Symposium

Seed drying, a key step in maintaining seed vigour

seedmeets technology

Program

13:30-13:35	Opening	Arjan Stolte, ASP – Quality Support BV
13:35-14:00	Perspectives from the seed	Steven Groot, International Seed Academy
14:00-14:20	The main drying systems, with their (dis) advantages	Johan van Asbrouck, Rhino Research
14:20-14:45	How to optimize drying efficiency and save energy.	Jan Appelman, Agratechniek
14:45-15:00	Discussion and closing	Arjan Stolte, ASP – Quality Support BV

seedmeets technology

Seed drying

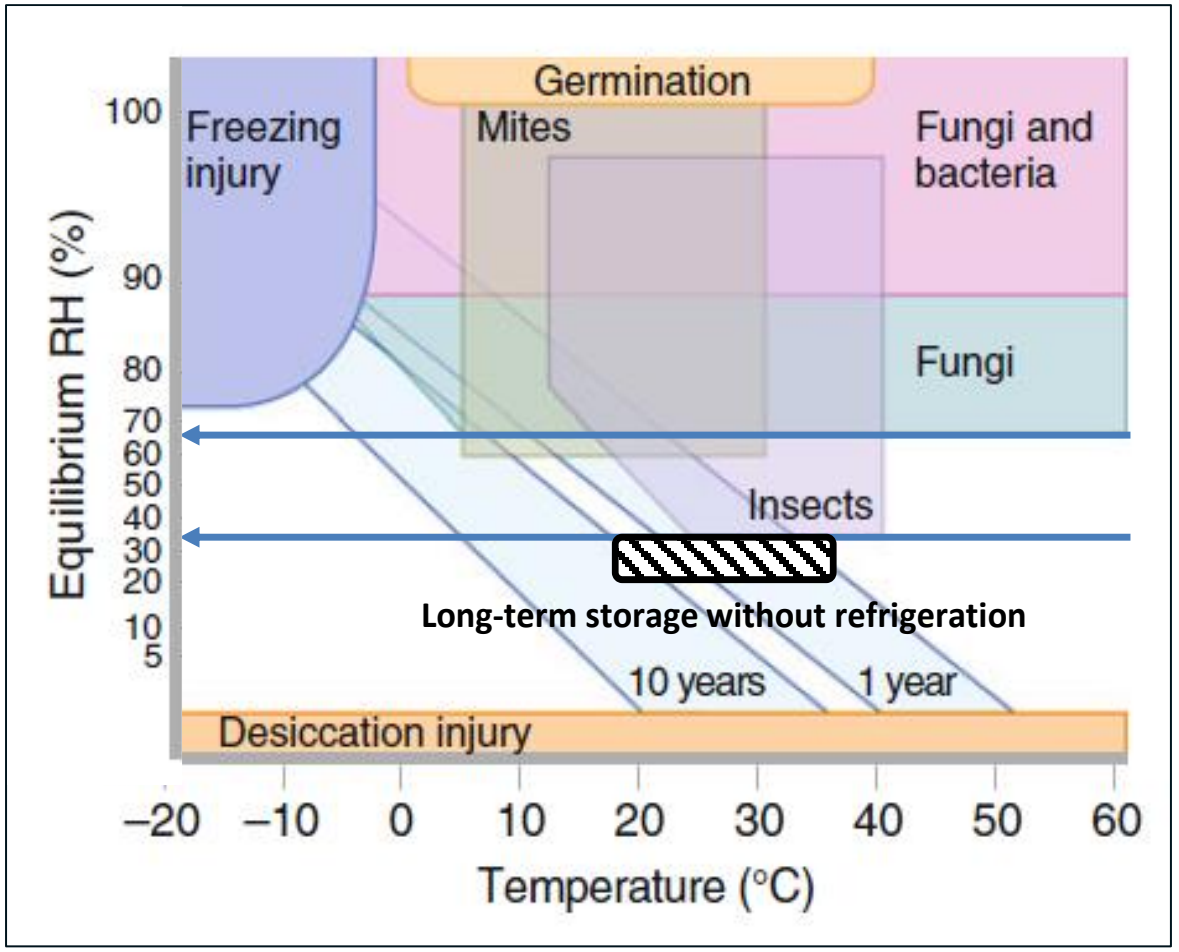
Perspectives from the seed

Steven P.C. Groot

Seed drying
Perspectives from the seed

Steven P.C. Groot, International Seed Academy Netherlands
26-09-2023

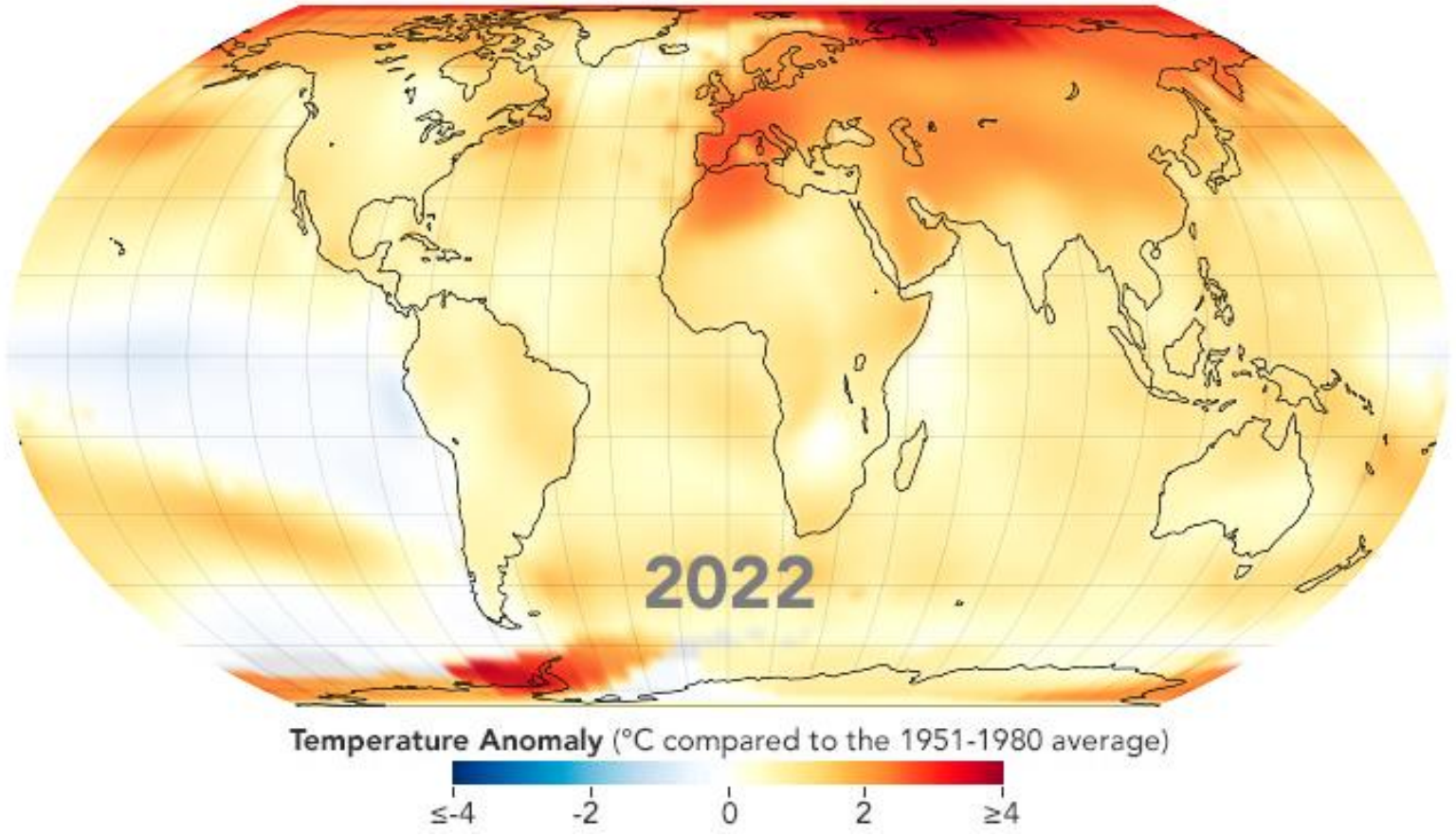
Drying is needed to prevent deterioration



Source: Roberts EH (1972) Viability of Seeds. Chapman and Hall Ltd., Syracuse, NY, pp 14-58.

INTERNATIONAL ISA SEED ACADEMY

Climate change demands more resilient seedlings



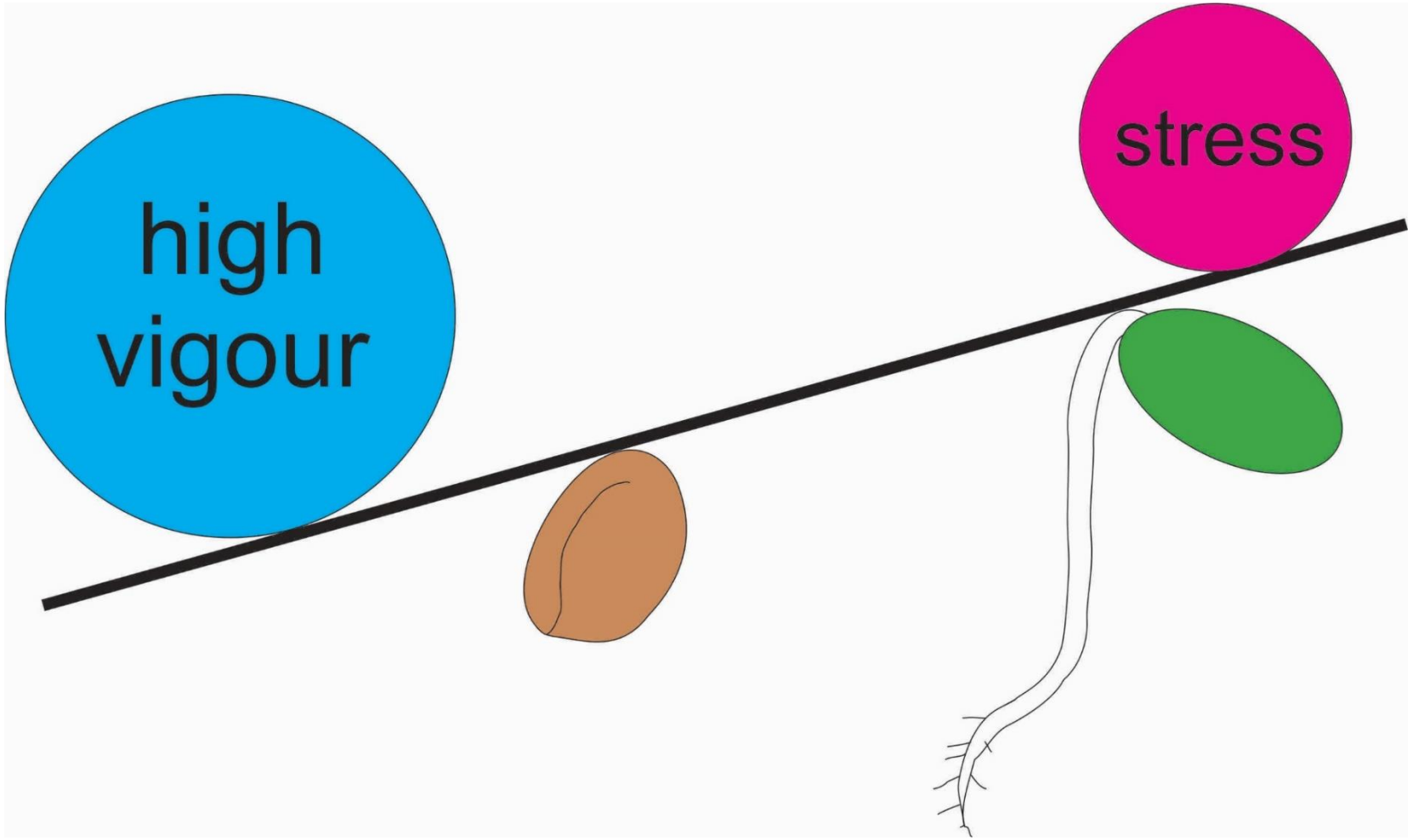
Source: https://earthobservatory.nasa.gov/world-of-change/global-temperatures

INTERNATIONAL ISA SEED ACADEMY

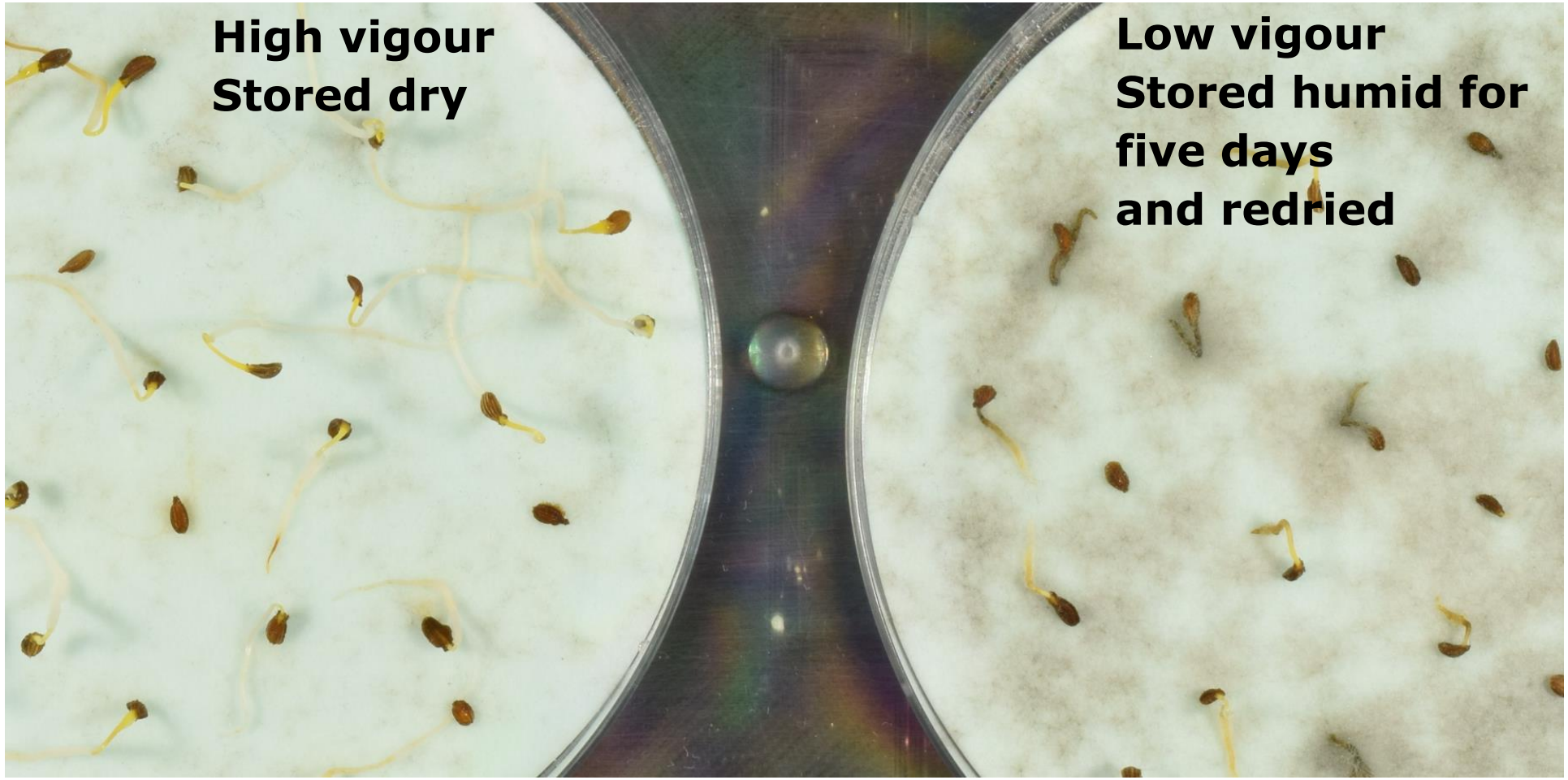
Chemical seed(ling) protection will decline in options

