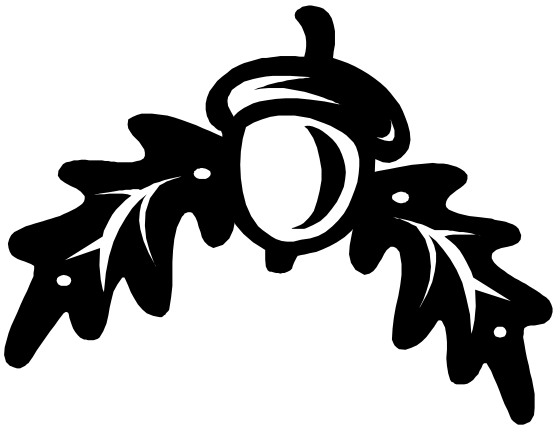
Seed Dormancy And Treatments



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Many seeds fail to germinate after processing and placement in favorable growing conditions—such seeds are said to be dormant. In some dormant seeds morphological changes must take place before germination can start. For others, parts of the seed must undergo physiological changes before a germination can occur. Under natural conditions necessary changes take place gradually under varying combinations of aeration, moisture, temperature, and light. By duplicating key conditions of the natural environment in the laboratory or nursery, dormant seeds can be induced to germinate with a reasonable length of time (Krugman et. al. 1974).

In general, there are two types of seed dormancy: seed coat dormancy and

internal dormancy. Seeds with seed coat dormancy usually have a seed coat that is impermeable to oxygen and/or water. Occasionally the dormancy is caused by an inhibiting chemical in the epidermis or adjacent interior membranes. Under natural conditions these seeds remain on or in the ground without germinating until they have weathered sufficiently, to allow penetration of water, exchange of gases, or neutralization of inhibiting chemicals. Seeds of some species germinate only after being subjected to fire. The length of time involved—it can be several years or more—depends upon the species and the environmental conditions. Seed coat dormancy is common in California lilac (*Ceanothus*), manzanita (*Arctostaphylos*), sumac (*Rhus*), and members of the legume family. If seeds of such plants are harvested when slightly green or immature and sown immediately before they dry out, germination problems may be reduced; however, once the seeds have dried out, the dormancy factor is present and must be counteracted to obtain prompt germination. Methods of breaking seed coat dormancy include scarification, hot water, dry heat, fire, charate, acid and other chemicals, mulch, water, cold and warm stratification, and light (Emery 1987).

Internal dormancy is a general term encompassing a number of physiological conditions that delay germination. Not all of these conditions are fully understood or easy to counteract. The most common one is called after-ripening. Seeds that require an after-ripening period, even though harvested when mature, germinate poorly or not at all until they have been subjected to moisture and either high or low temperatures or both in sequence; sometimes, however, a period of dry storage is sufficient to break dormancy. As might be expected,

internal dormancy is most often found among species that grow in the high mountains or deserts. The more common method for breaking internal dormancy is cold stratification. In some cases, the use of chemicals can be substituted for part or all of the stratification requirement (Emery 1987).

Multiple dormancy factors also occur. In one general type there is seed coat dormancy plus internal dormancy. Seeds with this dormancy combination must be treated for the impermeable seed coat first, then for internal dormancy. In another type there are two or more distinct internal dormancy factors, which unlock sequentially at different temperatures. One group requires warm temperatures first for a small amount of primary root growth, then cold to break shoot bud dormancy, then warm again to initiate shoot growth and complete germination. Another group needs cold temperatures first to break primary root dormancy, then warm to initiate a small amount of root growth, then cold again to break shoot bud dormancy, then warm again to initiate shoot growth and complete germination. In the wild, seedlings of plants with these dormancy types would not appear until the first or second spring after the seeds had matured and dropped from the parent plant (Emery 1987).

A general summary of methods for breaking seed dormancy is outlined in the next few pages.

