

SEED DORMANCY

Seed dormancy refers in seeds to failure of a viable seed to germinate even when given favorable environmental conditions. In many species can get a clue about requirements for breaking dormancy by studying the natural environment of the plant.

In nature, dormancy mechanisms assure that seed will germinate at the proper time.

In cultivation, have highly bred crops such as cereals, which have been bred for reduced period of dormancy so that during storage dormancy controls disappear and then seeds germinate immediately upon planting.

Important Terms

Dormancy - general meaning: *lack of growth due to any external or internal cause.*
Seed dormancy - Failure of a viable seed to germinate even when given favorable environmental conditions.

In nature dormancy is a mechanism that allows various species to survive in particular environments. Regulates the time and place of germination to be most favorable for survival of the small seedlings and the plant during its juvenile period. Much dormancy has been bred out of cultivated seed.

Quiescence - condition in which seed can germinate upon absorption of water. No internal germination barriers exist.

After-ripening - Physiological processes that occur in the seed after harvest that enables germination to take place.

Primary dormancy - Dormancy which develops when the seed is attached to the plant and exists when first harvested.

Secondary dormancy - A condition that develops to prevent germination after the seed has been detached from the plant and is exposed to specific unfavorable environmental conditions.

Example: Spring ripening species often germinate immediately in the spring when soil is moist, temperatures are favorable, and has entire season to grow. If conditions are unsuitable, such as drought, will not germinate and will then

require chilling as well. This ensures that it germinates the following spring, when it again has the entire season to grow.

Note that when seeds ripen they may be dormant or not dormant. If they are dormant, they are referred to as having primary dormancy. Some seeds are not dormant when mature and they are known as quiescent. They germinate readily when given the proper environmental conditions of water, temperature, and/or other factors. Seeds that do not have primary dormancy often acquire dormancy as they dry.

There are 3 major mechanisms for imposing dormancy:

1. Seed coverings

Restrict water uptake, embryo expansion, gas permeability, leaching of inhibitors

2. Chemical inhibitors include growth regulators etc.

3. Morphological aspects such as small, undeveloped embryos.

Commonly seed dormancy is based on a combination of morphological and physiological criteria.

General listing of seed dormancy (per Nikolaeva 1977)

- I. Primary dormancy

- A. Exogenous dormancy – Due to factors *outside the embryo*

1. Physical
2. Mechanical
3. Chemical

- B. Endogenous dormancy – Due to factors within the embryo itself

1. Morphological
 - a. Rudimentary
 - b. Linear
 - c. Undifferentiated
2. Physiological
 - a. Nondeep
 - b. Intermediate
 - c. Deep

- C. Combinational (two kinds of dormancy)

