HORT 604
Applied Physiology of Horticultural Crops

Spring 2022

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Seeds
Germination
Priming
Dormancy

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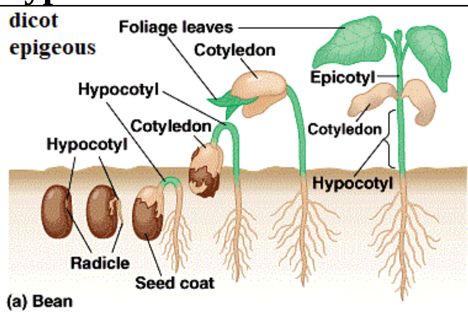
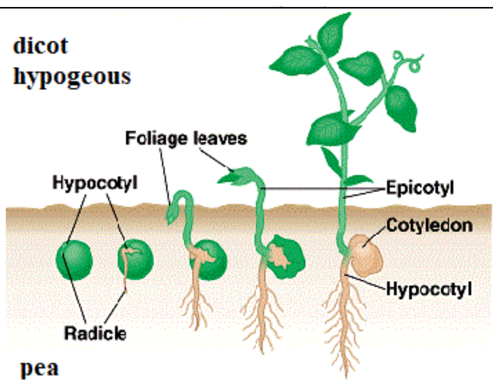
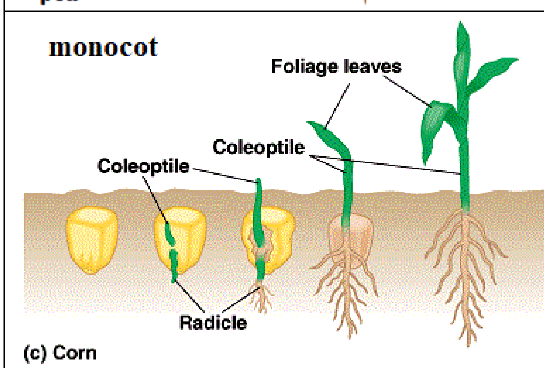
Terminology

pollination - deposition of pollen on the stigma of the pistil.
fertilization - the union of male and female gamete (nuclei, 1N) to produce zygote (2N).
double fertilization - in higher plants only (angiosperms)

- union of 1 1N male gamete with 1 1N female gamete (the egg) to
- produce a 2N zygote; and union of 1 1N male gamete with 2 1N
- polar nuclei to produce a 3N endosperm.

apomixis - development of an embryo without fertilization; hence, it is not true sexual propagation even though it produces a seed.
parthenocarpy - development of fruit without seeds.
vivipary - germination of seeds inside the fruit while still attached to the parent plant.

Types of Seed Germination

<table>
<tr><td>
</td><td>Epigeous Germination – Dicot
hypocotyl elongates & bends
cotyledons emerge from soil
apical meristem protected in cotyledons during emergence</td></tr>
<tr><td>
</td><td>Hypogeous Germination – Dicot
epicotyl elongates & bends
cotyledons stay below soil
apical meristem protected by leaves of plumule during emergence</td></tr>
<tr><td>
</td><td>Hypogeous Germination – Monocot
(not always called hypogeous)
epicotyl elongates
reduced cotyledon & endosperm (stored food) stay below soil
apical meristem protected inside coleoptile</td></tr>
</table>

Images from Pearson Education, Inc., Benjamin Cummings

STAGES OF SEED GERMINATION

Stage 1

- **imbibition** - initial absorption of water to hydrate seed
- **leak solutes** – may occur due to membrane leakiness
- **activation of metabolism** - increased respiration
- **release** - stored protein (α-amylase) and mRNA may be released