Scarification

[for some members of legume family]

Mechanical scarification is a technique for overcoming the effect of an impermeable seedcoat. Mechanical scarification can be done by rubbing seeds

between two pieces of sandpaper (Schmidt 1980), or using a file, a pin, or a knife to rupture the seed coat. Seed may also be mixed with coarse sand and shaken vigorously in a jar (Schmidt 1980). Even a vise can be used to squeeze seeds along the suture until they crack open. Care must be taken not to injure the embryo. It may be necessary to open a couple of seeds to see where the embryo is located in relation to the micropyle, the former point of attachment to the fruit. Large seeds like those of the bush lupine (*Lupinus*) are easily scarified with a knife; the hot water treatment is easier for small seeds (Emery 1987).

Hot Water

[for some members of legume family]

For small to medium-sized seeds or large quantities of seeds, the hot water treatment is more practical than scarification. For this treatment seeds should be dropped into about six times their volume of 180º-200ºF pre-heated water (rain water is desirable if it is near neutral in pH). They should be left to cool and soak in the water for 12 to 24 hours, after which they are ready for sowing. The container used for this treatment should not be made of aluminum as it may be toxic to the seeds. Also softened water should not be used since the amount and ratio of salts may be toxic to the seeds. Another and more drastic hot water treatment is sometimes used for corn—especially thick or hard-coated seeds. For this treatment, the seeds should be placed in vigorously boiling water for a specific length of time depending on the species, then immediately removed from the boiling water and cooled in cold water (Bonnan et. al. 1974, Emery 1987).

With both hot water treatments, the seeds should be sown promptly and not

stored again.

Dry Heat

Oven or dry heat is not often recommended, and the temperatures required are more suitable to an incubator than a kitchen oven. For this seed coat treatment the seeds should be placed in shallow containers in a preheated incubator or oven. The specific temperature and duration depend on the species. After the treatment, the seeds should be cooled immediately and sown.

Where the temperature suggested is between 180º-212ºF, it is possible that the hot water treatment of the same temperature and for the same length of time would give comparable results (Emery 1987).

Charate

The char from burned plant stems has been shown to be a good neutralizer of germination inhibitors in the seeds of several herbaceous species associated with chaparral fires. Golden yarrow (*Eriophyllum*), and *Phacelia* species have enhanced germination with the addition of a small amount of chamise (*Adenostoma fasciculatum*) charate to the sown seeds (Emery 1987).

Charate can be prepared by burning chamise stems of 3/8-inch or less in diameter with a propane torch until they are blackened through and then grinding the charred stems in a Wiley mill to produce a uniform powder. Try 0.154 ounces of charate to each petri dish of 20 to 50 seeds (Emery 1987).

Charate made from woody species other than chamise gives different degrees of germination enhancement for different species. Baking the stems (500 ºF for 10 minutes or 347 ºF for 30 minutes) instead of treating with a blowtorch

may give comparable results. In some cases, seeds heated in an oven for short periods and then treated with showed further enhanced germination, sometimes synergistically (Emery 1987).

In the family Hydrophyllaceae there are many fire-following species with seeds that are difficult to germinate. *Phacelia* has been tested with charate, and germination has been enhanced (Emery 1987).

Fire

Seeds of some genera have tough, thick seed coats and germinate best when subjected to the heat of fire. For this treatment the seeds should be sown in the fall in a slightly moist medium but not watered. A layer of dry pine needles or excelsior, four to six inches deep, should be placed over the top of the seedbed. A few small pieces of wadded paper will help to ignite the material. One or two strips of aluminum foil placed over the exposed edges of the wood container will prevent it from burning; plastic containers should not be used. After the seedbed has cooled following burning, it should be thoroughly watered and then treated as any other batch of sown seeds. Since the small flash fire produced by this treatment is quite hot, this method should be used outdoors in the open, away from combustible material, and on a calm day. The seeded container should be left outdoors for germination, since seeds of many plants also have internal dormancy factors and therefore need a cold, moist period for germination. Even using this treatment, manzanita (*Arctostaphylos*) seeds require a minimum of two months to germinate. If the seeds are sown and treated in mid-October and no germination has occurred by June, the seedbed can be dried out for the remainder

of the summer. Watering should be resumed in the fall when the weather begins to cool. Some germination may occur as late as the following spring (Emery 1987).