1. Morphophysiological
 - a. Epicotyl

- b. Epicotyl and radicle (double dormancy)
- 2. Exo-endodormancy

II. Secondary dormancy

- 1. Thermodormancy
- 2. Conditional dormancy

CLASSIFICATION AND EXPLANATION OF DORMANCY

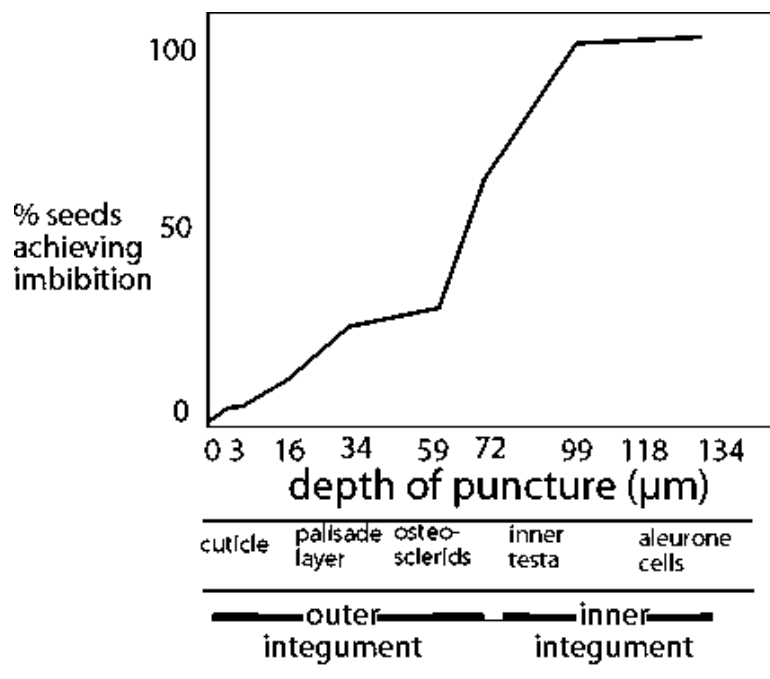
I. Primary dormancy

A. Exogenous dormancy

1. **Physical** - seed coats are impermeable to water. Seeds are at low moisture level. Legumes are an example. Embryo is generally quiescent.

The cause of physical dormancy is the structure of the outer cell layer which becomes impermeable to water. Macrosclereid cells, a mucilaginous outer cell layer, or a hardened endocarp are three reasons that seed coats become impermeable to water. Such seed coats develop during the last stages of seed development.

A study with *Coronilla varia* seeds showed that as the depth of a puncture to the seed coat increased, so did the permeability of the seed coat to water.



2. **Mechanical dormancy** - Seed coats are too hard to allow the embryo to expand during germination. Causes include: Structure of seed coats or remaining fruit. Occurs in olive.

In nature - coats are softened by environmental agents such as acid in guts, microorganisms in warm, moist, environment, forest fires etc. To overcome horticulturally - Scarify with sandpaper, hot water, acid, warm moist

environment, fire (melts resins in cones), use immature fruits. Once scarified water can get in. Have to be careful because then seed is also more susceptible to damage by microorganisms.

3. Chemical - presence of chemical inhibitors in the outer coverings of many fruits and seeds. This occurs in fleshy fruits, hulls, and capsules of many dry fruits. Examples are apples, citrus, grapes, desert plants. Very often this kind of dormancy disappears with dry storage. This kind of dormancy may also be present in other tissues surrounding the embryo such as the endosperm.

In addition – O₂ may be restricted by mucilaginous layers. Occurs in spinach, some of the Asteraceae.

In *nature* - overcome by heavy rains which can LEACH the inhibitors in tropics, deserts; some soil absorbs toxins such as ammonia given off.

To overcome *horticulturally* - Leach with running water; change water daily for several days; chilling for a few days; excising the embryo (=removing seed coat); use of hormones, especially GA₃.

B. Endogenous dormancy

1. Morphological dormancy

Embryo is not fully developed at time of ripening. Need additional embryo growth after the seed is separated from the plant. Described in terms of how much space the embryo takes up in the seed. In several herbaceous flower seed such as Ranunculus, poppy; woody species such as holly; tropical plants such as date palms. Often combined with other kinds of dormancy such as hard seed coats.

Rudimentary - about proembryo stage. May be inhibitors present.

Ranunculaceae, Papaveraceae, Araliaceae (ginseng)

Linear - at torpedo stage. Takes up about a 1/2 of seed cavity. May be inhibitors present. Umbelliferaea, Ericaceae, Primulaceae.

Undifferentiated - orchids

To overcome horticulturally - Alternate warm and cool temperatures; also hormones such as GA₃. Exposure to cool temperatures (59°F).

Some tropical species require extended period at high temperatures for full development of embryo. With date palms often takes several years to germinate. Takes this long to reach full embryo development. Often high temperatures (100 °F) will accelerate this

2. Physiological

a. Non-deep – Often short-termed and disappears with storage. Usually lasts from 1 month to 6 months. Disappears as the seed is stored. The major problem is in seed testing labs.

Photodormancy - Controls are thought to be in inner membranes of freshly harvested seed. May be due to 1. inhibitors 2. control of gas exchange (oxygen). Often seen as thermodormancy or light requirements in freshly harvested seed. These disappear with storage. Last from 1-6 months. In seeds such as lettuce there is an interaction between the light and temperature requirements. For example – lettuce seed requires light to germinate when the seed is fresh. But this light requirement can be substituted by cool temperatures – growing the seeds in the dark below 73° F.