Seed vigour

High vigour seeds and are more tolerant to biotic and abiotic stresses



Seed vigour and biotic stress tolerance



Tolerance of carrot seeds to *Alternaria radicina* damping-off

Warehouse seed storage

Vegetable seeds

15 °C and 30% RH

Open boxes <-> laminated foil bags

Maize seeds

Ambient conditions

Plastic-wrapped paper bags

Rice seeds

Ambient conditions

Woven bags

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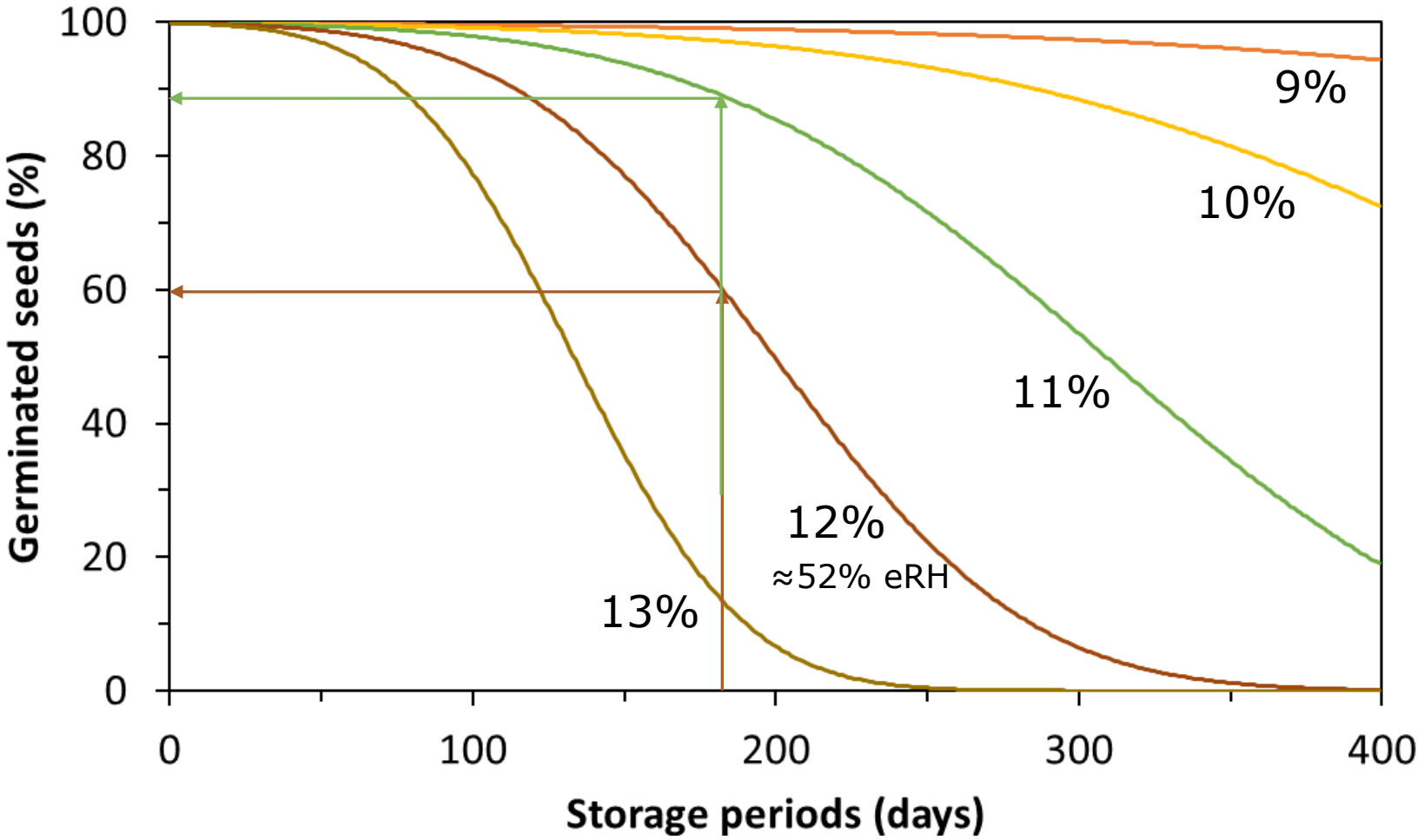
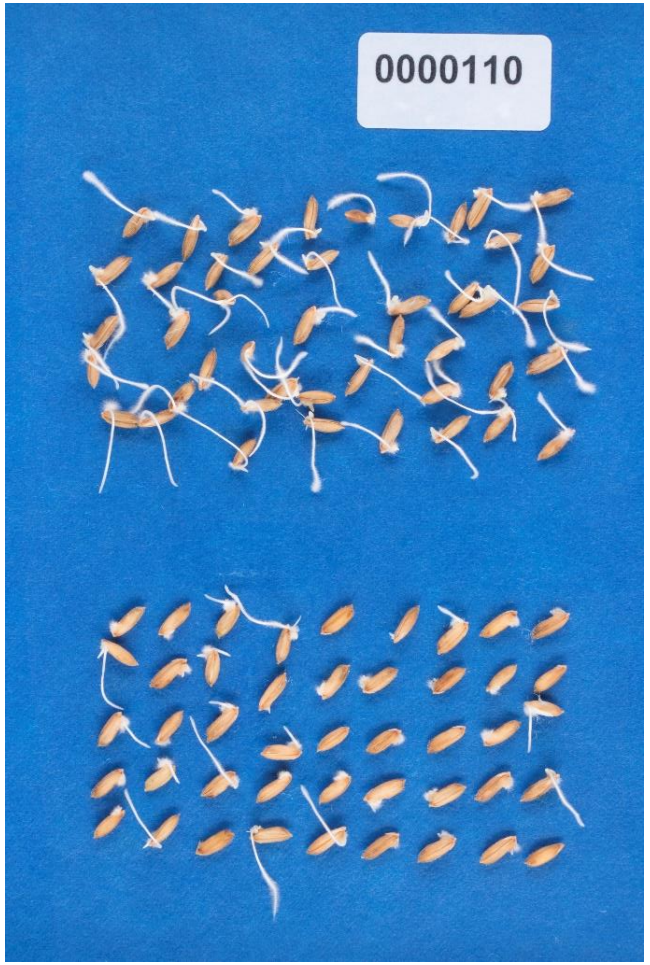
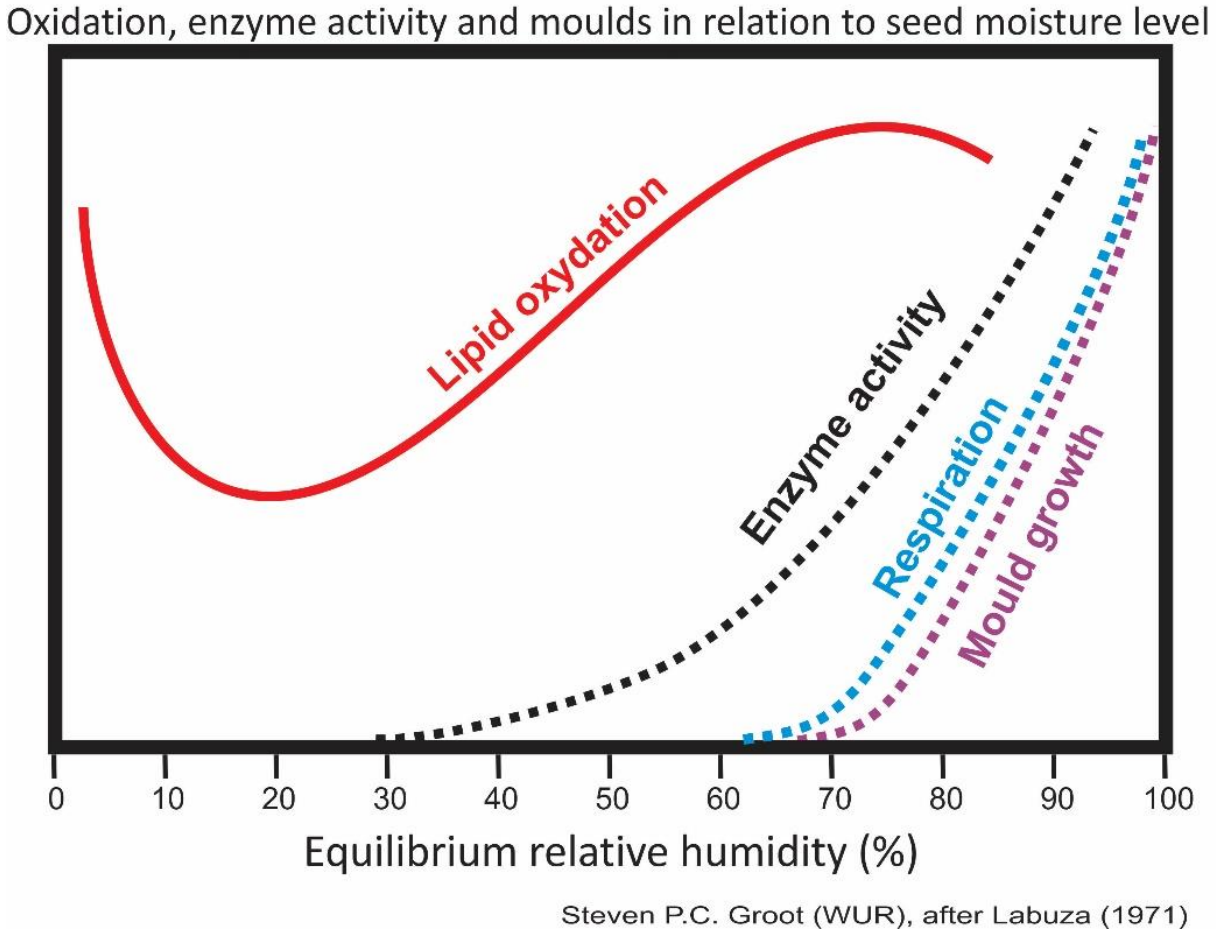
Effect of MC on rice seed ageing at 30°C





What happens in the seed at various RH levels?



- Above ≈75% RH mould growth
- Above ≈70% RH enzymatic (repair) activities and respiration
- Below ≈50% RH nor or hardly enzyme activity
- At ≈20-30% RH least oxidative damage

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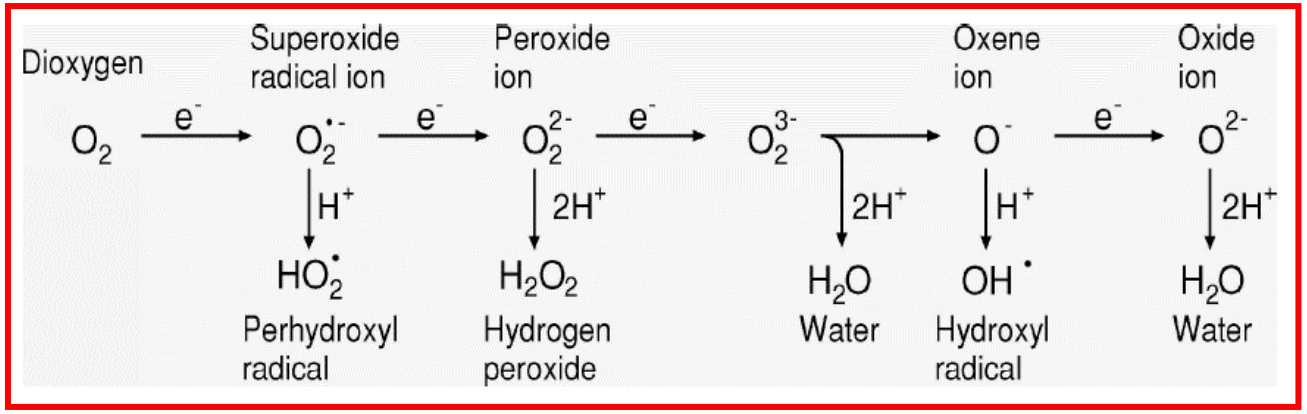
Oxidation is the main threat to seeds

Oxidation during harvest, drying and storage:

- DNA oxidation, protein oxidation, lipid oxidation,
  - ➢ DNA breaks, cell membrane damage, mitochondrial membrane damage
  - ➢ Cell leakage, impaired energy production, poor seedling establishment

Oxidation is caused by reactive oxygen species (ROS)



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

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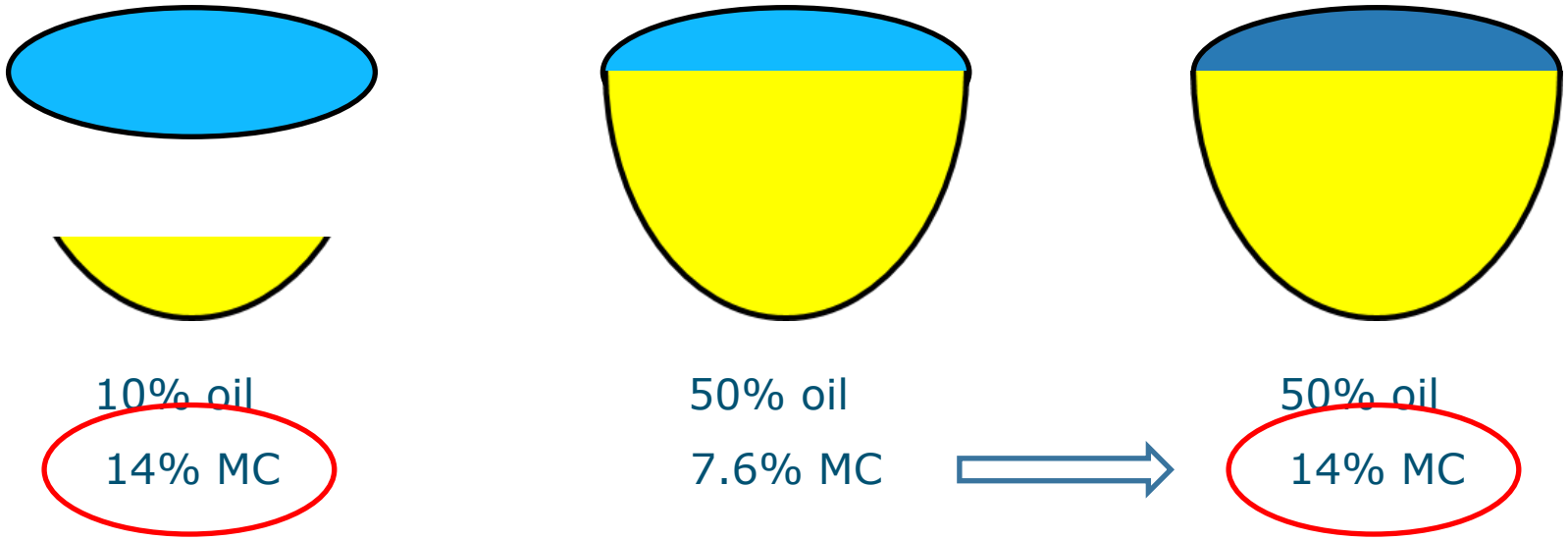
The relation between equilibrium RH and seed moisture content is crop-specific

