Seed Dormancy

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Seed dormancy presents a considerable problem to the seed analyst - the seeds are alive but fail to germinate under the conditions prescribed. The problem is further complicated by the fact that seeds generally lose their dormancy with time. Thus, germination test results of samples tested soon after harvest and several months later might be vastly different. The Rules for Seed Testing prescribe treatments which are generally effective in overcoming dormancy in certain kinds of seed. However, the analyst is often confronted with seed kinds not included in the Rules, or for which the special treatments prescribed are not completely effective.

Definition of a Dormant Seed

A dormant seed is a live seed which fails to germinate over a range of conditions favorable for germination of non-dormant seed of the same kind. Dormancy may be manifested as the complete inability of the seeds to germinate or as an increased specificity in their germination requirements, i.e., they might require some special temperature, moisture condition, or other special treatment.

Occurrence of Seed Dormancy

Dormancy of reproductive structures is a constant phenomenon in the plant kingdom - algal and fungus spores are dormant; fern spores are dormant; seeds are dormant and also buds, corms, tubers, bulbs, rhizomes, etc.

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Relatively few of the major cultivated crop species have deeply dormant seed. Plant breeders over many years have selected or bred plant for the non-dormancy characteristic. Wild plants and species taken under agricultural management comparatively recently, however, usually exhibit a deep-seated type of seed dormancy. Such species include forage grasses and legumes, some vegetable seed, and most kinds of tree or shrub seed.

Dormancy as a Survival Mechanism

Apparently seed dormancy has evolved as a survival mechanism or adaptation to a particular climatic condition. In temperate regions, the main threat to survival is the relatively cold weather prevailing during the winter season. If seeds of plants maturing during the late summer or early fall germinated promptly, they would develop only to the seedling stage and would not be able to withstand frost or freezing temperatures. In other climatic regions, hazards to the continuity of plant life might be different: the prolonged wet and dry periods characteristic of certain tropical climates, or the extreme aridity prevailing under desert or semi-desert conditions. That dormancy is a survival mechanism is supported by the fact that generally for any given type of climatic condition, the particular hazard to survival (cold, drought) provides the best means of overcoming the dormant conditions, e.g., prechilling for temperate climate plants, predrying for tropical and sub-tropical plants, leaching for plants of arid climates.

Advantages and Disadvantages of Seed Dormancy

Seed dormancy enables plants to survive seasonal hazardous conditions in the highly resistant seed stage. It distributes germination over time. Some type of residual dormancy is necessary in all kinds of seed, for without dormancy,
the embryos of developing seed would continue growing and germination in the field would result.

There are many disadvantages to seed dormancy. Dormancy prevents prompt and uniform emergence of seedlings; interferes with planting schedules; contributes to "volunteering" of crops; and causes problems to the seed analyst.

Classification of Types of Dormancy

Seed dormancy - although the end result is the same - is not restricted to a single cause or mechanism. Some knowledge of the cause of dormancy is essential if effective means for overcoming it are to be devised.

Seed dormancy can be classified into the following types on the basis of mechanism or locus of restriction or inhibition.

1. **Impermeability to water** (hard seeds). Hard-seededness is characteristic of the Leguminosae, Malvaceae, Convolvulaceae, and many tree and shrub seeds. The seed coat does not allow penetration of water into the seed. The embryo is not dormant.

2. **Impermeability to oxygen**. Gaseous impermeability of the seed coat or pericarp is considered - at least by some investigators - to be the principal mechanism of dormancy in seeds of Graminae, and some Compositae. The embryo is not dormant.

3. **Embryo dormancy**. This is a complicated type of dormancy. The embryo itself is dormant. In some cases certain parts of the embryo are dormant. This type of dormancy is poorly understood and is characteristic of many tree, ornamental shrub, and some vegetable species.

