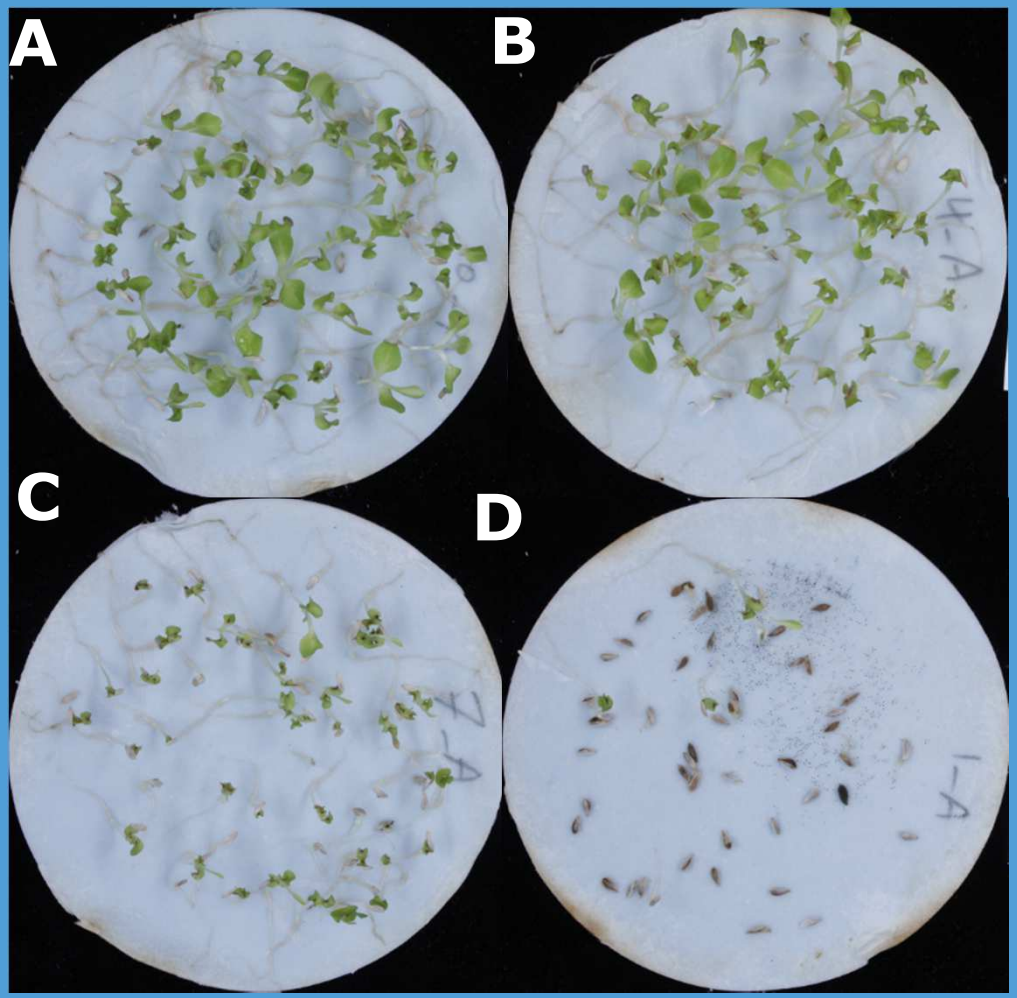
# 3 year old lettuce seed lot




A
4 w air
1 bar
$PO_2$ = 0.21 bar

B
4 w $N_2$
180 bar
$PO_2$ = 0.21 bar

C
4 w air
180 bar
$PO_2$ = 38 bar

D
4 w $O_2$
180 bar
$PO_2$ = 179 bar

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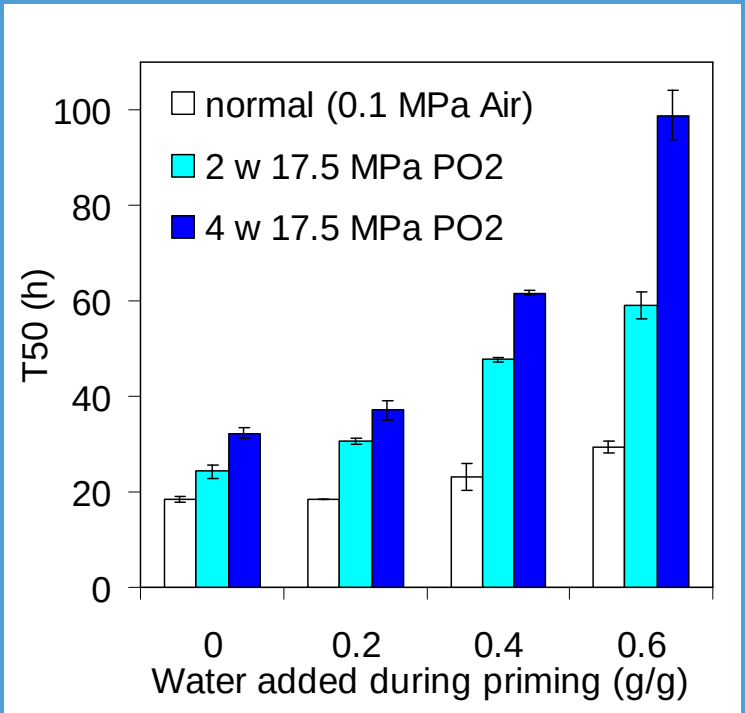
# Primed lettuce seeds