This fire treatment is not exact, and the results obtained may not be a consistent because the amount and duration of heat actually reaching the seeds is governed by several variable factors (Emery 1987).

Acid

Acid treatments are often used to break down especially thick impermeable seed coats. Since seeds placed in concentrated sulfuric acid (H_2SO_4) will become charcoal in time, the temperature of the acid and the length of time the seeds are soaked are very important. The acid should be used at room temperature for a period of a few minutes to several hours depending on the species. The seeds should be immersed in acid in a glass, china, or earthenware container, and should be stirred occasionally with a glass rod; however, too much stirring will cause the acid to heat undesirably. The seeds must be removed from the acid just before any acid penetrates the seed coats. When the allotted time is finished, the seeds should be removed promptly and washed thoroughly in several changes of water to neutralize completely all remaining acid. For some species the duration of the acid bath depends on the specific batch of seeds and can only be determined empirically. After treatment and a thorough washing, the seeds may be sown or dried and stored for several months (Emery 1987).

Since sulfuric acid is caustic and dangerous to handle, its use is recommended only for those familiar with the use of caustic chemicals. Water

must not be splashed into the acid, as a violent reaction will occur. All workers should wear suitable safety clothing, gloves, and goggles or other eye protection (Bonner et. al. 1974). In lieu of the acid treatment for seeds with thick coats, such as manzanita (*Arctostaphylos*), the fire or mulch treatments can be used. With thinner-coated seeds, hot water or scarification is satisfactory (Emery 1987).

Other Chemicals

About 50 years ago researchers in various agencies and private industry began experimenting with chemicals to neutralize dormancy conditions present in seeds. Results have shown that inhibiting chemicals can be present in one or more parts of the seed; other dormancy-causing factors (i.e., immature embryos or impermeable seed coats) may also be present in a given seed.

Three chemicals that have proven very helpful in breaking certain types of dormancy are gibberellic acid (GA_3), potassium nitrate, and thiourea. The aqueous solutions of these chemicals should be used at room temperature. The concentration and length of treatment depends on the species to be treated. Seeds soaked in GA_3, or thiourea should be stirred occasionally and not rinsed afterwards, unless specified, but sown immediately. After this soaking they can also be air-dried and stored for short periods and then sown or given a subsequent treatment. The no-rinse-afterwards also applies to the use of potassium nitrate and hydrogen peroxide, other chemicals occasionally recommended as aids to germination (Emery 1987).

Great care should be taken in working with these chemicals as some are poisonous. Due to their toxic or poisonous nature, some are difficult to obtain;

however, in nearly all cases there is an alternate method of seed treatment noted. The main advantages of these chemicals are speed, ease of use, and unaltered physical condition of the seeds following treatment (Emery 1987).

Mulch

The mulch treatment hastens the microbial breakdown or softening of the seed coats. It is a slow method but is what often occurs in the wild. For this treatment, fill a six- to eight-inch deep container half full with seedbed medium. Then the sown seeds should be covered with a mulch of wood shavings (not redwood or cedar). A one-inch thick layer of old composted shavings is best; but if not available, a three-inch layer of fresh shavings is satisfactory. If fresh shavings are to be used, they should be soaked a few hours in a bucket of water first and mixed with a compost starter of microbial inoculant. Neither the seeds nor the medium should be treated with a fungicide. If this treatment is initiated in early spring or early summer and if the shavings are kept moist all summer, germination will require three to four months or longer, depending on the species. This mulching technique also works well in a ground bed; however, transplanting may be a bit more difficult (Emery 1987).