Stage 2

- **transcription -** to produce new mRNA
- **translation -** to produce new proteins
- **digestion of stored food** - for example, starch to sugars in cotyledon or endosperm
- **mobilization** – food reserves towards embryo
- **DNA synthesis** – begins
- **cell division** – begins
- **radicle emergence** – signifies the end of Stage 2 and beginning of Stage 3
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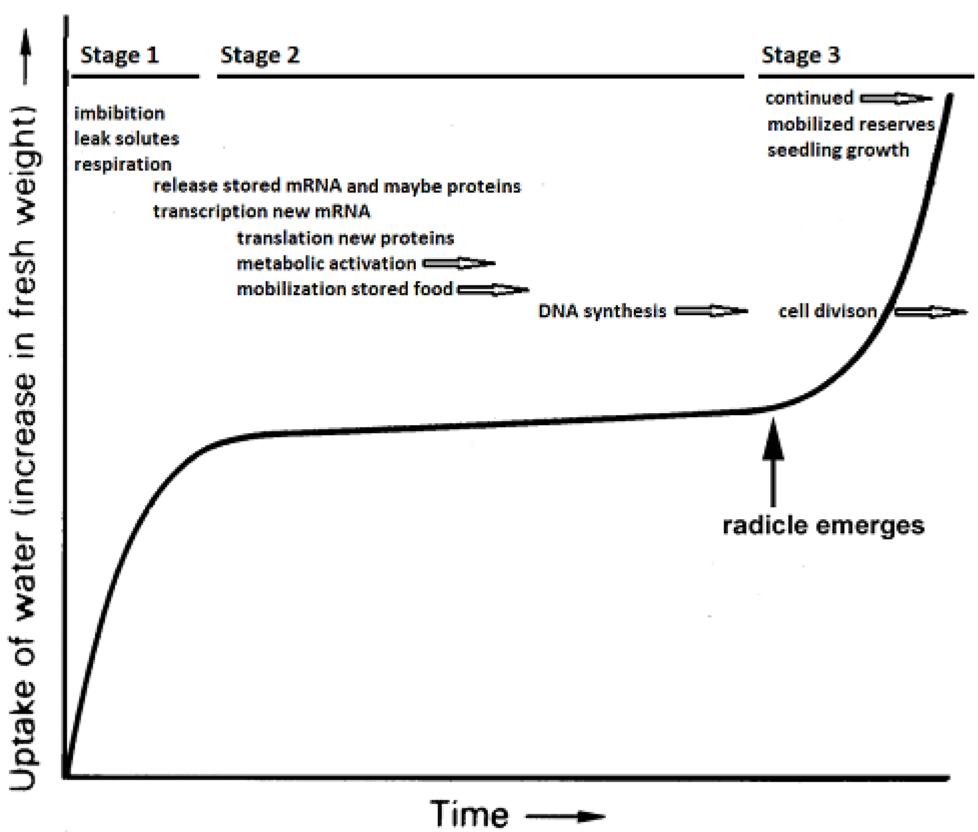
Stage 3

- **continued growth and development:** mobilization of food reserves, cell division, seedling emergence, and seedling growth and development



Seed Treatments to Enhance Germination

Seed Priming

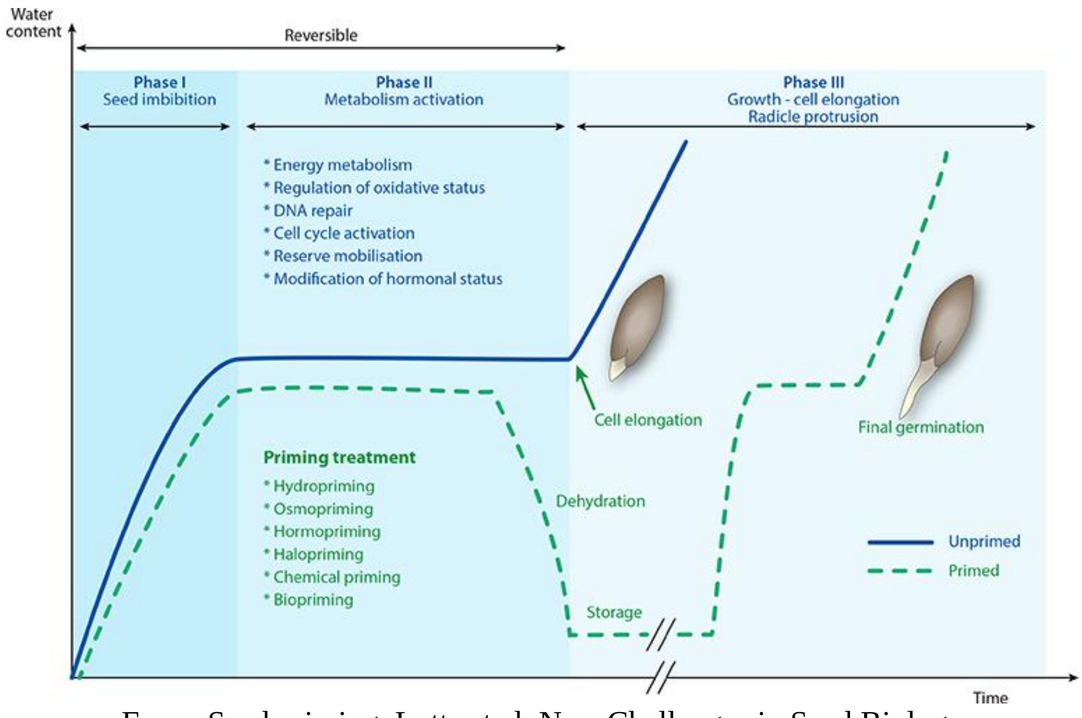
Seed priming is a seed treatment that allows imbibition and activation of the some of the metabolic events associated with Stage 1 and Stage 2 of seed germination, but prevents radicle emergence and growth, thus prevents the start of Stage 3 of seed germination.