Hormones can have an effect on germination of light sensitive seed. ABA inhibits germination in the light and in the dark. Kinetin (a cytokinin) can overcome the effect of ABA, but only in the light. ABA treatment plus GA₃ results in no germination in the dark, but with kinetin, the seeds germinate.

Control of photodormancy appears to be through phytochrome. Sunlight (R:FR=2:1) results in phytochrome in the active form. Under foliage (R:FR=0.12:1 to 0.70:1) far red dominates resulting in phytochrome in the inactive form.

Characteristic of herbaceous plants such as annuals and veggies. May be a problem in seed testing labs where they deal with very fresh seed. Often disappears with storage. As seed dries, membranes dry out and are no longer physiologically active.

To overcome *horticulturally* - Dry storage, pre-chilling for several days, light, alternating temperatures, KNO₃, hormones such as GA₃.

b. Intermediate internal - Controls thought to be in seed coats and in tissues surrounding embryo as well as in the embryo itself. Is characteristic of conifers. The embryo itself is quiescent, not dormant and will germinate if excised. The exact mechanism is not known. Chilling reduces time to germinate but is not absolutely required. The amount of stratification required is considerably less than that in deep physiological dormancy.

One effect of the chilling appears to be an increase in the force generated by the radicle. The force increases as dormancy is released and will even emerge from the seed coverings if kept cold long enough. Geneve calls this growth potential which is an indirect method of measuring force used by the radicle to penetrate the seed coverings.

Some seeds that were originally placed in exogenous dormancy – such as olive and walnut – have been reclassified by Geneve as intermediate internal since they require a chilling period in addition to the mechanical dormancy imposed by the endocarp.

To overcome *horticulturally* - stratification for 1-several months. Will respond to GA₃ treatment. (Details on stratification follow under deep physiological dormancy)

c. Deep physiological dormancy -

Controls are within the embryo itself. Characteristic of many temperate trees. Excised embryos not receiving stratification will exhibit physiologically dwarfing – stunted growth, rosette-like stature. The meristem is the site of perception of the incomplete chilling. If the shoot tip is cut off, the lateral buds will grow normally. The amount of stratification required is generally greater than 8 weeks.

In *nature* the pattern is that the seed ripens in the fall, are dormant, are moistened and chilled in the winter, and then as temperatures warm up in spring, the seed germinates, having received sufficient chilling. In colder regions, get longer chilling requirements. Thus will escape spring freezes.