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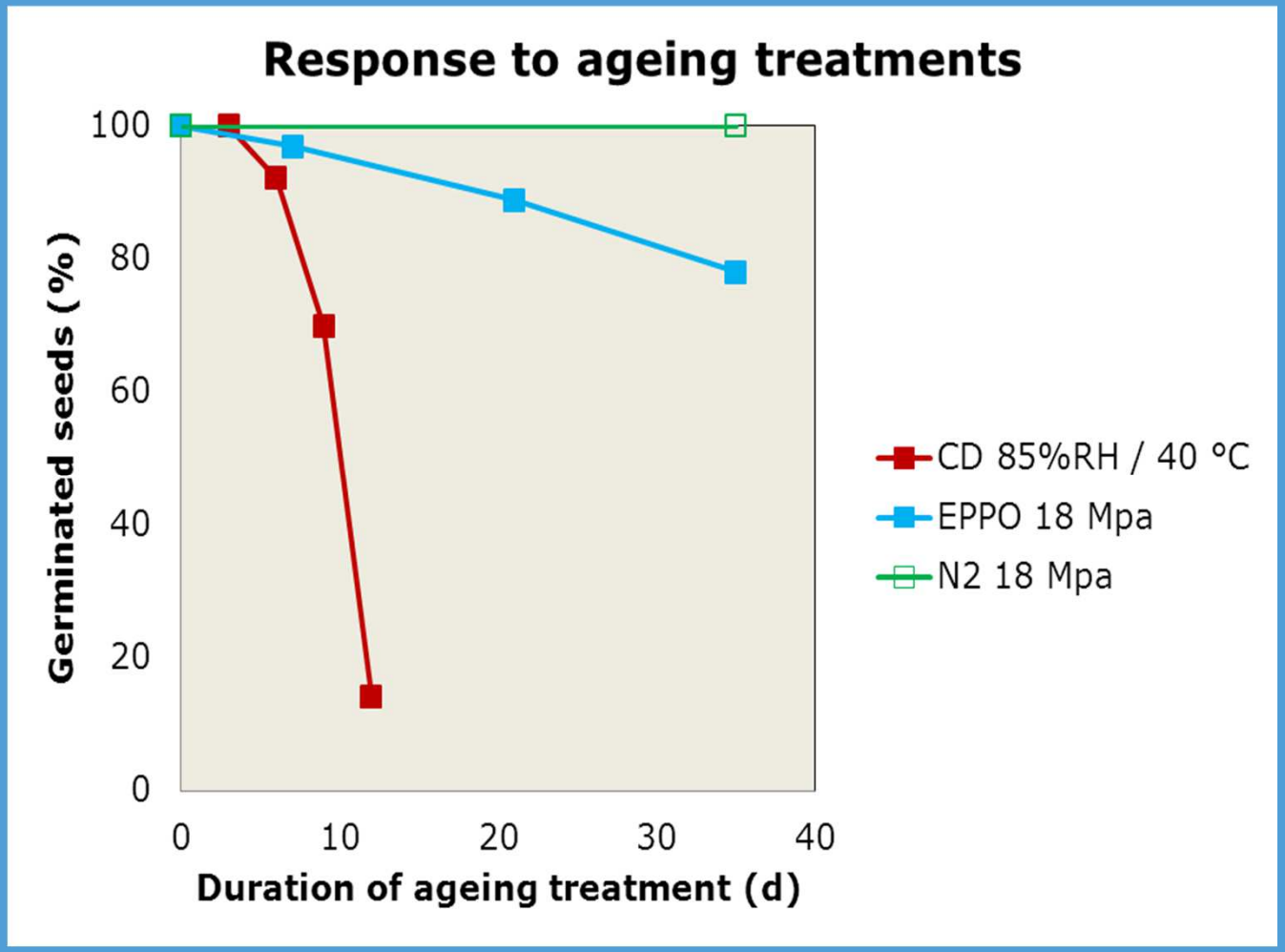
