From Forest Nursery Notes, Winter 2009

178. Germination of difficult perennial seed. Pyle, A. R. International Plant Propagators' Society, combined proceedings 2007, 57:323-331. 2008.

Germination of Difficult Perennial Seed©

Allen R. Pyle
C. Raker & Sons, Inc, 10371 Rainey Rd. Litchfield, Michigan 49252 U.S.A.
Email: allen@raker.com

INTRODUCTION

Although seed can be an economical way to propagate perennials, propagating perennials from seed is not without its challenges. Seed size and shape varies tremendously among species, and small or irregular seed can be challenging to handle and sow, whether by hand or with automated equipment.

In addition, perennial seed can be contaminated with weed seeds, debris, or other materials. Finally, it is not uncommon to see extremely wide variation in germination and vigor among different seed lots of a given perennial species, particularly those that have dormancy mechanisms. Together, these characteristics can make consistent success germinating perennials challenging for growers.

KEY FACTORS IN GERMINATION

Moisture, temperature, and light are the three primary keys to germinating perennial seed. The goal with moisture management is to provide sufficient moisture for germination, without oversaturating the media. Oversaturation reduces oxygen levels, slows growth, and promotes disease.

Raker uses three general temperatures for germinating perennials. A dark, cool chamber (60–65 °F, 15–18 °C), bench germination in the greenhouses (70–75 °F, 21–24 °C), and a lighted, warm chamber (80–85 °F, 26–30 °C). Remember that medium temperature is the key for germination, so bottom heat — applied directly under the trays — is the most efficient way to provide heat during germination. Hot water systems are excellent for providing bottom heat, but electrical heating systems can also be effective for small areas.

In addition to temperature, light is also important in germination, with some perennials benefiting or requiring light for germination, and others benefiting from dark conditions for germination. An easy way to manage light levels during germination is to provide a medium cover for seed that needs dark conditions, and leaving light requiring seed uncovered. Consider using artificial lighting (even 5–10 foot-candles of fluorescent light is sufficient) for light-requiring species when using a germination chamber.

See Table 1 for production recommendations for a wide range of perennials.

TIPS FOR DIFFICULT-TO-GERMINATE PERENNIALS

When dealing with a difficult-to-germinate perennial species, background research on the plant can be helpful in identifying the most effective germination environments. A good agricultural library is an indispensable resource, particularly those that contain old USDA and other government publications. Be sure to check for information under older, out of use, scientific names for plants which have been reclassified.

Research the plant's native habitat for clues, including what time of year it flowers and what environment the seed is likely to encounter when seed is produced.

Species that flower in the late summer and fall in cold climates, for instance, may have seed which needs a cold period to stimulate germination. Remember that seed dormancy evolved to benefit a species. Based on the information you turn up, consider setting up trials of the most promising environments, but whenever possible, germination trialing should use several seed lots from different suppliers, and always include a control sowing (untreated seed) when trialing different seed treatments.

"Frost germinators" (Table 2) are plants which require a cold temperature period to germinate, often from immature embryos that need further development before seed can germinate. The general strategy for dealing with frost germinators is providing 2–4 weeks at warm temperatures (65–75 °F, 18–24 °C), then 4–6+ weeks at cold temperatures (38–41 °F, 3–5 °C), before returning to a warmer germination environment. If germination is poor, another cooling period may be helpful. In addition, freshly harvested seed may germinate better in some frost germinator species.

"Fresh germinators" (see Table 3) are species with short storage life after harvest, generally < 6 months. For some species, using "frost germinator" strategy will help germinate older seed, but the best option is to sow seed as freshly harvested as possible. In some cases, particularly *Helleborus* species, the easiest solution may be to collect seed from your own mother plants and sow immediately after harvest.

ENHANCED SEED

A number of perennial seed suppliers now offer enhanced perennial seed for an increasing number of perennial species. Enhanced seed is specially treated to be easier to handle and sow and/or to germinate more quickly and at higher percentage than standard, untreated seed.

Treatments to Improve Handling. Defuzzing of seed is the removal of wings and other exterior structures from seed coats, to make seed easier to handle and sow. Sometimes removal of exterior structures on seed can also improve germination.

Film coating is the application of a thin, colored layer to seed to make it easier to sow mechanically, and easier to see in the tray, which helps ensure good sowing accuracy. Fungicides are sometimes incorporated into a film coat, to provide disease control.

Pelleting is coating small seed with clay and other material to increase the seed size for easier handling and sowing, especially with mechanized equipment. Sometimes multiple seeds (2–5 or more) are put into each pellet, for items that are typically multiple sown.