4. **Inhibitors**. This type of dormancy is characterized by the presence of specific chemical substances which inhibit germinative processes. It is possible that inhibitors are involved in all types of dormancy. They are probably responsible
for the embryo type of dormancy. Specific inhibitors have been isolated from Avena and Oryza seed, Beta seed, and some tree seed.

5. Light requirements. Some kinds of seed require light for germination, particularly when freshly harvested.

6. Mechanical restriction of seed coat. This has been suggested as a mechanism of dormancy but it appears to have little validity.

7. Combinations. Some kinds of seed have extremely complicated types of dormancy - combinations of embryo dormancy and hard-seededness, etc.

Hard Seeds
(water impermeability)

Impermeability to water is the major cause of dormancy in the Leguminosae - an important group of plants. It is also of importance in species of Malvaceae, and some tree and shrub seed.

In legume seed, hardseededness or water impermeability is related to the seed coat. The cells of certain layers in the seed coat are heavily suberized which water proofs the seed. In other species (Malvaceae), pectic substances impregnating the seed coat are responsible for its impermeability to water.

Value of hard seeds

The value of hard seeds is controversial. Some investigators claim that hard seeds are of value as insurance against initial stand failure or as "replacements" in thinning stands. Others contend that late germinating seed could not compete successfully with established seedlings and that if a general stand failure results, the remaining hard seed would not be sufficient for establishment of an effective stand. In spite of this controversy, it is assumed by most seed analysts that 75% of the hard seed in Medicago sativa contribute to the stand, while only about 50% of the hard seed of Melilotus spp. contributes to the stand.
Methods for overcoming hardseededness

All methods for overcoming hardseededness depend upon some alternation of the physical integrity of the seed coat - in some way the seed coat must be ruptured, scratched or punctured.

(1) Use of solvents - hot water (Abutilon theophrasti), organic solvents (Robina)

(2) Impaction - impaction of the seed against a hard surface will cause fractures in the seed coat. Some commercial scarifiers operate on this principle.

(3) Scarification (abraison) - the seeds are abraded against a rough surface causing minute scratches in the seed coat.

(4) Acid scarification - seeds are soaked in concentrated sulfuric acid for 10 minutes to 1 hour (depending on the kind). Dissolution of the seed coat by the acid destroys its impermeability.

(5) Extreme cold - temperatures on the order of -50 to -100° C. will cause fractures in the seed coat.

(6) Heat - temperatures in the range 60° to 80° C. for 1 to 1 1/2 hours effective. Very short treatments with dielectric or infrared heating sources are most effective. A 1.4 sec. exposure to a 110 W infrared source increases germination of Medicago sativa hard seed.

Hardseededness is one of the easiest types of dormancy to overcome. The treatments required are as simple as rubbing the seed over fine sandpaper. Yet, the "safety factor" of the treatments is narrow. Each of the treatments will severely injure seed if their application is not accurately controlled and timed.
Gaseous Impermeability

The primary mechanism of dormancy in Graminae may be impermeability (absolute or relative) of the pericarp-seed coat complex to oxygen. This supposition is largely supported by two critical facts: that dormancy in most species of Graminae can be overcome by rupturing the pericarp-seed coat complex, and that water impermeability is not involved. Beyond the statement relative to the effectiveness of rupturing the seedcoat, we cannot generalize. For grass species vary widely in their response to other dormancy breaking treatments.

Perhaps the only species in which the oxygen-impermeability theory has been definitely established is in Xanthium spp. In Xanthium spp., the upper and lower seeds differ in their requirement for external oxygen pressure for germination. The upper seed requiring the highest external pressure. High temperatures appear to lower the requirement of both seed for external oxygen pressure.

In the case of Graminae, it has been shown that increased partial pressures of oxygen stimulate germination of Avena fatua, Chloris ciliata and Agropyron smithii.

Inhibitors also appear to be involved in the dormancy of some grasses.

**Methods for overcoming dormancy in Graminae**

There are many methods which will break or overcome the dormant condition in species of Graminae.

1. **Rupturing seed-coat pericarp.** Dormancy in most species of Graminae can be overcome by pricking or rupturing the seed coat near the embryo.