The changes that occur during priming can be:

- RNA synthesis increases, or the seed resume RNA synthesis quicker
- Protein synthesis increased significantly
- Enzymes involve in mobilization of reserves increases, such as α-amylase, malate dehydrogenase or isocitrate lyase.
- Gene expression may occur or change

But, DNA synthesis does not increase because the seeds are kept in the Stage 2 lag phase, and cell division usually starts at the end of Stage 2 and throughout Stage 3.

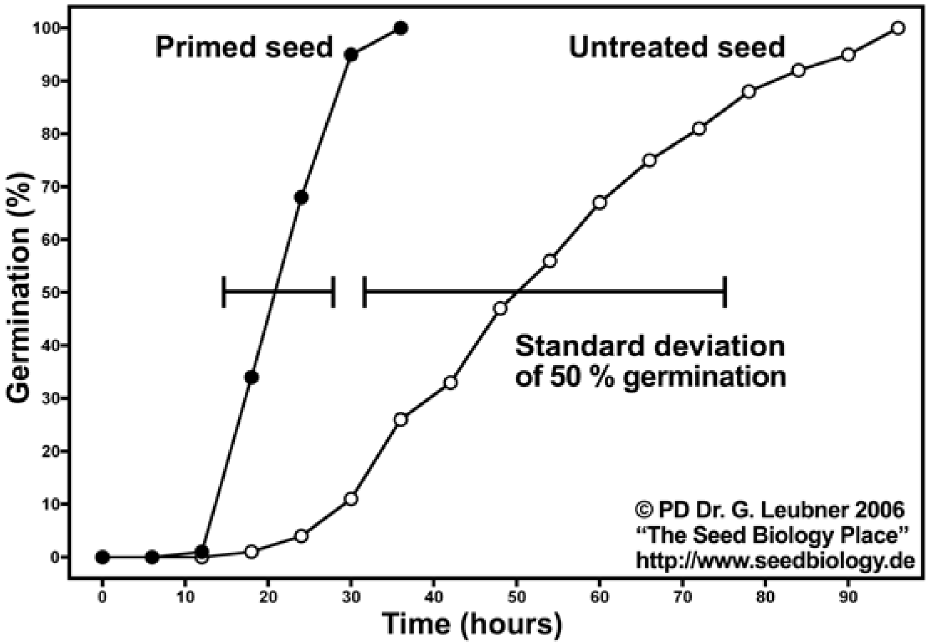
Many seeds are tolerant of desiccation. Even though during seed priming imbibition allows water uptake, the tolerance to desiccation upon dehydration is not lost. Thus, after priming the seed can be dried again and stored. If the seeds are primed too long, desiccation tolerance may be lost, and the seeds may loose viability upon re-drying. The secret to successful seed priming is to stop the priming treatment at just the right time to allow re-drying without the loss of seed viability.