60% equilibrium Relative Humidity

96% equilibrium RH



10% oil

14% MC

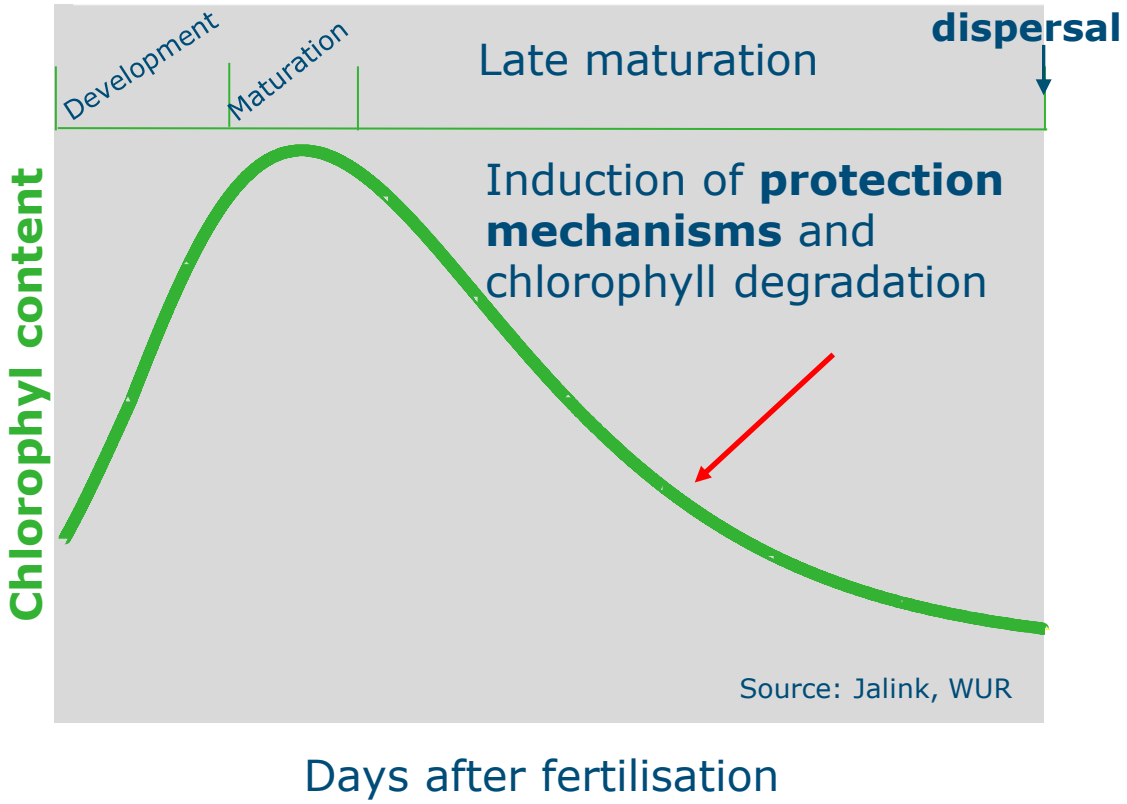
50% oil

7.6% MC

50% oil

14% MC

Seed maturation is important for vigour



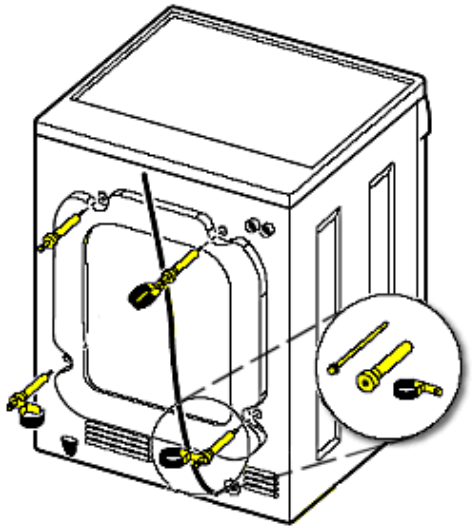
The late seed maturation process is important for acquiring full vigour

- Protective proteins
- Anti-oxidants
- Chlorophyll degradation

- Finishing maturation needs time and water
- Too early drying fixes the seed in a less mature stage

➢Less seed vigour

Development and protection



Compare seed development to the production of equipment.
High value and need for protection during transport and storage.

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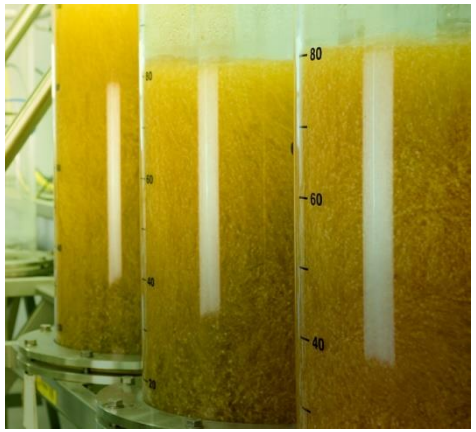
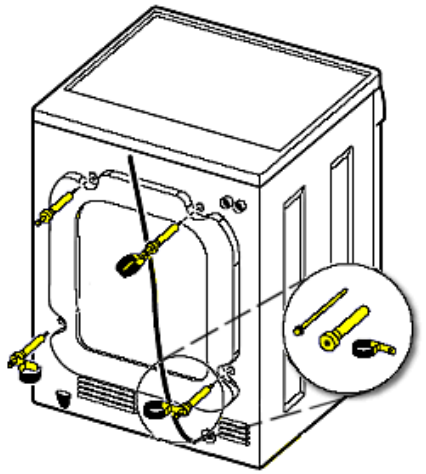
Partial loss of protection during start of germination

When a seed is fully mature, it has the highest level of protection.

However, when germination starts while still on the mother plant, or during priming, part of this protection is removed. This can have an impact on the seed's sensitivity to ageing.



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Seed maturation drying is important for vigour

Optimal seed drying at harvest

- Determine seed maturity status

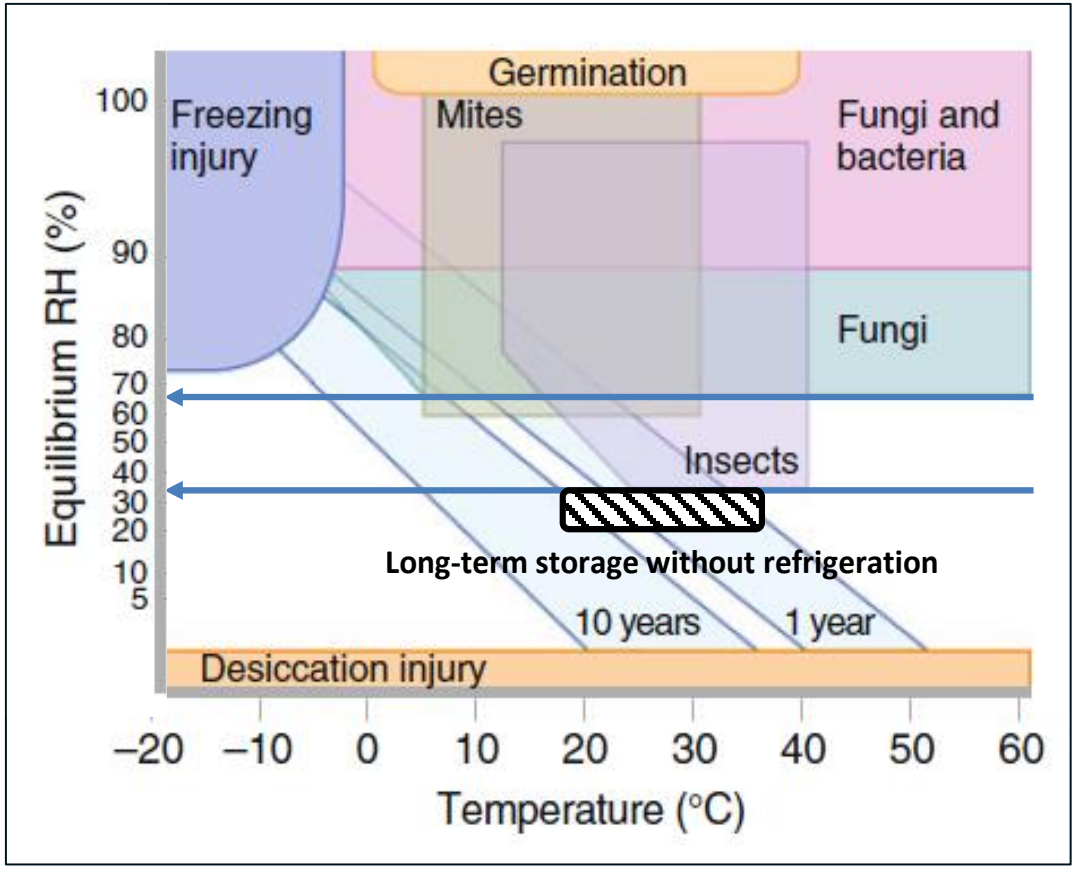
- Cut the crop and let it initially dry slowly
  - This allows less mature seeds to finish maturation
  - Take care of too-slow drying, as it may result in moulds and ageing

- After threshing dry **soon** to low RH and **keep the seeds dry**

Maintain seed vigour from the start!

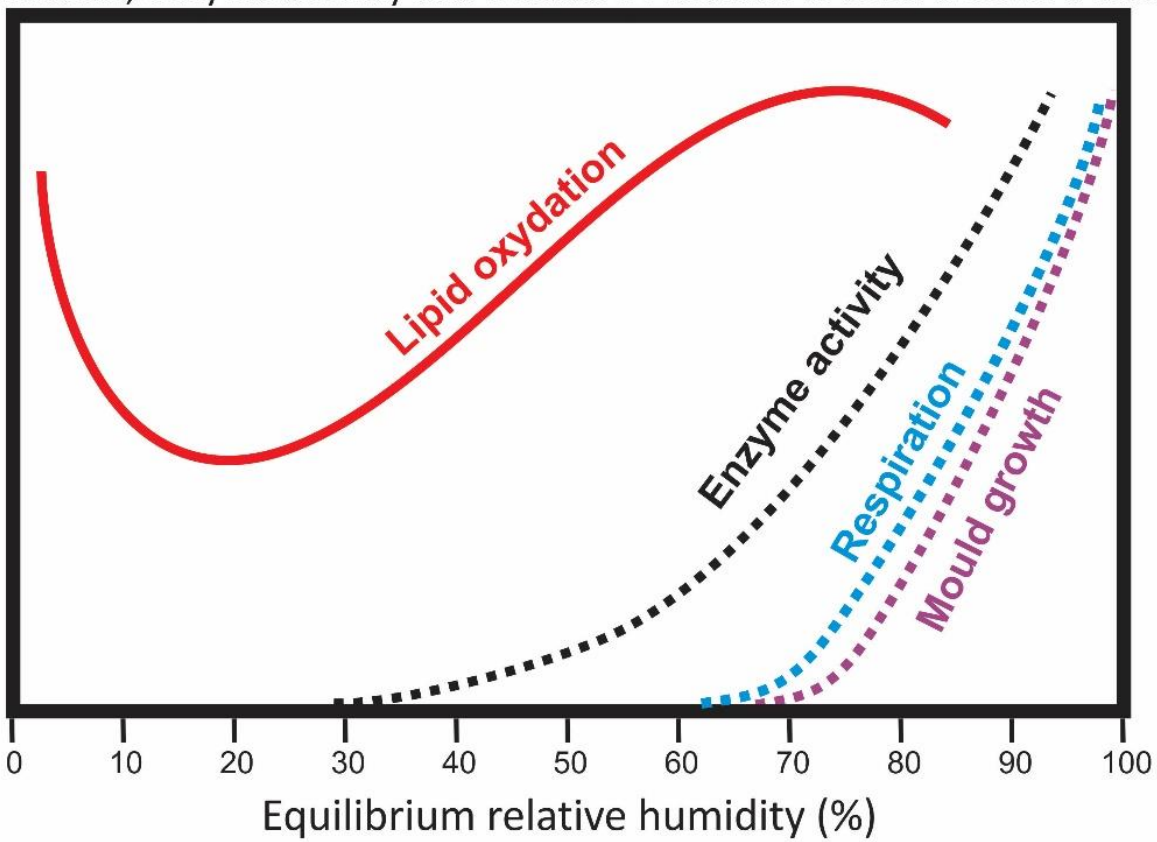
- **Drying and temporary storage at seed producers and transport conditions are underestimated**

Conclusions for a perspective from the seed



Source: Roberts EH (1972).

Oxidation, enzyme activity and moulds in relation to seed moisture level



Steven P.C. Groot (WUR), after Labuza (1971)

Thank you for your attention!

Vincent van Gogh, The sower, 1888.
Kröller-Müller Museum, Otterlo, The Netherlands

- **Questions**?

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The main drying systems, with their (dis) advantages

Johan van Asbrouck

Rhino Research

The Rhino Group

Seed Meets technology 2023

26 to 28 September 2023

Some questions concerning drying techniques

Johan Van Asbrouck

Rhino

Impact of timely and sufficient drying?

Sun drying, a curse or a blessing?

Drying with desiccants?

Drying and conditioned warehouses?

Forced air drying?

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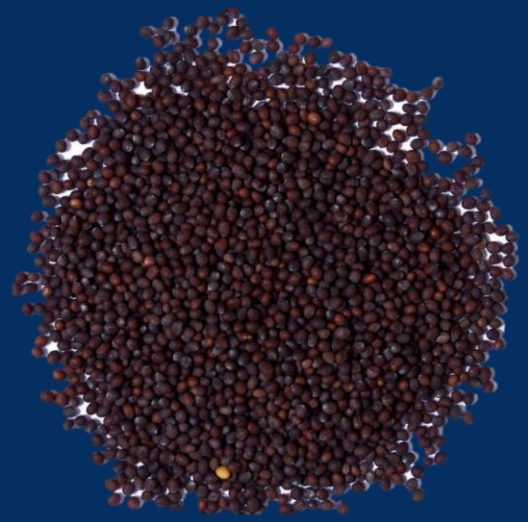
QUALITY



A story on produced cabbage seeds

QUALITY

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1

Impact of timely drying

Do we win or loose if we wait with drying our harvested seeds?