Water

For the occasional species whose seed coats contain a readily water-soluble, germination-inhibiting chemical, this substance can be removed by soaking the seeds in tap water or by leaching the seeds in slowly running tap water for various lengths of time just prior to soaking. The length of time depends on the species. With the water bath, changing the water every 12 to 24 hours will hasten this

leaching process. Softened water should not be used for this treatment (Emery 1987).

Cold Stratification or Prechilling

Cold stratification, or prechilling, for seeds with internal dormancy simulates cold winter conditions. The embryo of many seeds fails to germinate because oxygen does not diffuse through the seed coat. At cold temperatures, more oxygen is soluble in water, so the oxygen requirements of the embryo are better satisfied. Cold-moist stratification imitates overwintering in a field seedbed (Young and Young 1986).

For small quantities of seeds, mix a ratio of 1:3 or more with moist peat moss or moist vermiculite, place in a tightly sealed polyethylene bag or glass jar, and store in the refrigerator at a temperature of 35º- 41º F. With a few species, freezing the seeds at 28º - 32º F is required. For bulk seeds, soak in water for a few hours first, then place wet in a sealed container. Containers can be boxes, tanks, trays, cans, or barrels, as long as they have perforated bottoms to allow drainage of excess water and to facilitate gas exchange between the seeds and the storage room. Of course, polyethylene bags can be used as well. In any case, the seeds must be kept moist during the entire length of the treatment. This will require periodic checking and the addition of water if necessary. Another reason for periodically checking the stratifying seeds is to see if they have started to germinate. If, for example, a California lilac (*Ceanothus*) species has a three-month cold stratification recommendation, it should be visually checked for germination a couple of weeks prior to the end of the third month. If any white

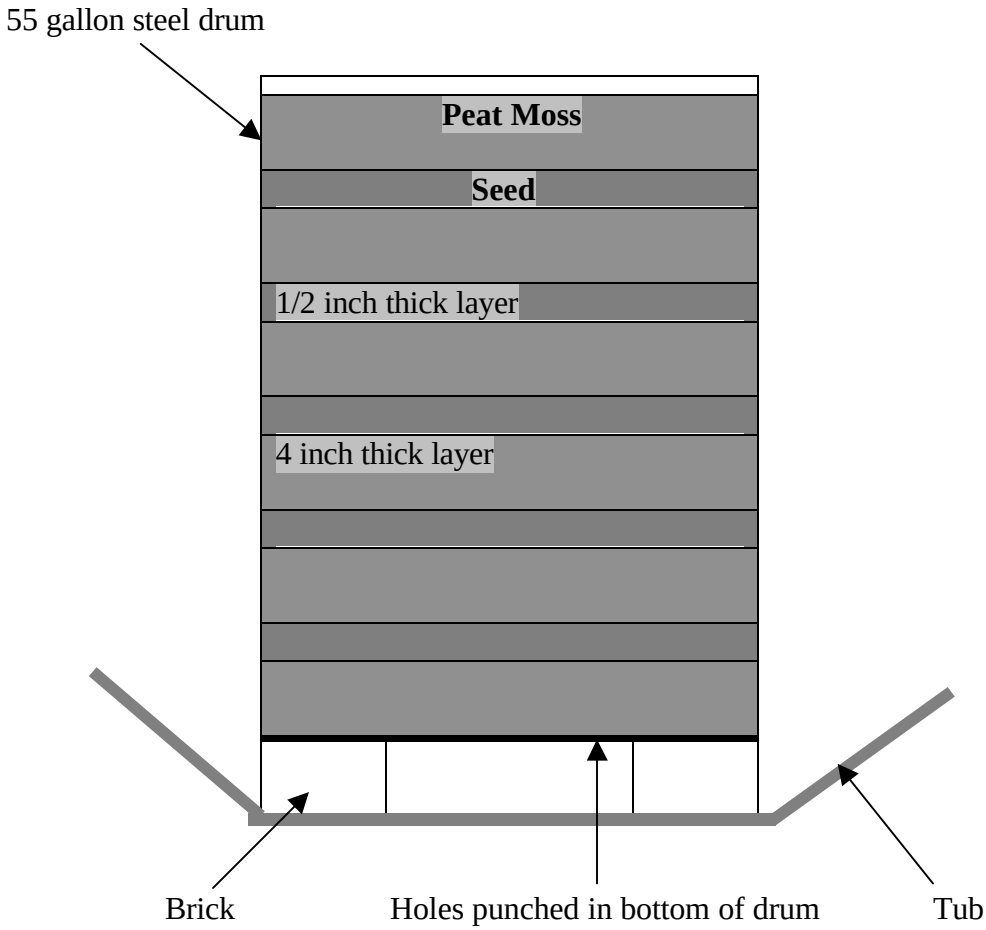
root tips are visible, the whole batch should be sown immediately. The longer the radicals are when the seeds are sown, the greater the probability of damage and the greater the mortality rate is apt to be. If the stratification period is inadvertently lengthened, it is usually not detrimental, providing the radicals are still very short or not yet showing (Bonner et. al., 1974, Emery 1987).