From: Seed priming, Lutts et al, New Challenges in Seed Biology

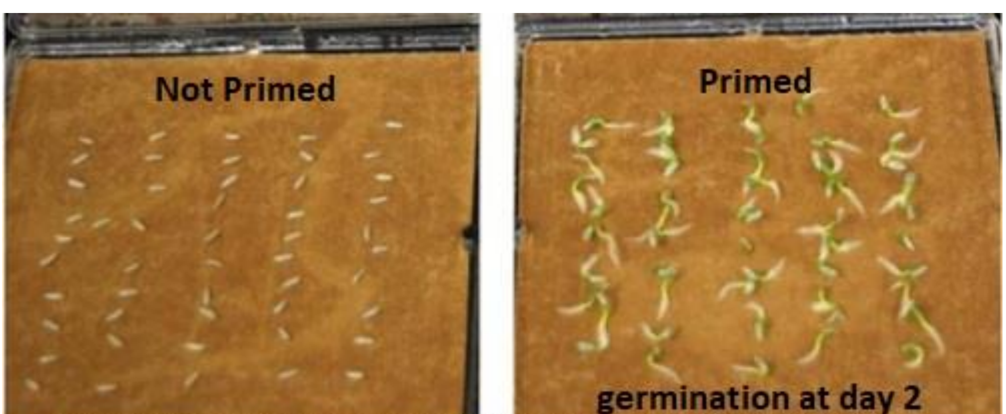
Advantage of Seed Priming

1) Germination time is greatly reduced; especially reduced lag phase



2) Germination is much faster and more uniform.

- See standard deviation bars in the top graph.
- See germination example below



From: Germains Seed Tech, From: Germains Seed Technology, germains.com

Disadvantages:

1) Typically, primed seeds cannot be stored as long as unprimed seeds.

2) Some primed seeds may require cool storage temperatures.

Types of seed priming

1) **Osmopriming** (osmoconditioning):
This is the most common technique used. The seeds are soaked in an osmotic solution to allow imbibition and metabolic activation, but the osmotic conditions do not allow expansion and growth of cells. Osmotica used are: mannitol, polyethyleneglycol (PEG) or salts such as KCl.

2) **Hydropriming**:
Imbibition is obtained by:
- partially hydrating seeds using a limited amount of water
- using very humid air
- exposing them for a short time in warm water.

3) **Matrix priming**:
A solid, insoluble matrix is used to obtain a water solution with low water potential. The matrix potential keeps the water potential low. Vermiculite, diatomaceous earth or cross-linked highly water-absorbent polymers are used.

Hormone Treatments to Enhance Germination

Seeds of some species are very difficult or slow to germinate due to primary and secondary dormancy, the need for after ripening periods, immature embryos, etc. Many of these seeds respond to hormones to increase the speed of germination, uniformity of germination and/or percent germination. For example, the seeds of many tropical foliage plants are difficult to geminate, but respond to hormonal treatments. Hormones can also be added to seed priming treatments.

1) **cytokinin** – 100 to 200 mg/liter for a 12-24 hour soak.

2) **gibberellic acid** – 200 to 1,000 mg/liter for 12-24 hour soak

Seed Longevity and Storage

Seed Longevity

Recalcitrant Seeds:

- Do not tolerate significant dehydration after maturity.
- Most begin to loose viability when moisture content drops below 25%
- May not have an after ripening period.
- Will not have pronounced dormancy.
- Sow the seeds soon after maturity.
- Examples: oak, maple, pecan, walnut, elm, many tropical plants

Orthodox Seeds:

- Tolerate drying after maturity.
- Can be stored for significant periods at 4-10% moisture
- May remain viable for years, some for decades, maybe centuries.
  Example, viable seeds found in ancient excavations, lotus in dry lake bed.
- Examples: majority of horticultural and agronomic crop plants.

Dormancy: many orthodox seeds have various types of dormancies that must be satisfied before germination can occur. – see next section.

Seed Storage

Orthodox seeds can be stored under conditions that maintain vigor, germination and viability.