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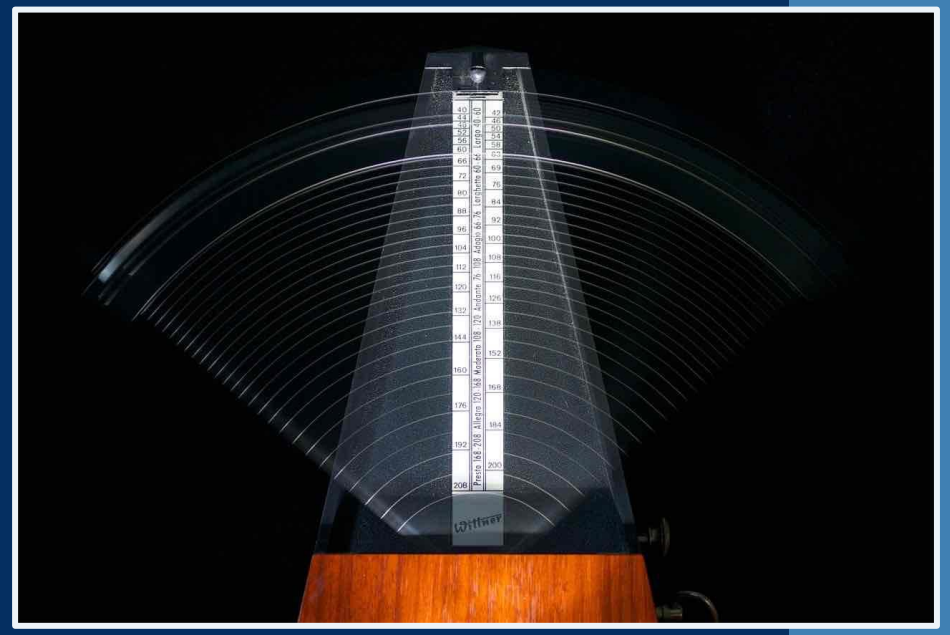
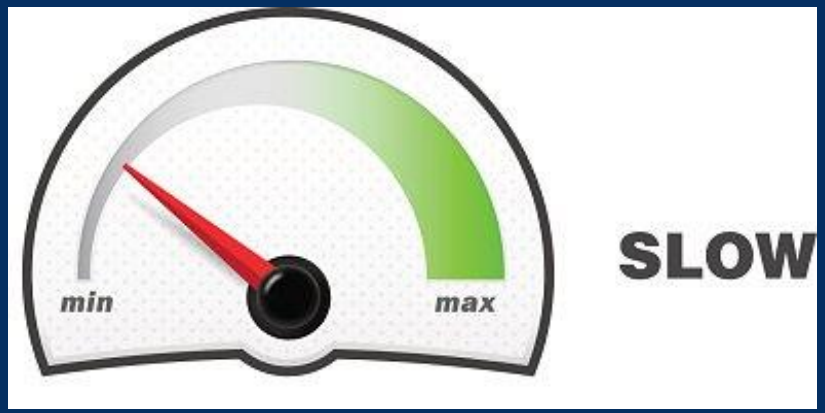
Invest your time, money and efforts there where you believe that the effect will be the biggest.

Check possible differences through the Ellis & Roberts equation (Rhino toolbox or seed information database website)



Dr. Bradford's metronome rule.



SLOW

FAST

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2

Sun drying, good or bad?

The most used drying technique over the whole of Asia, is it a blessing or a curse?

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Sun drying, good or bad?

Sun Drying
Using the sun for drying seeds

Shade Drying
Reducing the risk of sun drying by shading the seeds
(no direct sun light)

Fan Drying
Using unheated, forced air

(Static Drying systems)
Using an adapted environment as an equilibration source

Sun drying, good or bad?

Difference between sun drying and shade drying

Should we use ventilated air flow or ambient air flow

How to control the temperature

Can we dry deep enough

What should be the thickness of the layer, stirring seeds?

When to start, and to stop a drying session

How to store your seeds between drying sessions

There are no good or bad answers … each case is different. But you should ask these questions to yourself, each time!

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The use of absorbents

How can we use absorbents in a smart way for drying?

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DryChain - the use of absorbents

- Drying of breeder seeds, foundation seeds …
- Drying of smaller seed lots
- Drying of pollen
- Drying of DNA samples
- Remote Drying
- Drying to very dry – even ultra dry – conditions
- Cost effective drying (you do not pay what you do not use)

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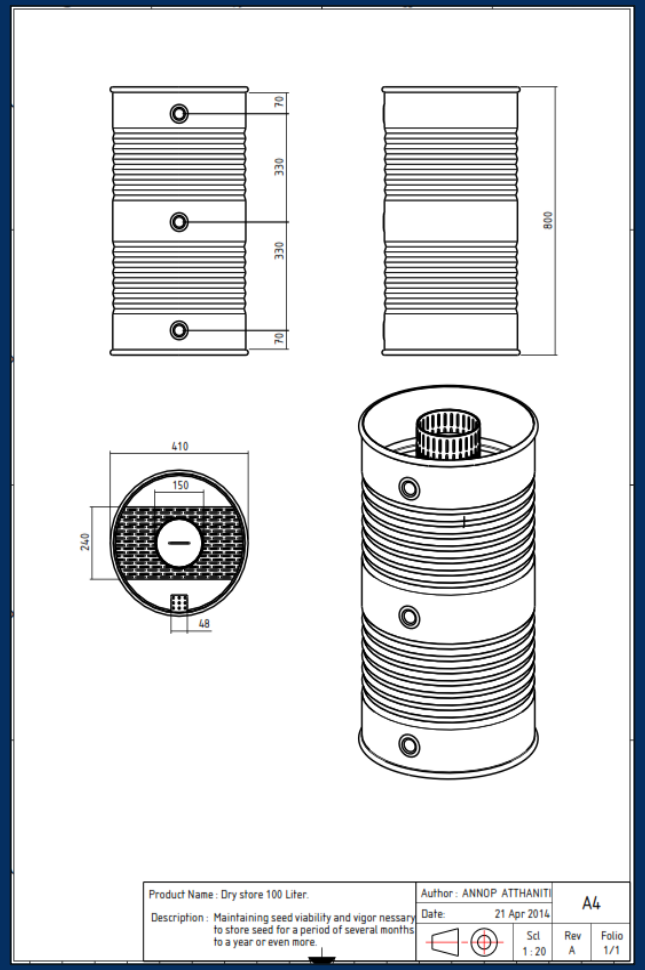
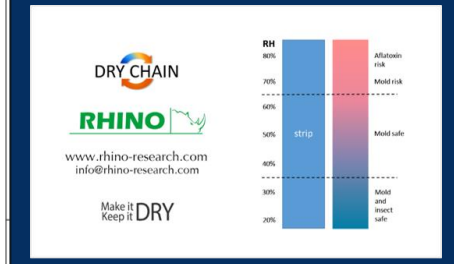
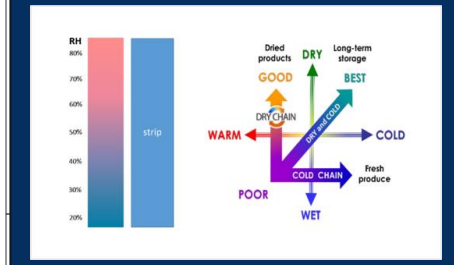
Some examples







One example – remote drying

Seed company

Empty drum with beads →

← Drum with (dried) seeds & beads

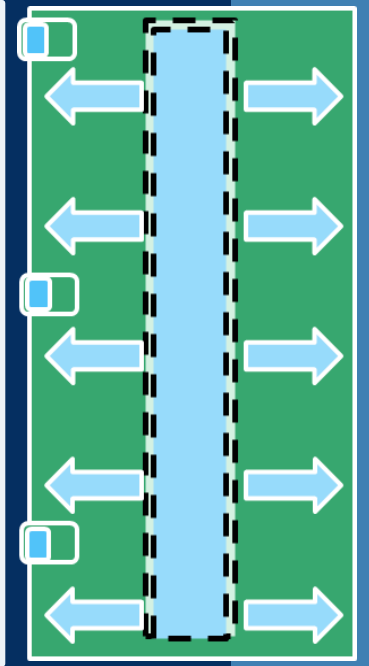
Farmer 1

- Sun drying
- Subsequent storage in drums

- Storage seeds ambient in sealed bags
- Regenerate beads

Empty drum with beads →

Farmer 2



Seed company uses this system for hybrid + seed production (tomato, chili, brinjal, onion, bitter gourd …) with a total of more than 20 ton. Time from harvest to warehouse is 3 to 4 days. MC at arrival in warehouse around 6 to 7%

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Can we dry our seeds in a conditioned warehouse?

We do invest a lot in our conditioned (e.g. 15 Celsius and 35 % RH), can we use this for drying purposes?

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Can we dry our seeds in a conditioned warehouse?

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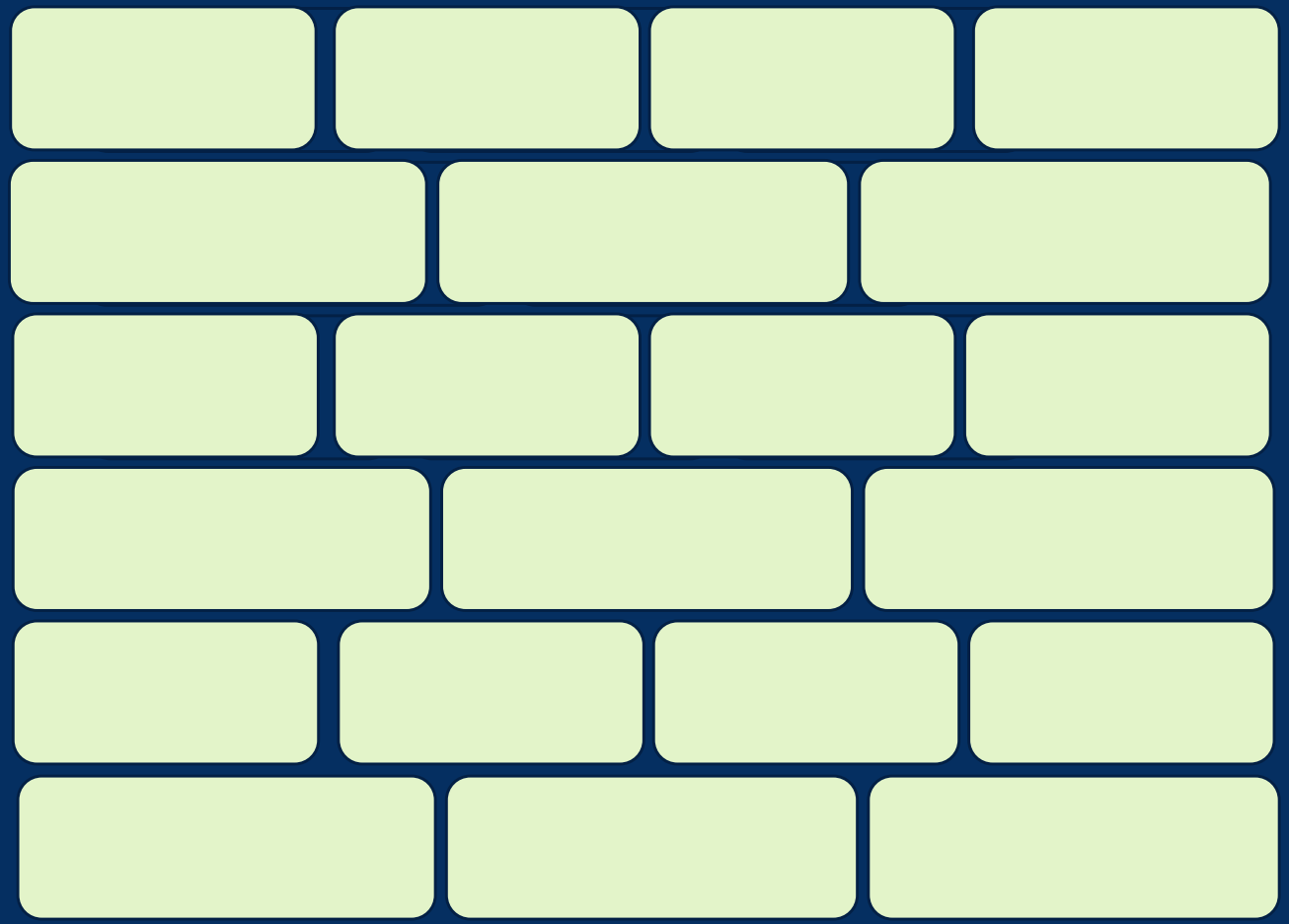

Type of packaging
- glass
- Wood
- Jute
- Woven plastic
- Woven with liner(s)
- Sealed plastic
- Alu foil

Air and water transfer 0% to x%?
Volume of each container
Airflow around (and inside) each container

Homogeneity within area (Temp and RH%)
Temperature (relative cheap investment) is often over dimensioned while the humidity (expensive investment) is often under dimensioned

Bringing sealed bags in a conditioned warehouse is “overkill”

Sudden temperature changes could result in condensation, only a few seeds will take up these droplets, resulting in pre-germination? Need for intermediate waiting places?

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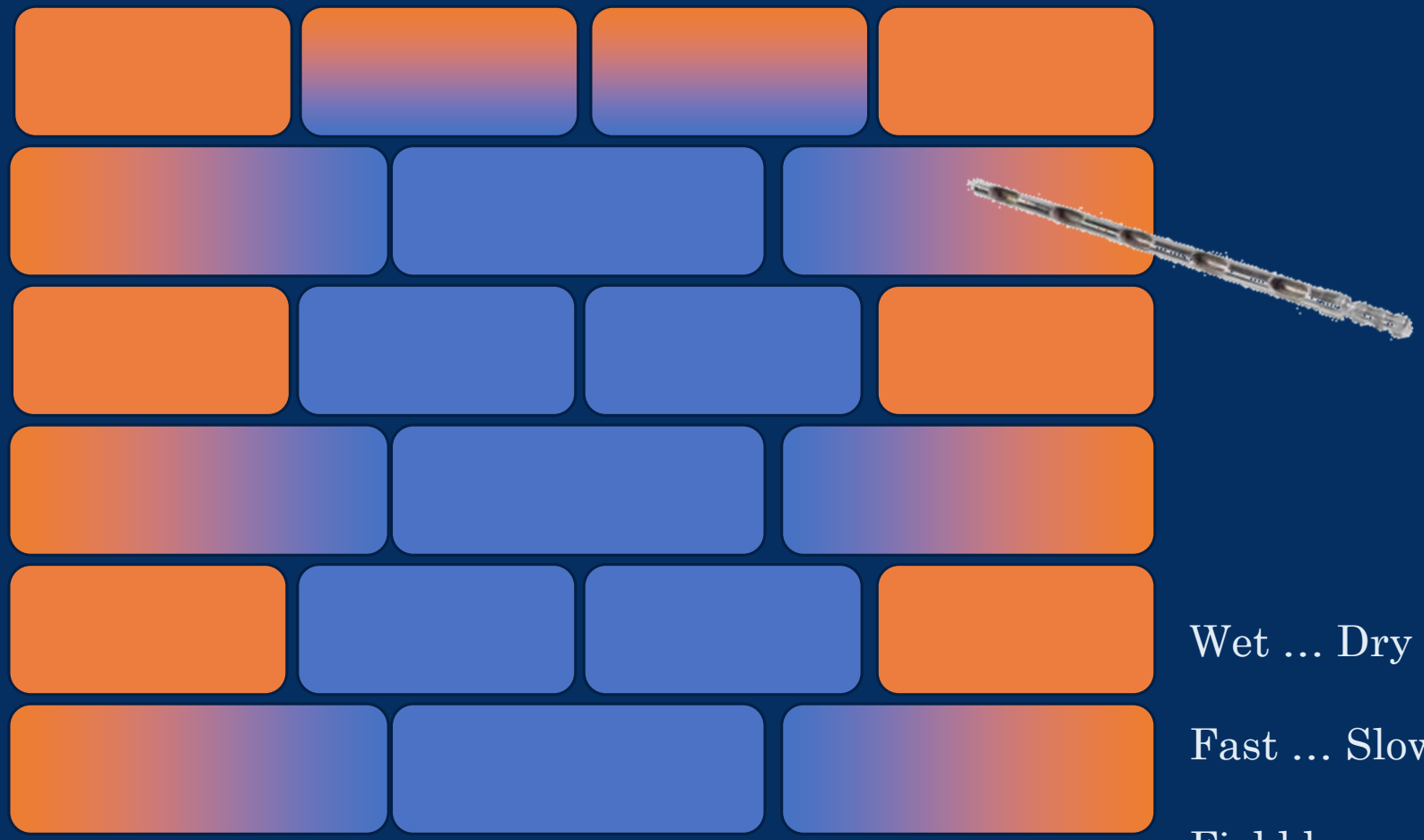
The outside will always dry first, center will remain “wet” for a long time



Wet … Dry

Fast … Slow aging

Field homogeneity going down

Sample quality

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Seeds at the outside dry much faster.
Therefore storability improves
After a certain storage, aging of the seeds in the center goes much faster,
Reducing average quality, and reducing homogeneity

Sampling stored seeds

But as sampling often has been taken only from the outside of the piles,
lab numbers are still good, and the problem will occur unexpected

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What about forced air drying?