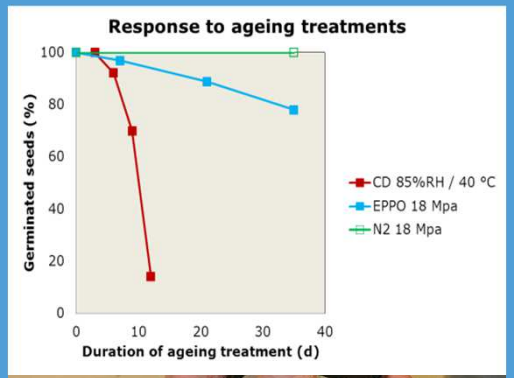
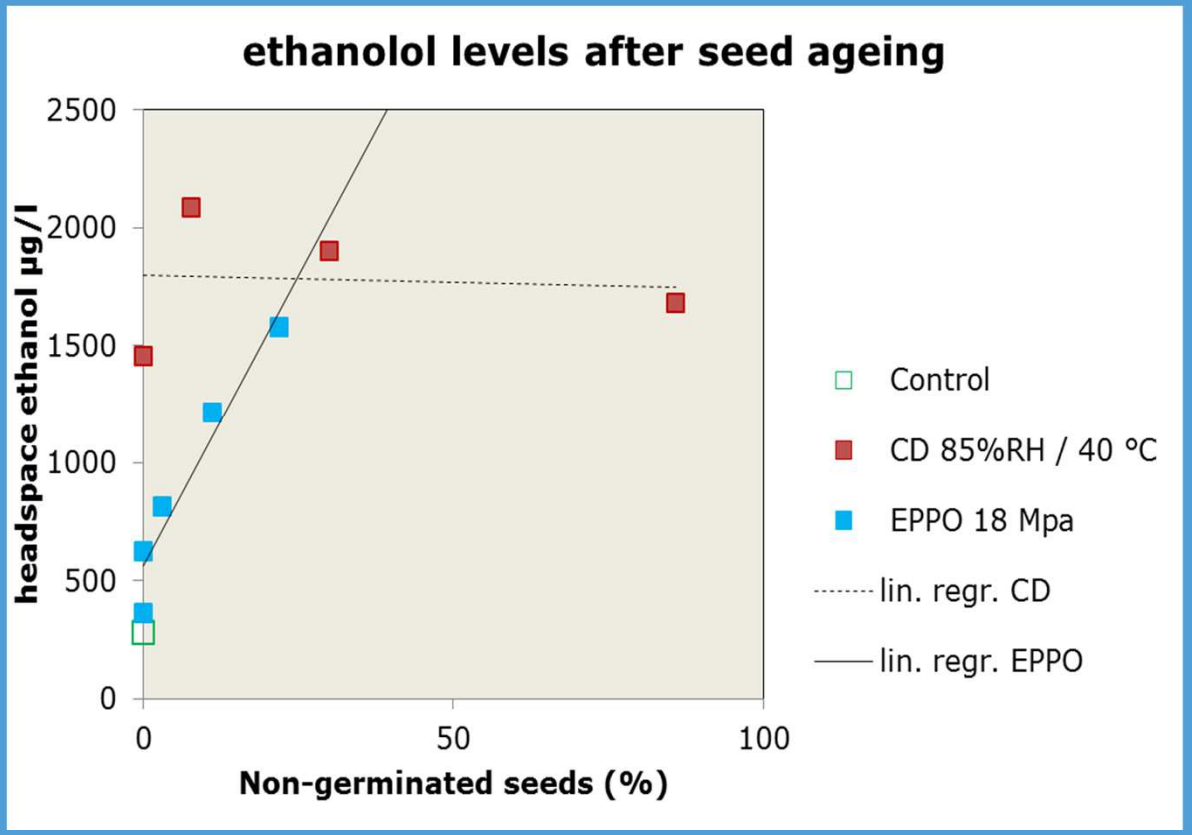
# Effect cabbage seed storage on germination



