Seed Drying Methods and Seed Quality

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Factors Affecting Seed Longevity

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

- Species
- Quality at the time of collection
- Conditions between collection and storage
- Conditions of storage
  - Moisture content
  - Temperature
  - Oxygen
Thumb Rules for Seed Storage

James’ Rule:
Temp (°F) + RH (%) < 100
Temp (°C) + RH (%) < 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.

Bradford’s Metronome Rule:
The “clock” starts running as soon as the seeds are mature and they have a total number of ticks before death. The rate at which the metronome ticks depends upon the temperature and moisture content.
# Seed Moisture Content vs. Relative Humidity

<table>
<thead>
<tr>
<th>Seed type</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
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<tbody>
<tr>
<td>Snap bean</td>
<td>5.0</td>
<td>6.5</td>
<td>8.5</td>
<td>11.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Pea</td>
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<td>7.0</td>
<td>8.5</td>
<td>11.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>7.0</td>
<td>8.0</td>
<td>9.0</td>
<td>10.0</td>
<td>12.5</td>
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<tr>
<td>Spinach</td>
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<td>8.0</td>
<td>9.5</td>
<td>11.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Onion</td>
<td>6.0</td>
<td>7.0</td>
<td>8.5</td>
<td>10.0</td>
<td>12.0</td>
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<tr>
<td>Carrot</td>
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<td>6.0</td>
<td>7.0</td>
<td>9.0</td>
<td>11.5</td>
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<tr>
<td>Tomato</td>
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<td>7.0</td>
<td>8.0</td>
<td>9.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Lettuce</td>
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<td>5.0</td>
<td>6.0</td>
<td>7.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Turnip</td>
<td>4.0</td>
<td>5.0</td>
<td>6.0</td>
<td>7.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>

*Seed moisture content, fresh weight basis (%)*

J. Harrington
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.
In addition to oil content (and temperature) the relationship between seed MC and equilibrium RH also depends upon whether the seed is losing or gaining water.

- Seeds losing water are on their desorption isotherm.
- Seeds gaining water are on their sorption isotherm.

The difference between the two isotherms (hysteresis) is often about 0.5 to 1% MC on a dry weight basis at the same RH.
Implications of Hysteresis for Seed Storage?

• Does hysteresis of isotherms have implications for seed storage?
• We seldom know which isotherm a given seed lot is on. Does it make a difference with respect to seed longevity?
• Could seed storage lives be extended by ensuring that they are on their lower (sorption) isotherms?
• Is the rate of seed aging driven primarily by the seed MC per se, or the water activity (equilibrium RH)?
Manipulating Seed Isotherms

By elevating seed MC and then transferring them to lower RH, we can ensure that seeds are on their desorption isotherm.

Or, by drying seeds to low MC and then transferring them to higher RH, they will be on their sorption isotherm.

We prepared seeds of several species in this way, then sealed them to preserve their MC and aged them at 50°C to determine their potential longevity.
Seeds of pepper (*Capsicum annuum*) were raised to ~15% MC, then equilibrated at different RH. Some seeds were dried to low MC after hydration, then transferred to higher RH. Longevity data for seeds equilibrated at 33% RH and stored at 50°C are shown in the right panel.
The maximum effect of this difference between isotherms on longevity seems to be at RH values in the 20 to 50% RH range. At higher RH, seeds age more rapidly and there is less difference between the MC and their longevities on the two isotherms.
Conclusions: MC Isotherms

• At normal storage RH values (<50%), seeds on their sorption curves had lower MC and greater longevity than did seeds on their desorption curves.

• Seed storage longevity is evidently determined more by the seed MC than by its water activity ($a_w$). Seeds equilibrated to the same RH (or $a_w$) may have different longevities if they are on different isotherms.

• Seed drying and treatment protocols could be modified to assure that seeds are on their sorption isotherms before being stored to extend longevity (i.e., dry to lower MC and allow to re-equilibrate to desired final equilibrium RH).
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.

Relative Humidity and Seed Longevity

Seed longevity is greatly reduced at high equilibrium RH.

http://data.kew.org/sid/viability/
Seeds are often dried in the sun, but this cannot reduce the seed MC to low levels if ambient RH is high.
Humid Conditions in Tropical Regions Cause Rapid Loss of Seed Viability

Ambient conditions in tropical regions often exceed 75% RH and 30°C during the monsoon season following seed harvest, resulting in rapid seed deterioration in open storage.
Drying Seeds Will Increase Their Longevity

Seeds can be dried using heat, but this is also relatively ineffective in hot and humid conditions.
Alternative: Drying with Desiccants

Desiccants can be used to absorb moisture from seeds.

Current desiccants have drawbacks that have prevented their widespread use for seed drying and storage.

Novel seed drying beads based on zeolites (molecular sieves) make it feasible to efficiently dry and store seeds at low RH.
Novel Desiccant Has Unique Properties

Zeolite desiccant beads absorb only water and bind it tightly until released by heating.

Improved drying at low RH compared to silica gel.
Beads Efficiently Reduce Air RH without Heat

RH air during cucumber trial on 6 November 2008 - TSA

Time

1 hour

RH (%)

0% - 60%

control T1 T2 T3 T4
Bead Regeneration for Reuse

Heat beads at 200°C for 2 h.

Cool briefly in covered container until safe to handle.

Package for storage in airtight containers.
Onion Seed Storage in India

Open bags

Seed MC reduced by 4% with beads.

With beads

Germination decreased by 45% in open bags vs no change with beads.

Stored for 1 year by farmers

Percentage of farmers (%)

Stored for 1 year by farmers

1 year of storage

Hort CRSP ANGRAU USAID
Pepper Seed Storage in Thailand

Before storage

All seeds germinate

After 6 months storage

Open stored vs Bead stored

Seedlings

Higher seedling vigor

Hort CRSP RR GROUP TVRC USAID
Dry Storage Prevents Most Storage Problems

Insect Control Using Seed Drying: ANGRAU, Hyderabad, India

Open storage in cloth bags versus sealed storage with drying beads. Both inoculated with bruchids.
Insect Control Using Seed Drying:
ANGRAU, Hyderabad, India

Six months storage
Without beads
With beads

Seeds Stored in Cloth bag + 10 pairs of bruchids (Control)
Seeds Stored in Airtight Container + Zeolite beads (1:1) + 10 pairs of bruchids

K. Kunusoth, unpublished
Scalable Technology using Desiccant Drying

For larger scale needs, systems using re-circulating air dried by beads are under development.
Conclusions

• Drying seeds to safe moisture contents is problematic in humid climates.

• Even heated air drying is inefficient and costly in warm, humid conditions, and cannot reduce seed MC to safe levels.

• Desiccant drying beads offer an alternative method to dry seeds to low MC without heat and enable both small- and large-scale seed drying and solve most seed storage problems.

• Drying beads could be a feasible approach to manipulate seed MC isotherms for improved seed longevity.
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