2 small and short comments that can make a significant impact in costs and quality

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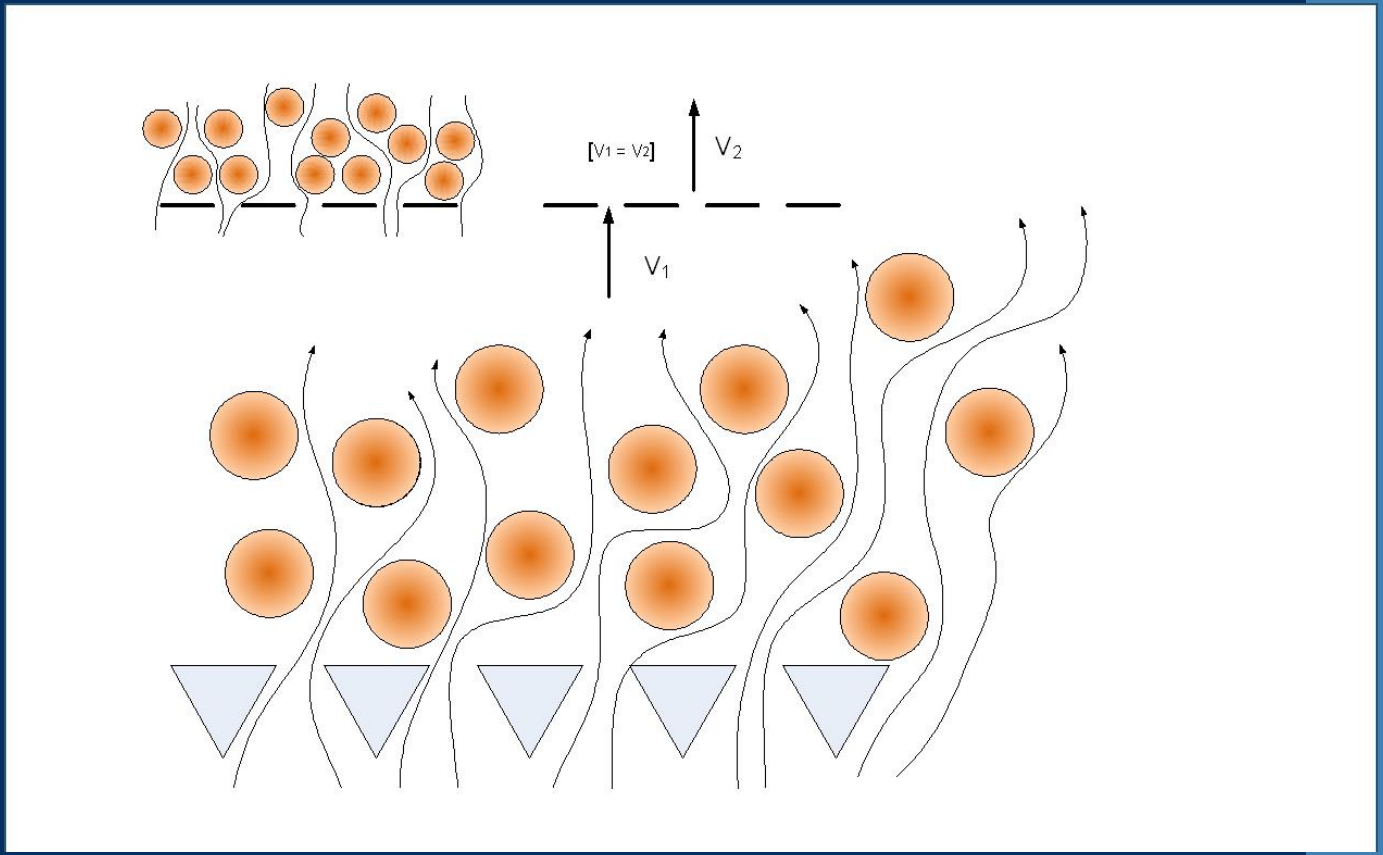
Fluidized bed drying

HOMOGENEITY

Means that the drying mass is completely lifted and surrounded by air, and therefore behaves as a liquid.

Shape density of the product are key here, but together with the air speed (lifting properties)

Fluidization is directly related with the air speed (not the volume)



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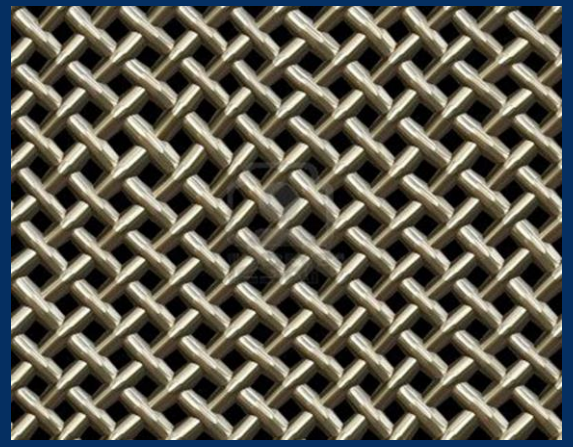

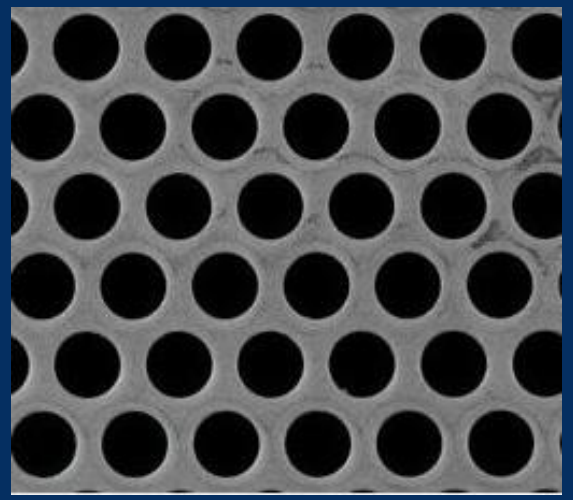

60 – 90 %Throughput

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Intermitted drying

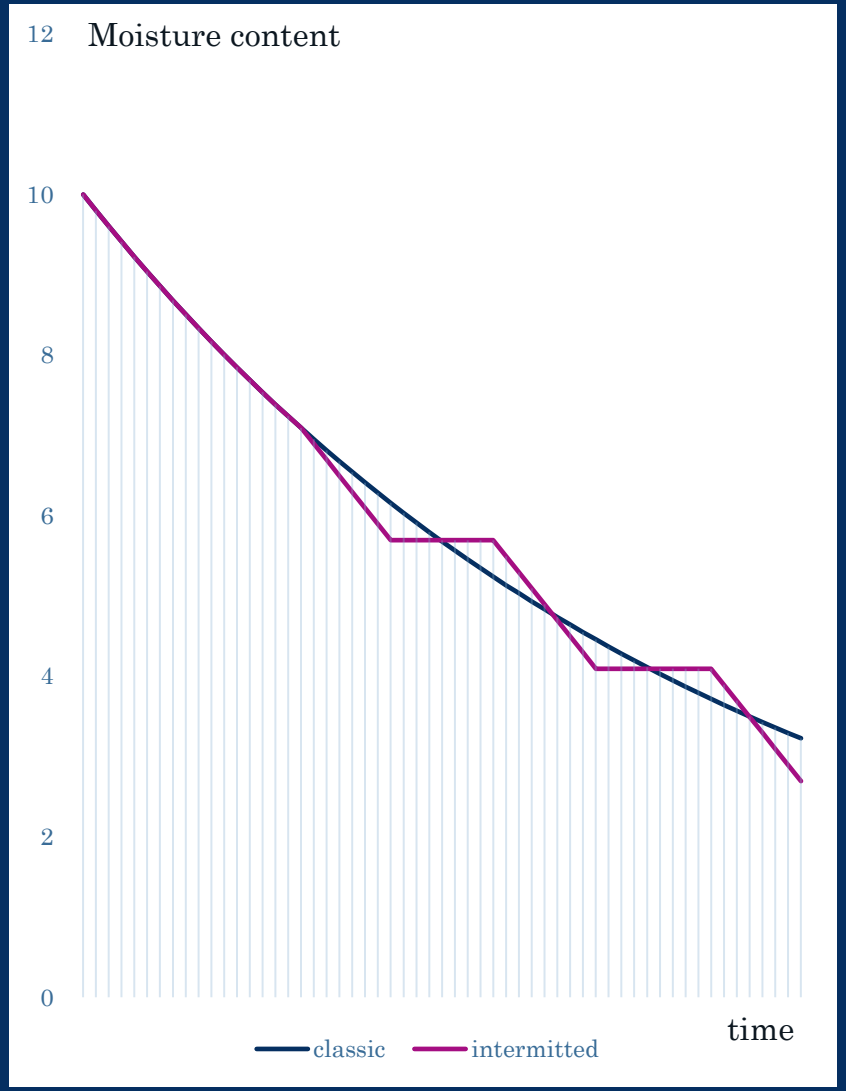
A smart way in efficient drying is “intermitted drying”

At regular (or measured) intervals we just stop drying.

During these pauses, the water (that is still present at the inner core of the seeds) will move outwards to the outer layers (that are already completely dried).

Once this equilibrium has been reached, we can restart drying.

The drying time will remain identical, but energy will be saved significantly.



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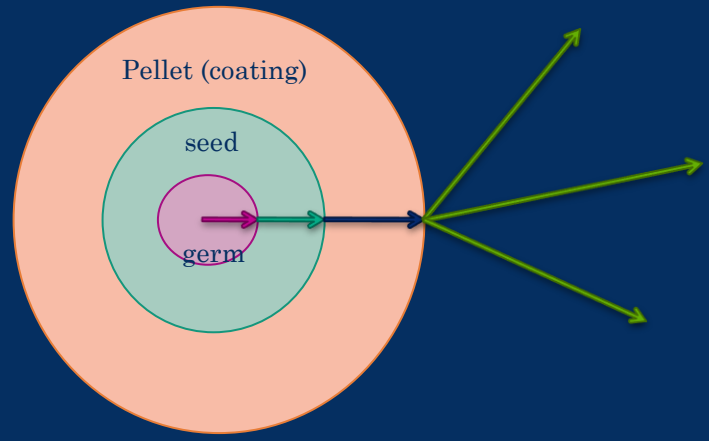
Drying speed is linked to the migration speed of the water in the seed

Migration speed depend on different internal and external parameters

External parameters are the temperature and the differential in RH
(and in a lesser extend the difference in pressure)

By taking a “drying break” the internal humidity will still move further from the center to the outer layers

By the next drying, more water will be available in the outer layers for drying



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Conclusion

There is no system available that would fit perfectly for all drying jobs. Therefore a combination of some different techniques, and the availability thereof would be highly recommended.

For further discussions, please send me an email … johan.rhino@gmail.com

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I wish that we could just dry our seeds for an additional thirty minutes and expect a perfect quality, homogeneity and storability, but that won't happen easily.

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Below you find one reserve topic

6

What is the impact when we cool our warehouses?

The fine print behind the James and the Harrington rules as described by Dr Kent Bradford.

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What is the impact when we cool our warehouses?

Air relative humidity (RH)

The amount of water vapour in the air *at a given temperature* is expressed as relative humidity (RH):

$$RH = \frac{\text{actual water vapour pressure}}{\text{saturated water vapour pressure}} \times 100$$

Dry air =
0% RH

Wet air =
100% RH

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RH equals 90%

RH equals 50%

RH equals 10%

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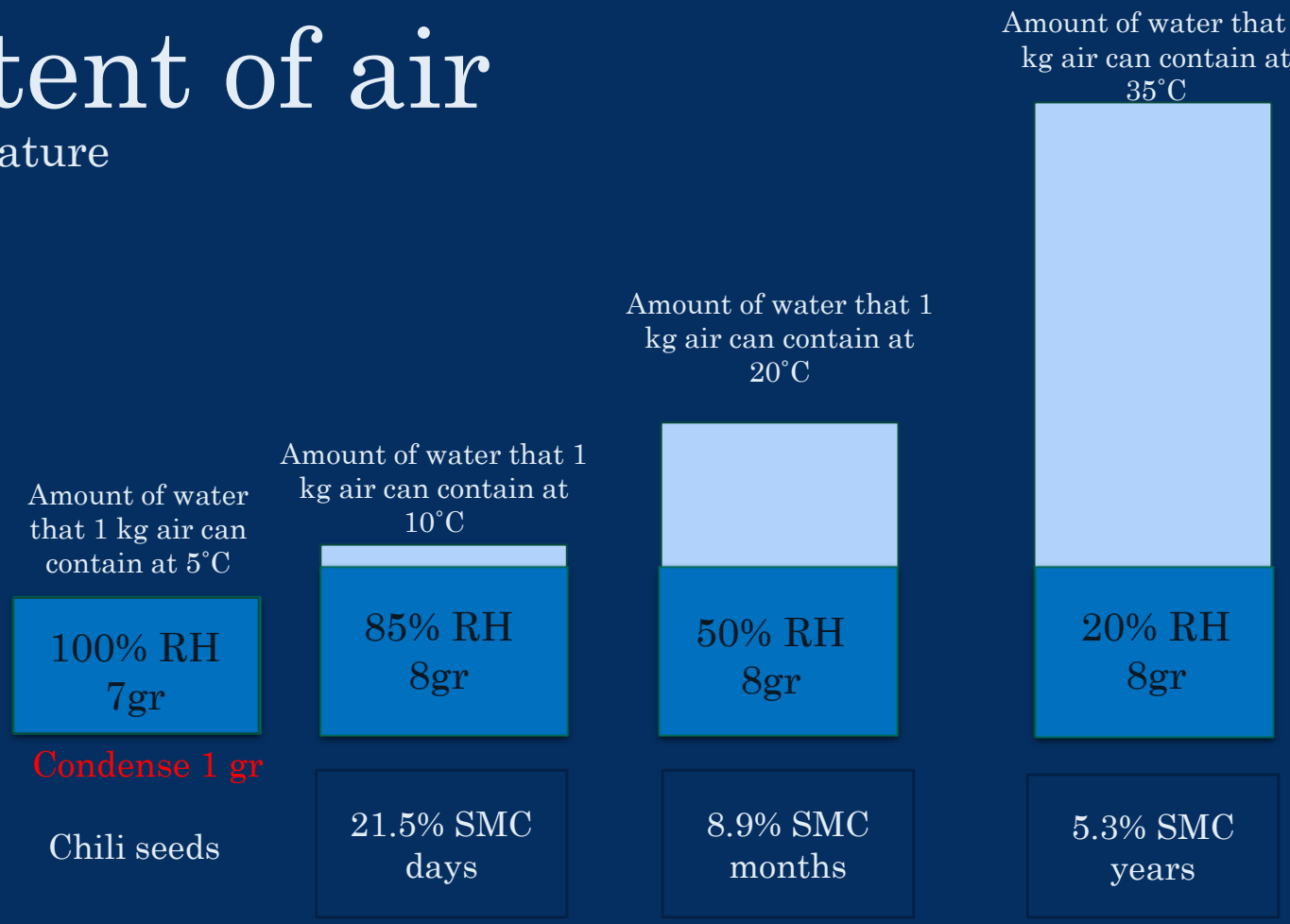
Water content of air

And the impact of temperature

ATTENTION
This tells us that cooling a warehouse can have an adverse effect on storability!