2. **Alternating temperatures.** The Rules specify alternating temperatures of 20 - 30° C., 15 - 30° C., and 15 - 25° C. for germination of many freshly
harvested dormant grass seed kinds. This treatment is effective but seldom forces complete germination of deeply dormant seed.

(3) **Use of 0.2% KNO₃.** The use of 0.2% KNO₃ as the substrata moistening agent is also specified in the Rules for many species including *Gramineae* species. This treatment increases germination but does not force complete germination of deeply dormant seed.

(4) **Prechill treatments.** Subjecting dormant grass seed kinds to a temperature of 5° to 10° C. for 5 - 30 days is often most effective in breaking dormancy. This treatment is most effective on cool season species such as *Poa, Phleum, Festuca, Triticum, Hordeum*, etc. It is seldom effective on warm season grasses, e. g., *Paspalum, Oryza*, etc.

(5) **Light.** Many kinds of grass seed respond to light. Again, this treatment alone is usually not sufficient to induce complete germination. In the case of grasses, light requirements are not satisfied by brief exposures – usually light exposure must be cycled throughout the entire germination period.

(6) **Increasing partial pressure of oxygen.** This treatment is moderately effective on *Avena fatua, Chloris ciliata* and *Agropyron smithii*.

(7) **Combination treatments.** Since some of the treatments indicated above are not completely effective when applied alone, combination treatments are often used. These include the treatments of light, 0.2% KNO₃, and prechill in various combinations. (Examples: *Poa, Festuca, Phleum, Panicum virgatum*.)

(8) **Other treatments.**

(a) **Chemicals – ethylene chlorohydrin** at 1000 ppm., and low concentrations of hydrogen peroxide and sodium hypochlorite have been shown to be effective in stimulating germination of a few *Gramineae* species.
(b) Water soaks - effective on some varieties of Avena and Oryza.
(c) Acid Scarification - has same general effect as rupturing the pericarp. Soak in concentrated $H_2SO_4$ for 10 to 30 minutes, then wash thoroughly.
(d) Predrying - sometimes effective on tropical and sub-tropical grasses. Pre-dry at 40 or 45°C for 1 to 4 weeks.

Embryo Dormancy

In embryo dormancy the seed coverings have little influence. They can be removed without affecting the dormant condition of the embryo.

Dormancy in embryos is manifested as the complete inability to germinate or as a general sluggishness in early growth and a drawfishness in the part of the plant developing from the epicotyl.

Embryo dormancy can be incredibly complicated by other factors.

(1) **Seeds with dormant embryos.** A single period of low temperature stratification will usually force germination. (Low temperature stratification involves subjecting imbibed seed to 2 to 5°C for 15 to 120 days.) Example: Pinus spp.

(2) **Seeds with dormant embryos and hard seed coats.** First the hard-seeded condition must be broken by acid or mechanical scarification. Then when the seeds are able to absorb water, the stratification treatment is applied. Examples: Symphoricarpus, Crataegus.

(3) **Seeds with dormant epicotyls which require development of root system.** Some tree and shrub seed have dormant epicotyls. This dormancy can be broken by stratification, but only after the root system has developed. Thus, the seeds have to be planted at a warm temperature - the roots develop - then the stratification treatment is applied. Examples:
Lilium, Paeonia, Viburnum. In cases when the root is also dormant, the seeds require (in order): stratification, warm temperature, stratification, warm temperature. These seeds are referred to as two-year seeds because under natural conditions two years are required for germination.

The changes that occur in seeds during stratification are referred to as after-ripening. Although some work has been done in an attempt to determine what happens during stratification, relatively little is known.

Inhibitors

It has been suggested that inhibitors are responsible for the dormant conditions of many kinds of seed. In only a few cases, however, is there sufficient evidence to support these suggestions.

1. **Beta** spp. Some kind of nitrogenous inhibitor appears to be the cause of dormancy or possibly some coumaric derivative.