To overcome in *nature* - natural stratification

To overcome *horticulturally* -
Stratification: moist chilling

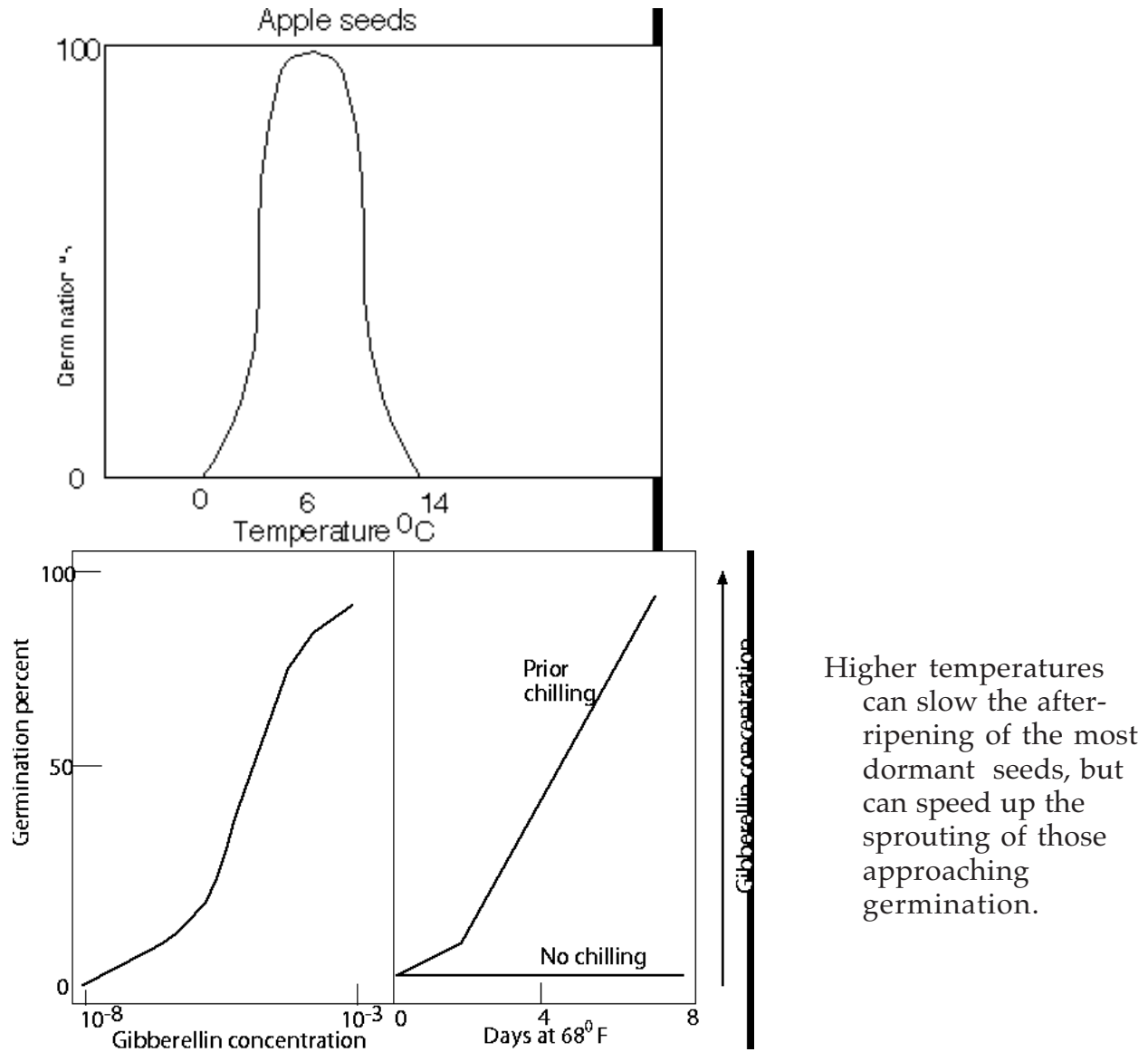
Requires:

MOISTURE: 50% moisture level. Cannot be allowed to dry out once after-ripening has started.

TEMPERATURE: temperature affects rate. Generally seed are kept at 35-45 °F (entire range). Note: if temperature is too high can induce secondary dormancy and then will require another chilling period before the seeds will germinate. For apple this is 17°C (62°F).

Also can get *physiological dwarfs* because of too warm temperatures. In peaches this temperature is 23-27°C (73-81°F).

Temperature is sensed by the apical meristem, laterals are normal. Thus if cut off apical meristem, the laterals will grow normally



Higher temperatures can slow the after-ripening of the most dormant seeds, but can speed up the sprouting of those approaching germination.

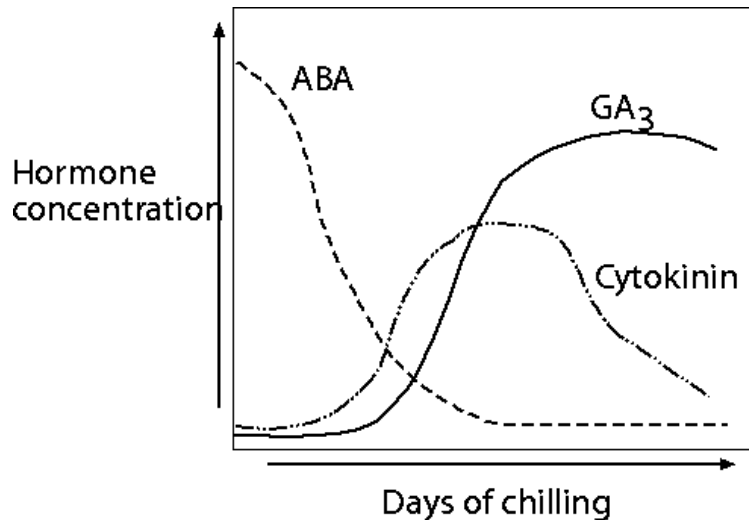
AERATION: Need a minimum amount of aeration since are dealing with physiological processes. As temperature is increased the solubility of oxygen is less in water and get oxygen fixation by phenolic substances in seed coats. Thus oxygen does not penetrate into embryo as well.