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How to optimize drying efficiency and save energy

Jan Appelman

Agratechniek bv,
Anna Paulowna

Jan Appelman

Director Agratechniek B.V.

Seed Drying Symposium

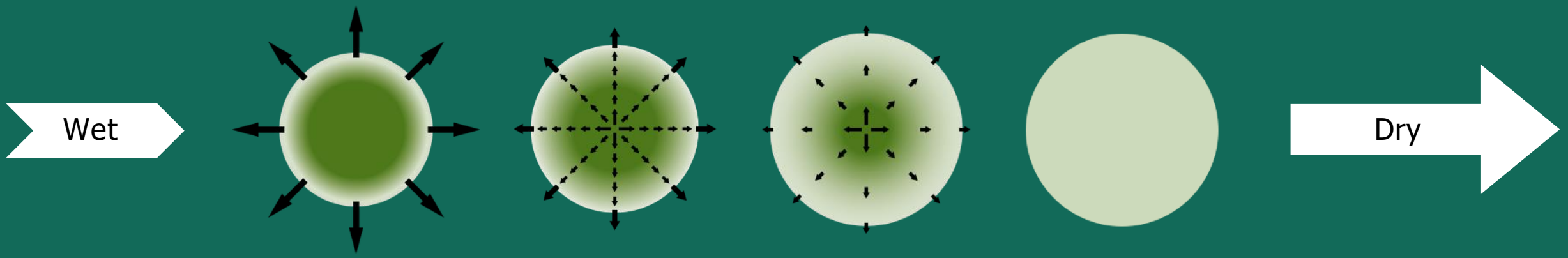
Optimizing drying efficiency and saving energy!

Topics of today
Agenda

1. the Principles of Drying
2. the Utilization of Dried air
3. the Nessecity of Smart Controllers
4. Saving Energy by Controlling Airflow and Temprature
5. Central Air-Driers
6. Upgrading Existing Drying Installations
7. Q&A

1. the Basic Principles of Drying

Balacing moisture in the seed with moisture in the air

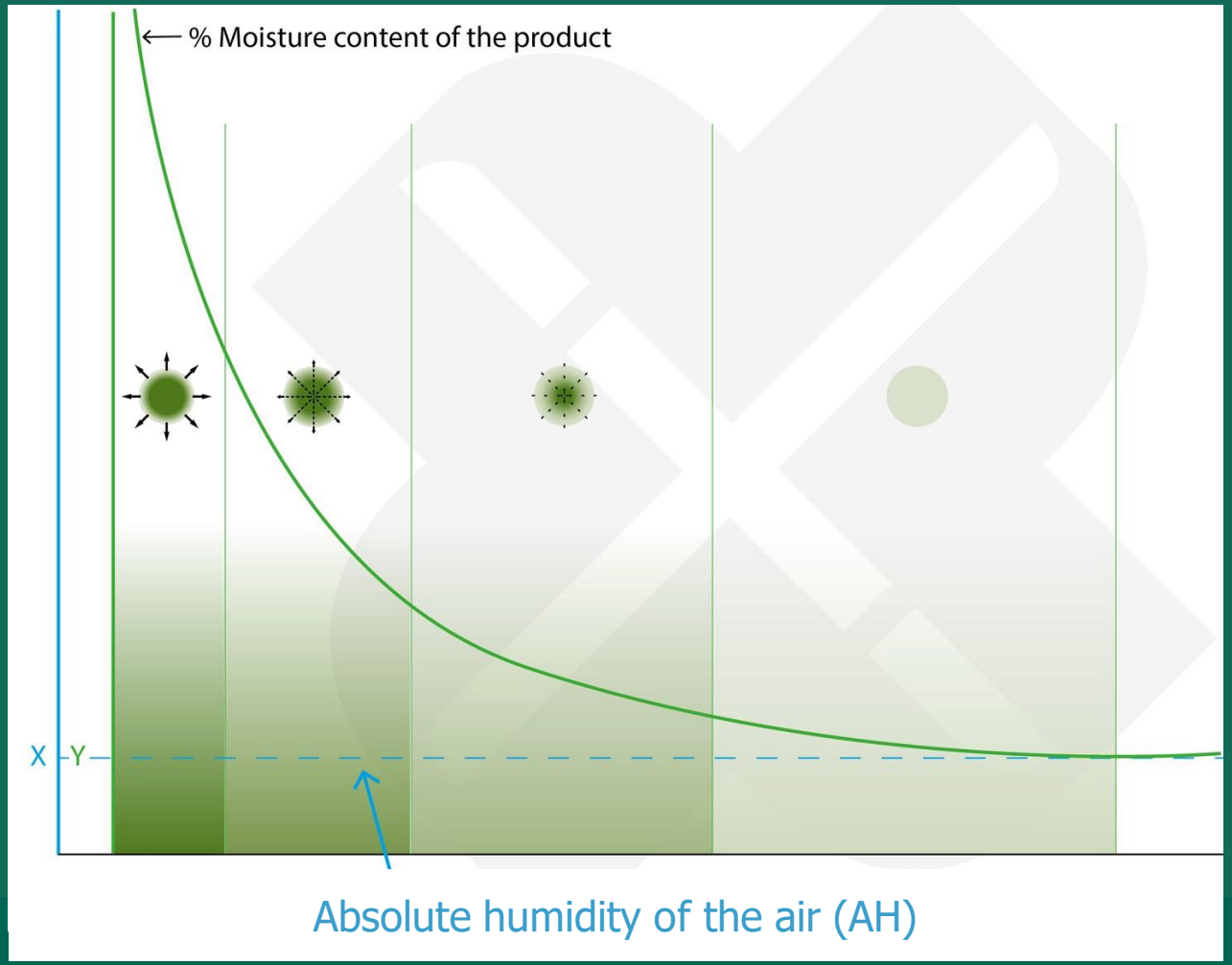


- Absolute Humidity (AH) and Relative Humidity of Air (RH)
- Drying in multiple stages to reach the desired low moisture content of your seed

1. the Principles of Drying

In nature, equilibrium is a fundamental principle

- The moisture content of a product naturally seeks to reach equilibrium with the moisture content in the surrounding air.



1. the Principles of Drying

In nature, equilibrium is a fundamental principle

1. Inital Decrease

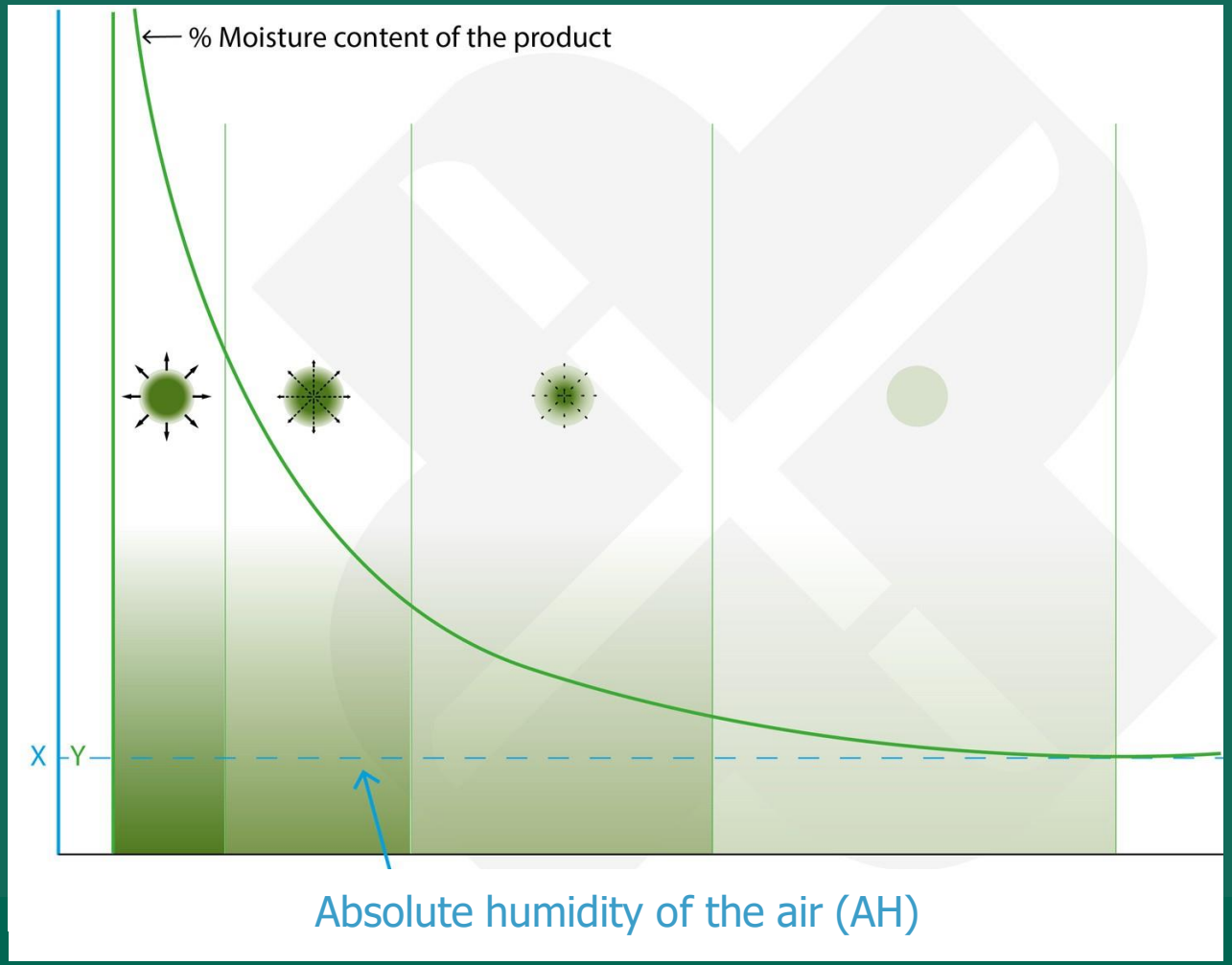
- Significant reduction at the start
- Rapid moisture loss

2. Gradual Transition

- Reduction slows over time
- Core Moisture migration

3. AH Impact

- Smaller AH difference with air
- Slows moisture reduction



1. the Principles of Drying

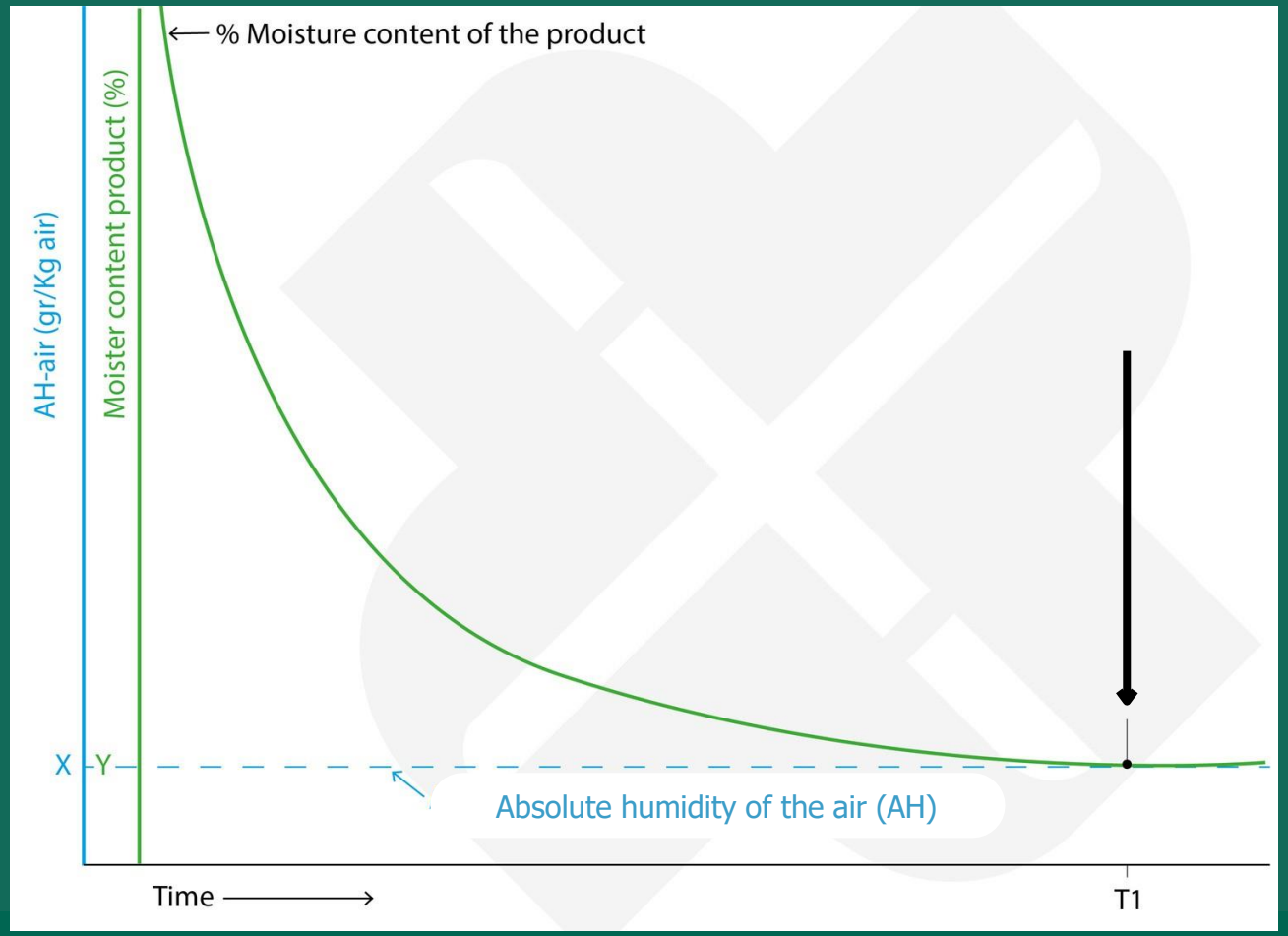
Achieving the equilibrium moisture content between the seed and the air.