2. **Avena** spp. The presence of an analyse inhibitor in the hulls has been demonstrated.

3. **Oryza** spp. A seedling growth inhibitor has been demonstrated.

4. **Pennisetum ciliare, Oryzopsis milicea**. Some type of water soluble inhibitor involved.

Most inhibitors appear to be water soluble and can be readily leached from the seed or seed coverings with running water.

Light Effects

Light stimulates the germination of many kinds of seed – some Gramineae species, **Nicotiana tabacum**, **Lactuca sativa**, **Lepidium** spp., **Pinus** spp.,
Plantago spp. Light inhibits the germination of a few species: Phacelia, Nigella. Many other species are light neutral: Zea, Triticum, Oryza, Trifolium, Hordeum.

Several treatments or factors will partially or completely substitute for the light requirement of light-sensitive seed:

1. **Time** - seeds lose sensitivity with age.
2. **Proper temperature** - some seeds are light sensitive only at certain temperatures.
3. **KNO₃** - mostly grasses.
4. **Gibberellin** - a most potent germination stimulant.
5. **Prechill treatment** - mostly grasses and tree seed.

**Action of light**

For many species it is necessary that they be exposed daily to light during the germination test period. Thus, there appears to be no induction reaction. In other kinds of seed, however, very brief exposures to light of proper spectral quantity and quality is sufficient for complete promotion of germination. Rather famous examples of this kind of seed are Lactuca sativa var. Grand Rapids, Lepidium virginicum, and Pinus virginiana.

Two portions of the spectrum appear to be involved in light reactions in dormant seed: red light in the region 5,800 to 6,950 Å, and far-red light in the region 6,950 to 7,900 Å. Red light stimulates germination in light sensitive seed; far-red light inhibits germination. The stimulating effect of red light and the inhibiting effect of far-red light are immediately and repeatably reversible. Lactuca sativa exposed to alternation periods of red and far-red light at the proper temperature will germinate or not germinate depending upon which type of light the seeds were last exposed. The mechanism of light action appears to be related to transformations in an absorbing pigment referred to as phytochrome.

From a seed testing viewpoint, two types of light requirements are recognized. The first involves daily exposures to light throughout the germination
test period. The daily period of illumination being about 8 hours and corresponding in time to the high temperature of alternating temperature conditions. The other type involves a single brief (30 min. to several hours) illumination of tests after the seeds are imbibed. (Lactuca)

Generally light of the cool white fluorescent type - which emits strongly in the red band - at 100 foot candles intensity is sufficient. (Two 40 watt cool-white fluorescent lamps mounted in a white reflector will provide 240 f.c. intensity at 12 inches, or 100 f.c. at 24 inches.)

Suggested Procedure for Studying Dormancy

The analyst often has to make germination tests on species about which little is known. Most often such species will be dormant. Thus, the analyst might become involved in developing a suitable method for germination of the species in question. In such cases an outline of investigative procedures facilitates the research. A suggested format for studying seed dormancy is described below.

(1) Determine if the seeds absorb water. If they do not, hardseededness is involved.

(2) If hardseededness is not involved, try puncturing the seed coat, or removal of the seed coverings. If dormancy is broken by puncturing the seed coat, then gaseous impermeability is probably involved.

(3) Apply standard treatments of KNO₃, light and prechill in various combinations at several temperatures, e.g., 20, 20-30° and 30° C. Based on response (if any) plan further experiments incorporating most effective treatments or treatment combinations.
(4) Determine the effect of water soaking. A response from soaking indicates a possible inhibitor.

(5) If all else fails try prolonged low temperature stratification (3 to 5°C for periods up to 4 months).

(6) Try some exotic chemicals in low concentrations applied as seed soaks or moistening agents: gibberellin, kinetin, ethylene chlorohydrin, hydrogen peroxide, sodium hypochlorite.

(7) Try predrying of the seed at 40 to 45°C for periods up to 4 weeks.