TIME: Requires from 1-3 months. Again if too little time will also get physiological dwarfs. A correlation found between seed and bud chilling requirements of a specific species. But

because the seeds are heterozygous will get a great deal of variability in individual seed germination time within a given seed lot.

Horticultural implications - If one has incomplete stratification get variability in stands, size of plants, maturity.

Hormone interactions during stratification



C. Combinational dormancy

1. Morphophysiological

a. Epicotyl dormancy

Separate after-ripening requirements for epicotyl, radicle, hypocotyl.

Seeds initially germinate during warm period, produce root and hypocotyl growth. Require 1-3 months chilling to release epicotyl from dormancy.

Lilium, Viburnum, Peony.

2. Epicotyl and radicle (double dormancy)

Require chilling period for embryo, followed by a warm period for root, then a second cold period for shoot growth. Trillium and other native perennials.

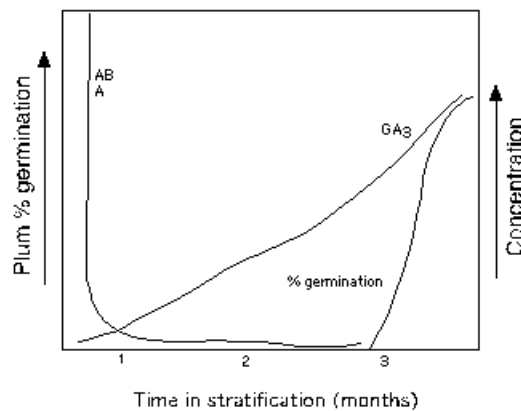
II. Secondary dormancy

Imposition of a new dormancy mechanism during unfavorable conditions. The critical point is that this dormancy occurs AFTER the seed has been separated from the plant. Prevents germination during unfavorable conditions in seed that have overcome primary dormancy. Eg. Maple seeds. Germinate in spring. But if there is insufficient water or too high temperature a secondary dormancy will set in that then requires chilling for the seed to germinate. How does this reflect natural conditions? Eg. Fresh lettuce seed. Will germinate if imbibed for 2 days in the dark. Thus only primary dormancy present. If imbibe for 8 days - will not germinate because secondary dormancy occurs. To overcome this dormancy need chilling, or light, sometimes GA₃.

Thermodormancy is a subcategory. If it is too hot when the seed starts to germinate, a secondary dormancy will set in. Germination will not occur when the temperature returns to normal. Seeds in this category – lettuce, celery - are handled to avoid secondary dormancy rather than overcome it.

CONTROL OF DORMANCY AND GERMINATION

Explanation of graph at right: ABA high at time of ripening, in both embryo and seed coverings. ABA fell to low level after 1 month of stratification. However, seed still did not germinate. Then during second month level of GA increased from very low to high. Control was in the seed coat because GA could not replace chilling unless seed coats were removed.



More about ABA - Thought to be responsible for lack of development in rudimentary embryos. Ethylene - Natural germination promoter for certain seeds. Especially found to stimulate germination in subterranean clover and Virginia-type peanut

Advantages of seed dormancy

1. Seedling survival
2. Creation of a seed bank
3. Synchronize germination - Insures a population of plants at same stage of development for outcrossing
4. Seed dispersal - eg. seed coat scarified by passing through a bird's animal tract