# Effect cabbage seed storage on mitochondria

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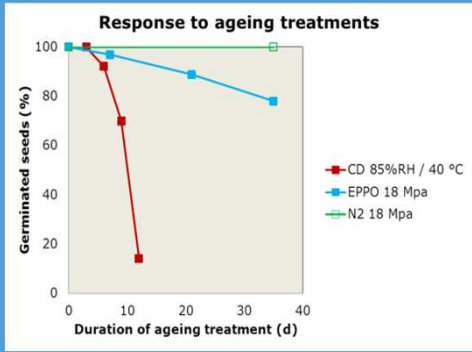
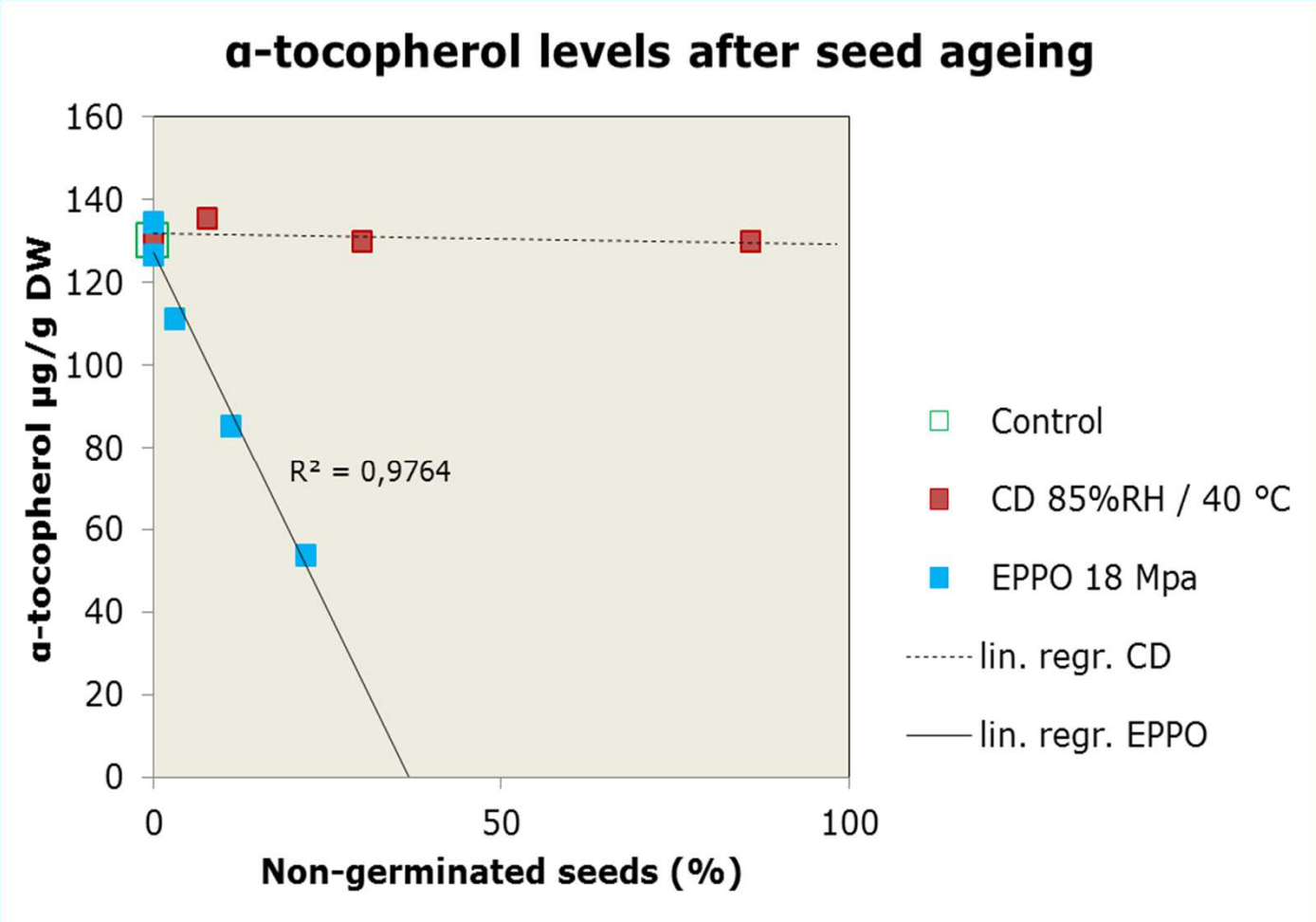
# Effect cabbage seed storage on vitamin E

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# Factors affecting longevity in dry storage:

**Seed moisture content**

**Storage temperature**

**Oxygen in storage environment**

# Conclusions

- Dry seeds ‘bind’ oxygen
- Low oxygen levels delay seed ageing
- Increased oxygen levels can accelerate ageing
- EPPO storage is a tool to study artificial seed ageing under dry conditions
- Aging under moist conditions differs from ageing under dry conditions
- Dry seeds cannot repair damage
- Aging starts directly after harvest

# Considerations

- Aging starts directly after harvest
- Dry seeds cannot repair damage
- Limitation of damage by oxidation relies on remaining anti-oxidant activity
  - Vitamin E
  - Phenolic compounds
  - Storage proteins
  - ...

# Recommendations

- Analyse for what type of seeds shelf life extension is important
  - Onion seeds?
  - Primed seeds?
  - ...
- Analyse the storage chain: where can you reduce the rate of oxidation?
  - At the company: before processing, during bulk storage?
  - Consumer containers?
- What is economically feasible and most efficient?
  - Drying deeper
  - Cooler storage
  - Anoxia storage

# Acknowledgements


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# Seed research at Wageningen UR

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