1. Equilibrium Reached:

- Seed moisture content (%) reaches equilibrium with air's Absolute Humidity (AH).

2. Time of Equilibrium:

- Equilibrium occurs at time T1.
- At T1, moisture transfer from seed to air stops



1. the Principles of Drying

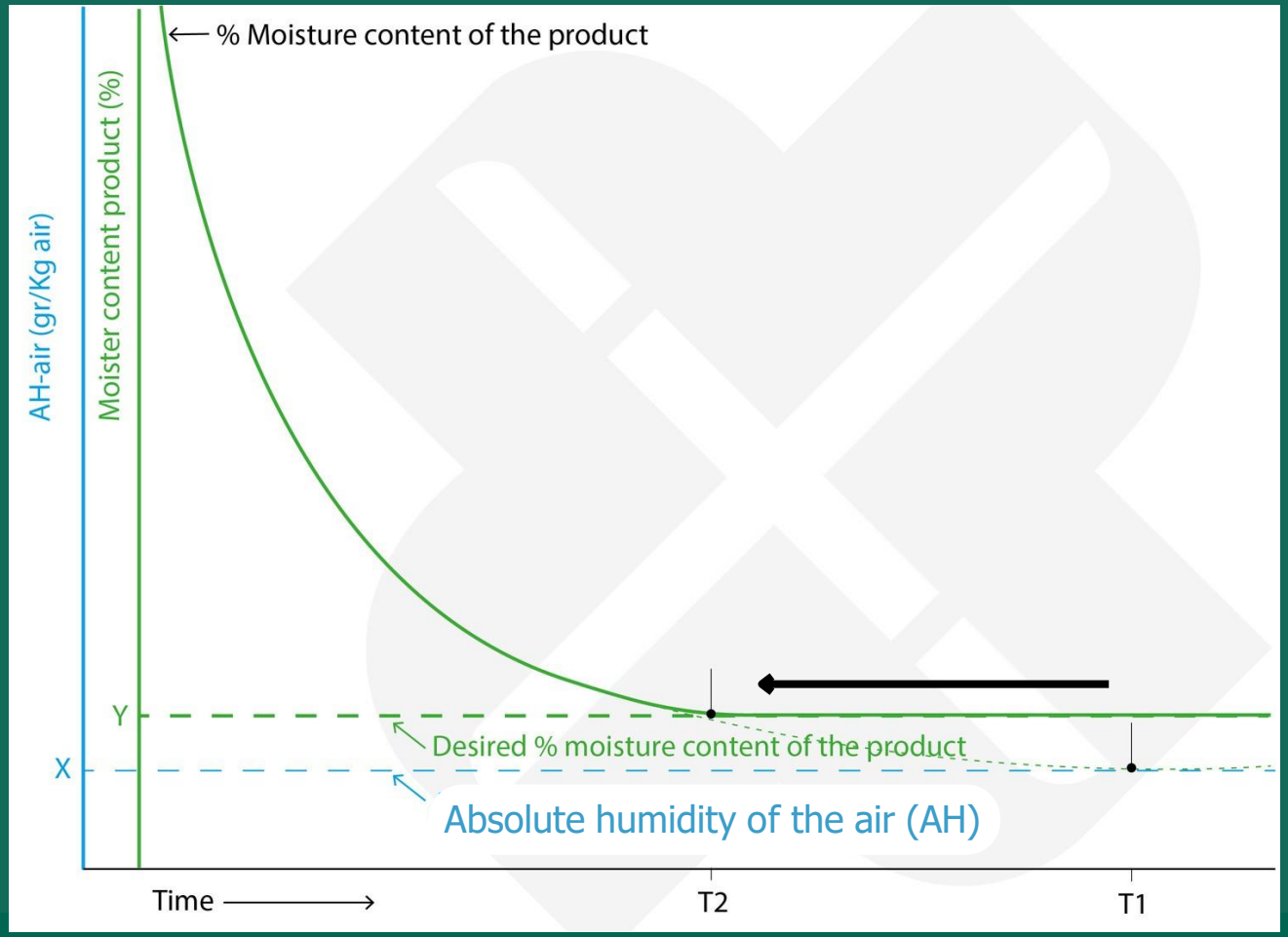
Reducing the drying time by setting the corresponding equilibrium moisture content

1. Achieving Desired Moisture

Setting a specific

- Absolute Humidity (AH) of the air:
- X (AH) > Y (% moisture content of the seed)

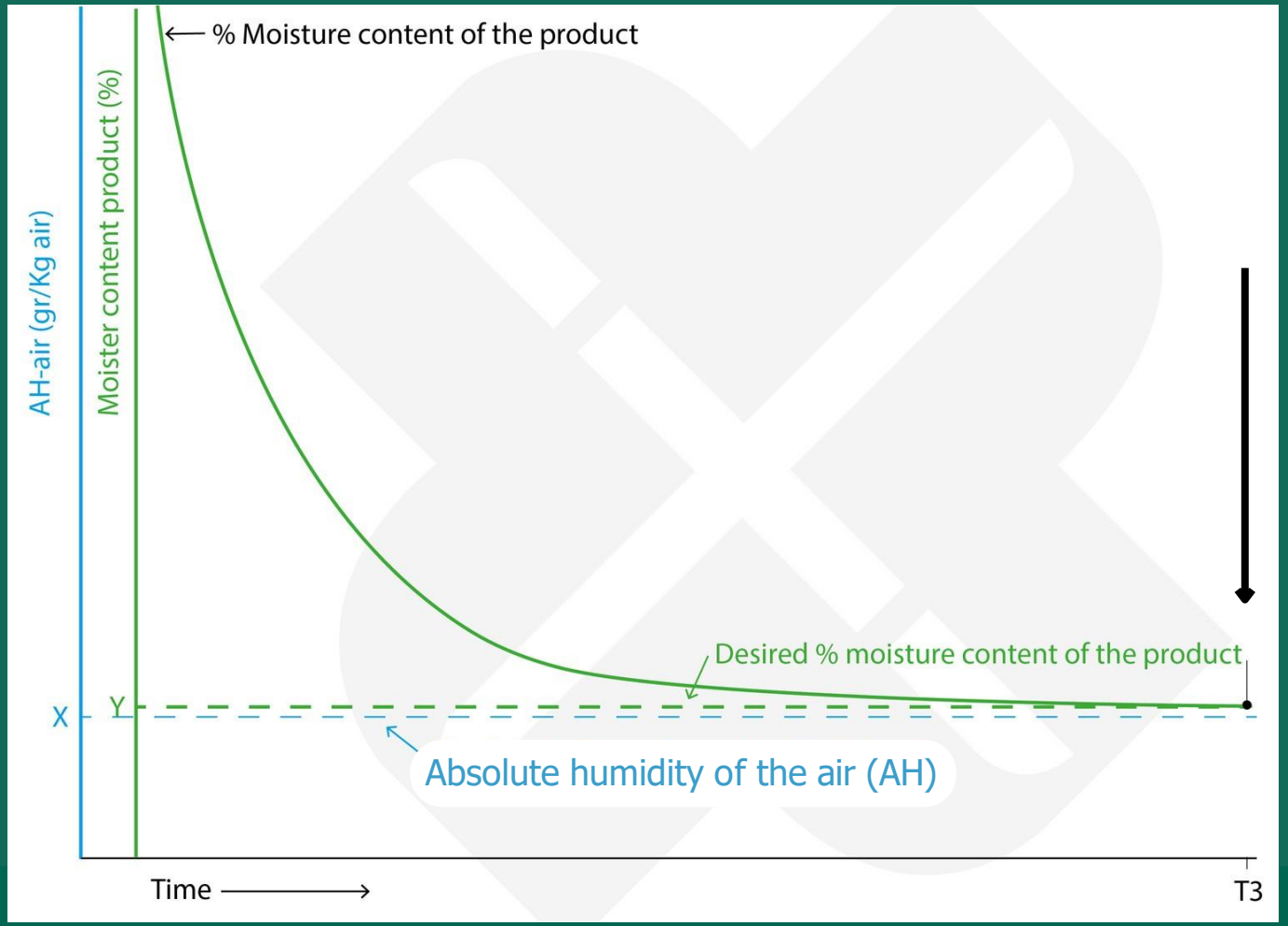
- **2. T2 Equilibrium**
- A larger difference between Y and X shortens the drying



1. the Principles of Drying

Achieving the desired moisture content when the process air is more humid.

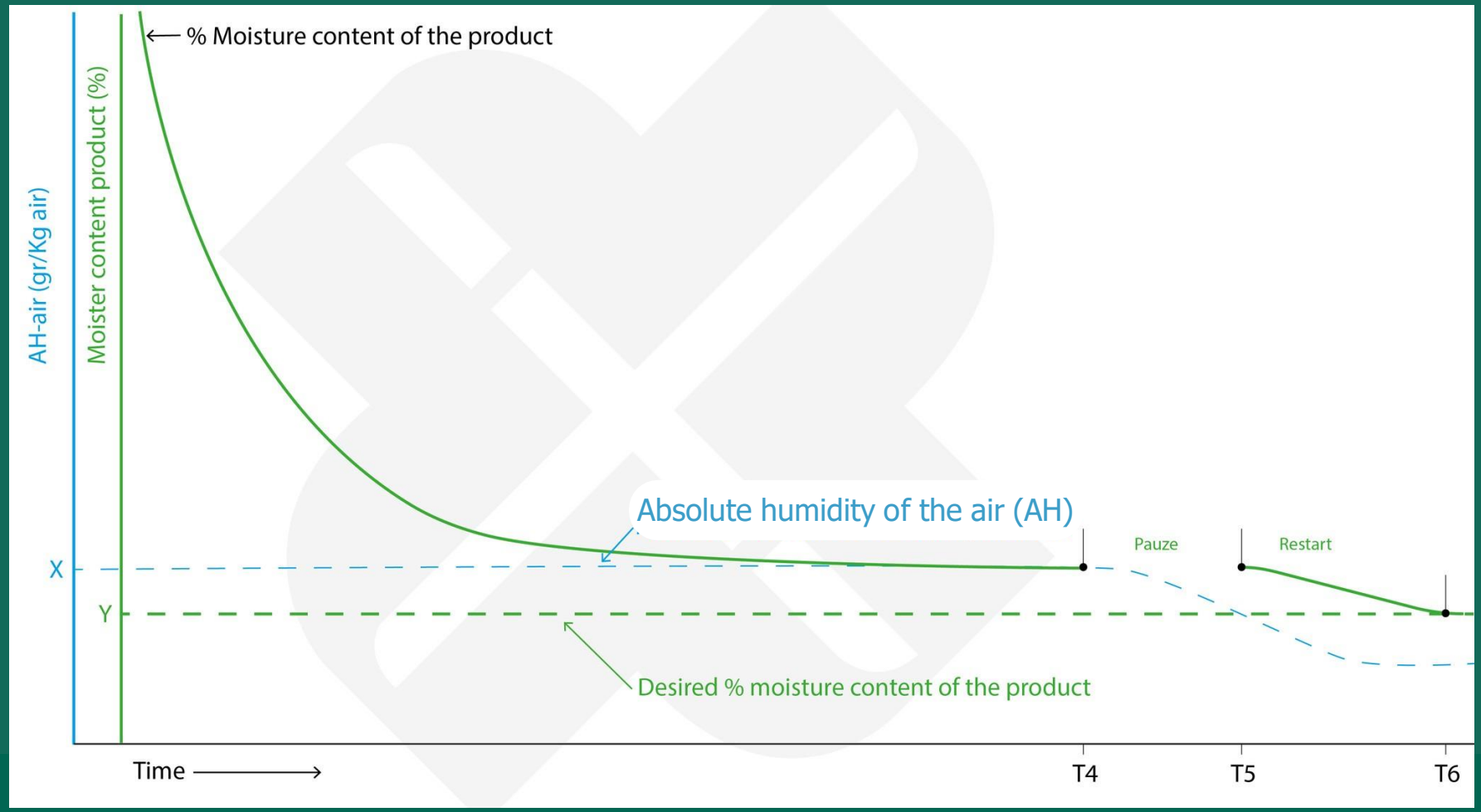
- With a small difference between X and Y, the drying time (T3) is much longer.



1. the Principles of Drying

Achieving the desired moisture content when the process air is more humid.

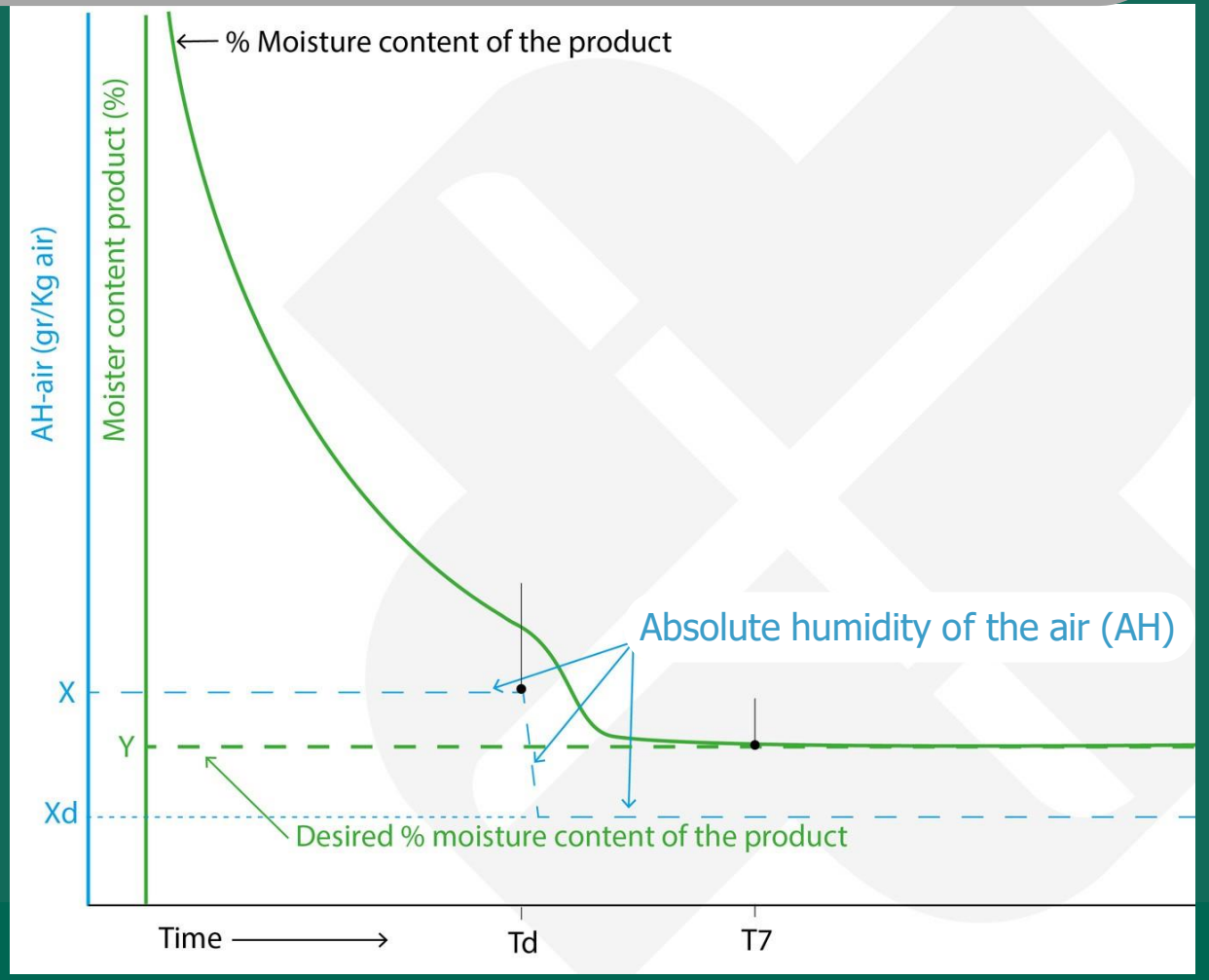
1. Equilibrium Mismatch (T4)
2. Extra Air and Temprature will not result in further drying (T4)
3. Restarting the Process (T5)
4. Achieving Target (T6)