- Maintain at least 4-6% seed moisture content
- Many tolerate room temperature, but it may beneficial to reduce the temperature to 40-50^{o} F.
- Low to moderate humidity

Harrington Rule of Thumb (James Harrington, Professor of Vegetable Crops, UC Davis)

- For every decrease of 1% seed moisture content, the life of the seed doubles.
  This rule is applicable when moisture content between 5 and 14%.
- For every decrease of 5°C (10°F) in storage temperature the life of the seed doubles.
  This rule applies between 0°C to 50°C.
- 50/50 rule
  - 50 ^{o}F / 50 %RH
  - ^{o}F + %RH <=100%
  - Good seed storage is achieved when the % of relative humidity in storage environment and the storage temperature in degrees Fahrenheit add up to hundred but the contribution from temperature should not exceed 50°F.

Take Home Lesson, in general best is cool temperature and moderate humidity.

Categories of Seed Dormancy

Modified from Hartmann, Kester, Davies, Geneve & Wilson, Plant Propagation Principles and Practices, 9th Ed, 2018

Categories of Seed Dormancy	Older terms	Dormancy Description:	Advantage or Reason	Method or Practice to Overcome
Primary Dormancy Dormancy present at end of seed development				
Exogenous Dormancy	Quiescence Ecodormancy	Factor outside the embryo		
Dry seeds:		Seeds of many plants are dehydrated in the fruit at maturity; 10-15%. This is not a type of dormancy, rather is probably a developmental process to prevent vivipary	Prevents vivipary	**sow** in moist soil
Physical Dormancy	Hardseededness	Impermeable hard seed coat	Spreads germination of multiple growing seasons.	**scarification** • physical abrasion (file, sand paper, rotating drum with sand) • chemical digestion of the seed coat (sulfuric acid).
Chemical Dormancy	Correlative Inhibition Paradormancy	Inhibitors in testa or pericarp; especially if fleshy.	Water soluble inhibitors: in desert plants acts as rain gauge. Inhibitors in flesh: prevents vivipary	• Inhibitors in dry testa or pericarp: **leach/soak** in water 24 hours to remove soluble inhibitors • Inhibitors in fleshy testa or pericarp: **extract/remove** seeds from fleshy tissue and rinse in water.

Categories of Seed Dormancy	Older terms	Dormancy Description	Advantage or Reason	Method or Practice to Overcome
Primary Dormancy - continued				
Endogenous Dormancy	Endodormancy	Factor inside the embryo		
Physiological After Ripening	After ripening	Many seeds will not germinate or respond to seed treatments for a period of time after seed maturity	Probably: • prevents vivipary • allows time for seed dispersal	**store** seeds in the appropriate manner for that species for a period of time.
Physiological Dormancy	Rest	Physiological factors inside the embryo, high inhibitors (ABA?) low promoters (auxin, GA?)	Assures germination in the spring.	**stratification** - cold (35-40 ^{o}F) moist storage for 4-12 weeks.
Morphological Dormancy		Immature or Underdeveloped embryo at seed maturity	• Prevents vivipary • Allows time for seed dispersal	• **Store** seeds in the appropriate manner for that species for a period of time until the embryo is fully developed. • **warm stratification** – may speed the process • **excise embryo** – place in tissue culture.
Morphophysiological Dormancy		Immature embryo and Physiological factors	• Allows time for seed dispersal • Spreads germination over multiple springs	**store** until embryo is developed, then stratification
Combinational Dormancy		More than one dormancy exists, such as hardseeded and physiological dormancy		Use the appropriate methods from above. Always scarify first.

Categories of Seed Dormancy	Older terms	Dormancy Description	Advantage or Reason	Method or Practice to Overcome
Secondary Dormancy Dormancy imposed after all primary dormancy/after ripening has been satisfied.				
Thermodormancy	Light requirement	High temperatures inhibit		• **store** normal ambient conditions • **cold stratification** • **growth regulators**
Photodormancy	Light Requirement	Lack of red light (darkness) or far red light	Usually seeds are very small. Assures the seeds are close to the soil surface • acts as a depth in the soil gauge.	• sow shallow or on surface • **expose** light ○ red light ○ any white light

NOTES