In contrast, to cut the stratification period short by even a few days could be harmful if no radicals are visible. By prematurely discontinuing stratification, primary dormancy may not be broken. Consequently, a secondary dormancy may be induced which is more difficult to break than the original dormancy. If one must err, do it on the long side. The cold stratification period necessary to break dormancy may last from a few days to several months, depending upon the species, with one to three months being the most common. Some species even require up to 3 years of stratification (Bonner et. al. 1974). After stratification, the seeds should be sown promptly before they have a chance to dry out (Emery 1987).

The following sequence of operations is normally used in cold stratification with a moisture-holding medium:

1. Moisten the medium uniformly. Peat moss should be just moist enough so that a little free water can be easily squeezed out by hand; excessive moisture can be harmful to some species. Mixing cracked ice with medium and seed to promote quick and uniform chilling should also help distribute moisture.
2. Mix seeds with the medium. The most common practice is to place 10 to

25 pound lots of seeds in loosely woven bags, which are flattened into disks no more than 3 inches thick. The bags of seeds are then alternated with layers of the moist media in the container (see figure below). Putting the same dry weight of seeds in each sack permits easy allocation of seeds in subsequent planting operations despite gains in weight during stratification. Mixing can also be accomplished by placing seeds in thin layers alternating with layers of medium; layers may be separated by cheesecloth. A third method is mixing the seed directly into the moist medium. The volume of the medium should be three times that of the seeds. This method is very effective, but since it creates a cleaning problem when treatment is finished, may have abandoned the practice.



Figure—Desired arrangement for stratification in a large drum (from Bonner et. al. 1974).

3. Cover the containers carefully. They should be loosely covered to prevent the seed and medium from drying unevenly; in no case should they be sealed. It may be necessary to add water later to prevent excessive drying. A check should also be made for proper drainage.
4. Label all containers clearly, and place them in the cooling facility.
5. Make inspections periodically, preferably weekly. Checks should be made to prevent excessive drying, heating, and poor aeration. If the

stratification period lasts longer than 30 days, the bags of seeds should be removed from the containers and inspected for mold and drying. The surface of seeds inside a large mass will usually dry before the seeds heat up extensively. Moist peat moss at the top of an open or partially covered container will often freeze and crust over because of cooling from evaporation, even when the temperature of the storage room is 37º to 38º F. Such freezing is no cause for alarm. It indicates only that the medium is drying rapidly and that moisture should be added to the top.