1. the Principles of Drying

Using Pre-dried Process Air to Achieve the Desired Moisture Content

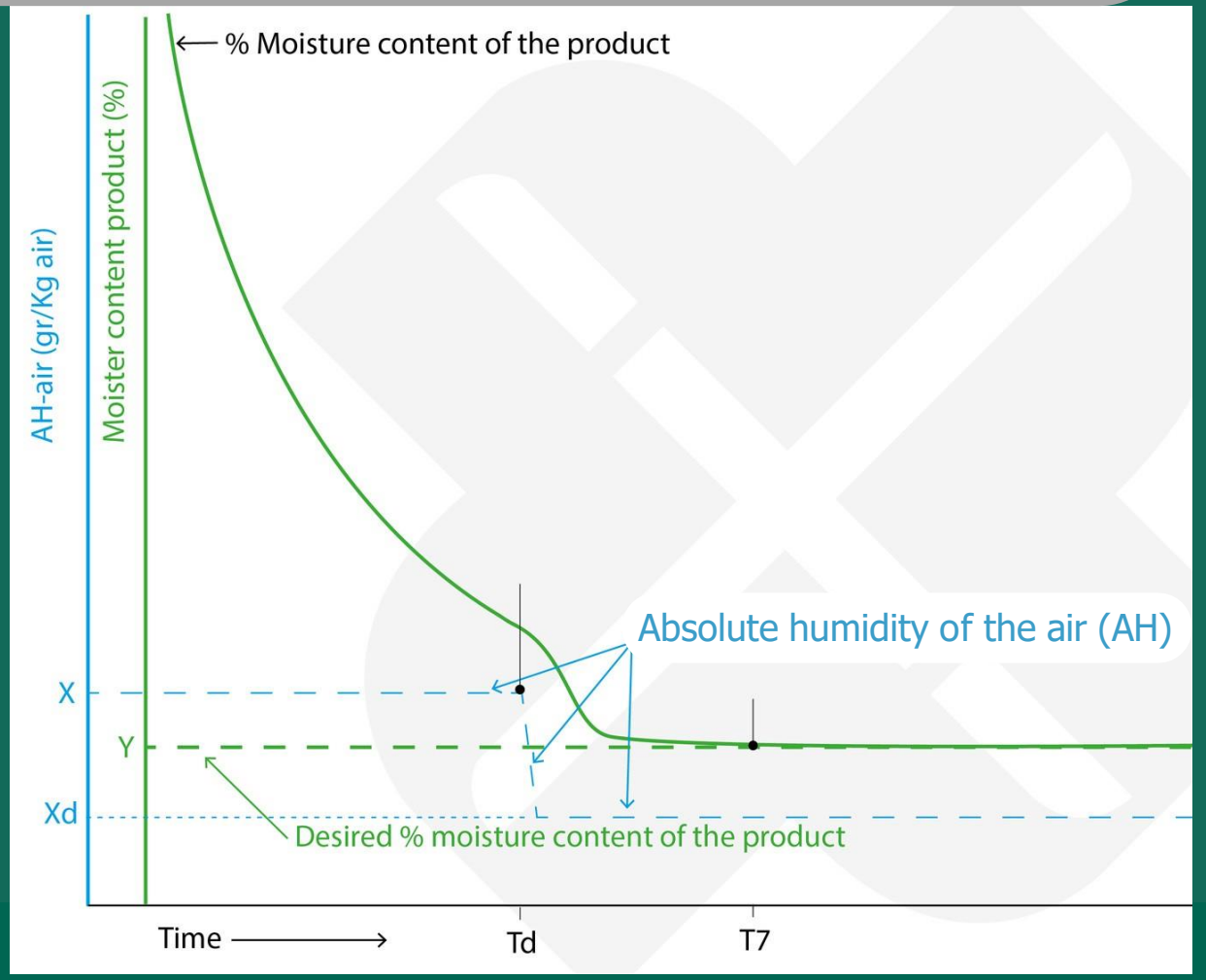
- By adding pre-dried air to the process air, the moisture content of the mixed air (Xd) is reduced to a level lower than Y.
- With dried process air, a low moisture content of the seed can always be guaranteed.
- Final drying phase importance



1. the Principles of Drying

Using Pre-dried Process Air to Achieve the Desired Moisture Content

1. Effective Moisture Reduction (Xd):
2. Increased Y-Xd Difference (T7):
3. Ensuring Low Seed Moisture:
4. Final Phase Importance:



2. The Utilization of Dried air

Why use dried air?

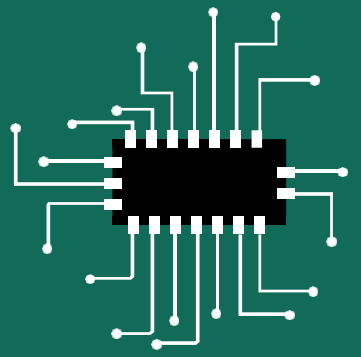
- By introducing pre-dried air into the process, the moisture content of the mixed air is decreased below the target moisture level.

Therefore:

- the Seed will always achieve the deisred %moisture content
- A shorter drying time at lower temprature will result in less Electricity and Heating costs
- the Capacity of your drying installation will increase

3. the Nessecity of Smart Controllers

Automatically control your drying process



- Simply using a start-stop button and a thermostat will not be sufficient to achieve an efficient and cost-effective drying process.
- The drying process consists of a dynamic exchange of moisture between the seed and its surrounding environment
- It is nessacary to continounsly measure the in- and outgoing process air in order to control the drying process
- The drying process should stop or pause automatically if the conditions are too humid and continue when more favourable

3. the Nessecity of Smart Controllers

the Benefits of an automatically controlled process

1. **Precision and Efficiency**

Adjusting Parameters

2. **Quality Preservation**

Maintaining Quality and Viability

3. **Energy Saving**

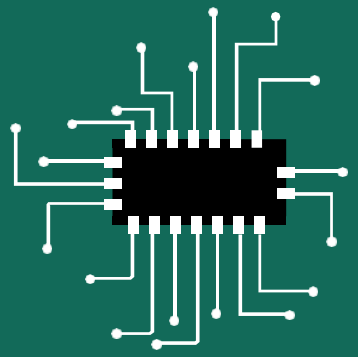
Optimize Usage

4. **Consistency and Uniformity**

Reducing Risks

5. **Adaptability**

Reacting to environmental changes



6. **Data Logging and Analysis**

Quality Control

7. **Remote Monitoring**

Manage large-scale operations

4. Saving Energy by Controlling Airflow and Temprature

A Smart Controller can enable significant Energy savings

Fixed Airflow and Heating → Variable Airflow and Heating

% control	kWe	m3/h	Delta-T	kW
100	22	30000	20	192
100	22	30000	20	192
100	22	30000	20	192
100	22	30000	20	192
100	22	30000	20	192
Total	**110,0**			**960 kW heat**

kW electric

- Reducing Energy Usage with Variable Airflow and Temperature Control of the process air

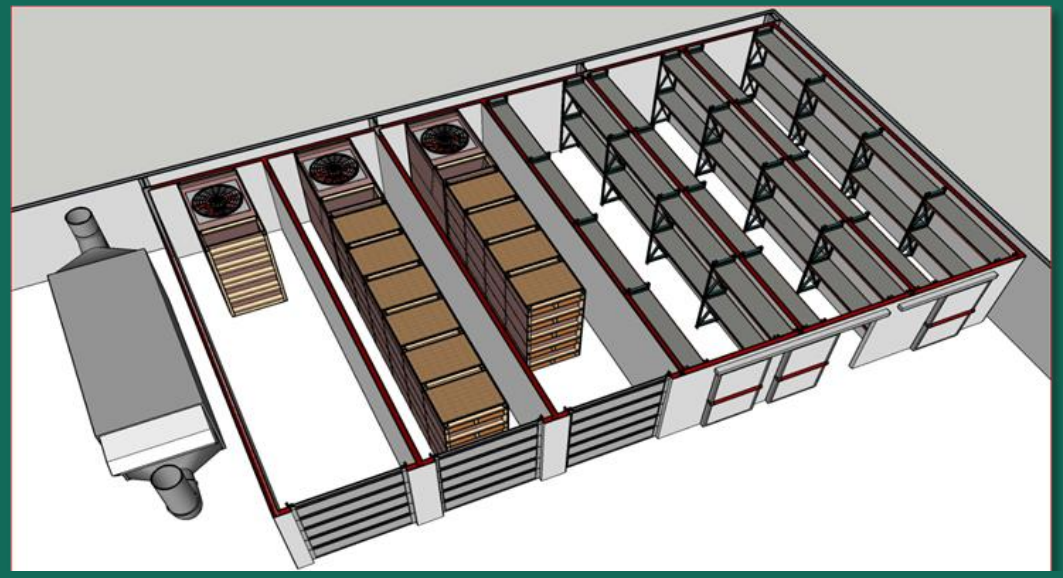
% control	kWe	m3/h	Delta-T	kW
100	22	30000	5	48
80	11,3	24000	13	100
60	4,8	18000	20	115
40	1,4	12000	20	77
20	0,2	6000	4	8
Total	**39,7**			**348 kW heat**

kW electric

- The application of variable parameters result in a significant decrease of kW electric (kWe) and kW heat (kWh)

5. Central Air-Driers

The distribution of dried air to multiple drying installations or sections

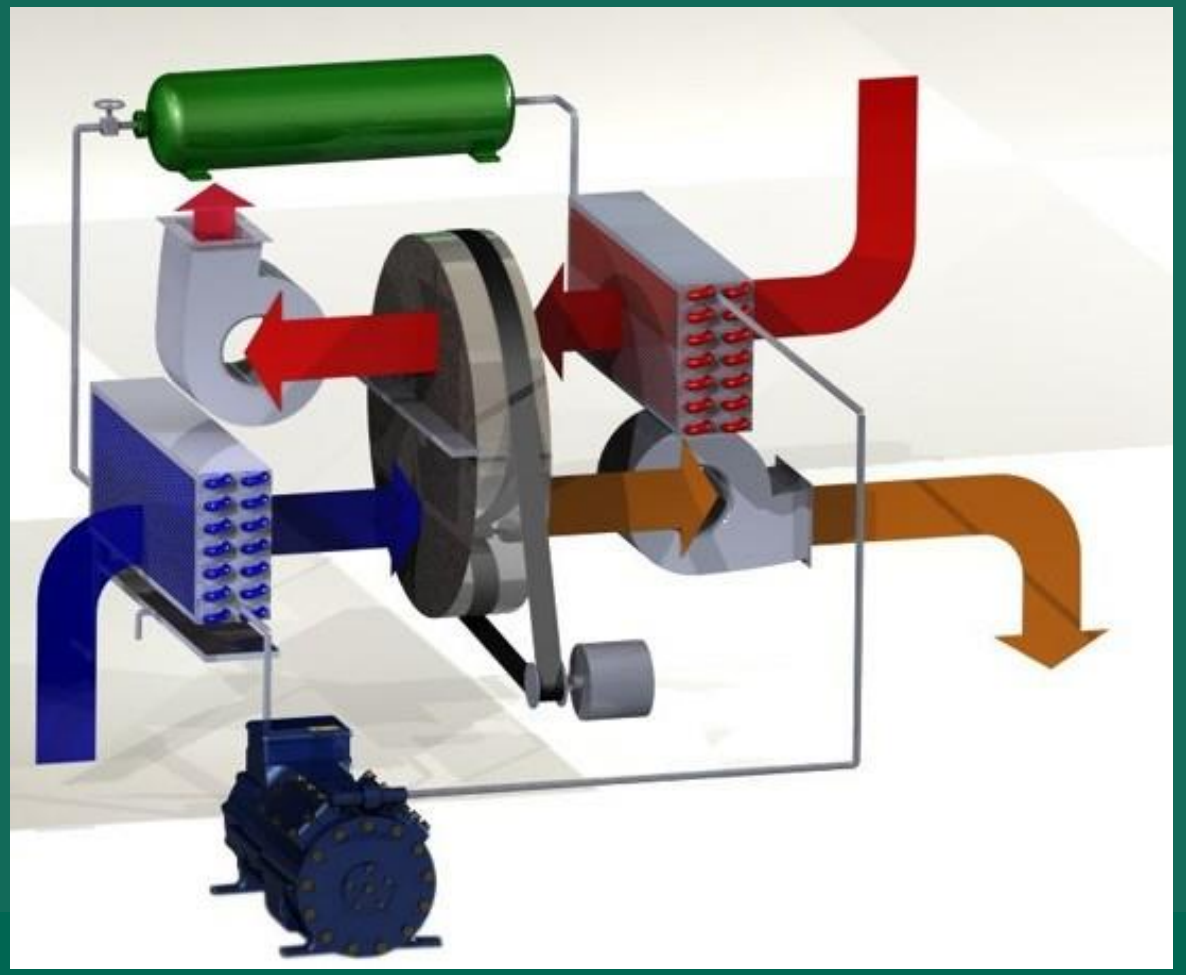


- In general, the demand for drier seed is increasing
  - With outside air becoming more and more damp, this is becoming increasingly difficult.
- Dried Air is only nessacary in the final drying stage
- **Benefits of a central hybrid air dryer**
  - Consolidates drying processes with a single, large air dryer.
  - Automatically directs dried air to where it's needed in the drying sections.
  - Adapts the volume of dried air to match drying requirements, minimizing electrical energy wastage.

5. Central Air-Driers

Dried air through Condensation and Absorption

- Supply of dried air through hybrid air driers
  - principle with the rotating adsorption wheel (in the middle) and the heat pump for pre-drying by condensation (blue) and drying the rotor (red).
- Optimzing efficiency
- Moreover, the use of solar panels could considerably save on the total energy costs.



6. Upgrading Existing Drying Installations

Improving your drying installation and capacity

- **Modulair Capacity**
  - The Temprature and Airflow adjusts automatically based on the changing drying conditions over time
- **Drying Curve Analysis**
  - Adjusting the Absolute Humidity to the specific drying needs of the seed
- **Smart Controllers**
  - Enabling Variable Airflow and Temprature to reduce kW electric and hea
- **the Central Hybrid Air Dryer principle**
- Central distribution of dried air to multiple drying sections
  -

7. Q&A

Any Questions?

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Booth #7
Seed Meets Technology

Thank you for your time!

SMT Symposium

‘Seed drying, a key step in maintaining seed vigour’

Discussion

seedmeets technology

Thank you for your attention!