6. Remove and clean seeds at the end of the stratification period. Heavy seeds can be separated by washing or by water flotation. For smaller seeds, drying to the point where separation by screen cleaners is possible is a good technique. Seeds should be sown soon after removal, because extreme drying before use may induce a "secondary dormancy" in some species. Most seeds are treated with repellents, fungicides, or a lubricating powder (for drilling) before sowing. These coatings help preserve moisture. For some species the seeds and medium may be broadcast sown together. Stratified seeds should be handled as gently as possible to avoid injury (Bonner et. al. 1974).

The following sequence is normally followed for stratification in plastic bags:

1. Bring seeds to a high moisture content. Full imbibition is essential for stratification in plastic bags without a moisture-holding medium. Water soaks as recommended for stratification with a medium should be used.

2. Place seeds loosely in bags. Do not pack. close the bags tightly to prevent loss of moisture.
3. Label all containers clearly, and place them in the cooling facility.
4. Inspect bags periodically. Poor aeration is more of a problem in naked stratification than it is when a medium is used, especially for large lots. There is some gas exchange through the bag walls, but frequent inspections and turnings are necessary. One easy means of detecting a lack of oxygen is to open the bags and smell the contents. an odor of alcohol indicates that anaerobic respiration is occurring because of insufficient oxygen. a faint smell of alcohol does not mean that the seeds are ruined, but it should be taken as a warning of imminent danger. Inspections should be more frequent than weekly on large lots, and all bags should be opened and turned.
5. Remove and wash seeds at the end of the stratification period. Washing at this point may not be necessary, but it will remove some potentially damaging microorganisms, especially with large hardwood seeds. Sowing soon after removal is recommended as for any stratification procedure (Bonner et. al. 1974).

Warm Stratification

The exposure of seeds to moist, warm conditions at room temperature (65ºF) or above is called warm stratification. Sometimes this treatment is necessary for seeds with internal dormancy to facilitate after-ripening of the embryos, in which case it is followed by cold stratification. Occasionally it is used in lieu of the acid

treatment for seed coat dormancy. It also may be an intermediate stage in a multiple dormancy treatment (Emery 1987).

For warm stratification, the seeds should be mixed with moist peat moss or moist vermiculite and sealed in a polyethylene bag or glass jar. Possible places for warm stratification include desk tops, kitchen cupboards, the top of a refrigerator, or perhaps near the furnace—anywhere that stays warm night and day for the prescribed period of time (Emery 1987).

Photochemical Dormancy

Seeds of some species are light-sensitive, and must receive light during germination. The intensity and duration of the light, as received by seed photoreceptors, interact with the available moisture and temperature to control germination. When light and temperature are each partially inhibitory, the effect can be synergistic. The first 36 to 72 hours of germination is the critical period. Photochemical dormancy is most pronounced in freshly harvested seeds and usually disappears naturally with age (Emery 1987).

When germinating seeds indoors in order to break photochemical dormancy, a cool, white fluorescent light source of 75-125 foot candles (750-1250 lux) for eight hours per day can be used (Emery 1987).

Seeds that require light should not be covered when sown but merely watered-in. A covering of glass or plastic over the container will help to maintain a saturated atmosphere around the seeds. A few species must be kept in darkness during the first part of the germination period (Emery 1987).

Germination Temperatures

Though not really a form of dormancy, undesirable temperatures used for germination can be partially or completely inhibitory. Temperature requirements for the germination of seeds of most native California species will be met if the seeds are sown at the proper time of year. The range of temperatures required by the seeds of a few species, primarily those of the desert and mountain regions, can be very narrow and specific. If seeds of these plants are sown at the wrong time of year or if temperatures in the area where the seeds are sown are not within the narrow limits for the species, no germination, or at best very poor germination, will occur (Emery 1987)..

If the recommended daily high-low temperatures are not present naturally, artificial means must be used to produce them, or the propagator will have to be content with poor germination. Where these specific and unusual diurnal temperature fluctuations are necessary, they are noted in the table for the species involved (Emery 1987).