Treatments to Improve Germination. Several perennial seed suppliers now offer seed treated for enhanced germination, focusing on the more difficult to germinate species. Most of these treatments are proprietary, and may involve priming, scarification, hormone treatment, or other techniques, including multi-step processes. Examples of enhanced seed include Benary's ApeX, Jelitto's Gold Nugget, Kieft's Tuned Seed, and many of PanAmerican Seed's perennial offerings.

Germination can be significantly improved compared to untreated seed for all these treatments. Keep in mind, however, that enhanced seed typically has a shelf life, ranging from 1 to 12 months. For this reason, it is best to purchase a new lot of treated seed for every sowing, otherwise performance can be inconsistent.

IN-HOUSE TREATMENTS

There are also treatments growers can do themselves to improve germination and overcome some common forms of seed dormancy.

Scarification. Scarification is a process used to break down hard, water-resistant seed coats and allow seed to take up water, so germination can take place. There are three basic types of seed scarification, chemical, physical, and mechanical.

Chemical scarificaiton is usually performed with a sulphuric acid soak, at the same acid strength that is typically used for treating water for greenhouse use. Typically, seed is soaked in acid for 5–30 min, enough to break down the seed coat sufficiently to allow seed to imbibe water, without damaging seed.

Be sure to take safety precautions when using acid for scarification. Always wear protective clothing (including gloves and eye protection), and neutralize leftover acid after draining and rinsing seed — add 1 part acid solution to 2 parts water, add about 0.25 lb (0.1 kg) sodium carbonate, and stir the solution until it no longer foams. Remember to never add water to acid — only add acid to water — due to the possibility of causing chemically heated water to splash over.

Physical scarification is typically done with an overnight hot water soak, with water at 190 °F (88 °C). Be sure water is no warmer than this temperature, as higher temperatures can damage seed. After the soak, seed can be sown wet, or dried before sowing.

Mechanical scarification is done by nicking, filing, or abrading seed with a knife, sandpaper, or file. This technique is most appropriate for small amounts of seed, but larger amounts of seed can be mechanically scarified in a rock tumbler with sufficiently coarse grit.

Crops benefiting from scarification are most commonly in the families Fabaceae (syn. Leguminosae) (*Baptisia, Lathyrus, Lupinus, Thermopsis*), Geraniaceae (*Geranium* sp.), and Malvaceae (*Hibiscus, Malva*).

Disinfection. Some diseases can be seed-bourne, and seed disinfection can be helpful in reducing disease problems in some cases. Either a 10% bleach solution or a ZeroTol solution [1.28 fl oz/gal (10 ml·L^{-1}) of water is the labeled rate for seed soaking] can be effective at seed surface decontamination. Generally 10–20 min of soaking is sufficient for seed surface decontamination. Crops which may benefit from disinfection include *Hibiscus, Iberis, Leucanthemum*, and *Lupinus*.

Hormone Treatment. Plant hormones, primarily gibberellic acid (GA_3), can be used to help break dormancy in some species. Gibberellic acid treatment is undoubtedly part of some of the proprietary treated seed available commercially. Soaking a filter paper in GA_3 solution, then placing seed on the filter paper is an easy way to treat small amounts of seed.

A very simple, low-tech way to treat seed with GA_3 after sowing is to lightly top dress sown trays with worm castings, which are a natural source of small amounts of GA_3.

Priming. Priming is soaking seed in a solution designed to allow seed to take up moisture, but not sufficient moisture to fully germinate. Polyethylene glycol (PEG) is one of the most commonly used solutions for seed priming, but other solutions can also be used, including mannitol, glycerol, and potassium nitrate (KNO_3). These "osmotic" solutions allow some moisture to be taken up by seeds slowly, without allowing seed to imbibe sufficient moisture to begin germination. Aeration is important during priming, particularly if seed is maintained in the solution for more than a few hours, to ensure seed is not oxygen starved.

After priming, seed can be sown wet or allowed to dry before sowing. Care must be taken to not damage seed during handling and sowing after priming, particularly for wet-sown seed. One advantage of primed seed is that seed may germinate acceptably outside its optimum germination temperature, giving growers better performance across a range of environments.

THE RAKER SYSTEM

Raker produces plugs and liners to order, year round, and ships about 170 million plugs and liners throughout North America annually. All trays are sold at a guaranteed count, of at least 90% (e.g., a 288-cell tray is sold at a count of 280 plugs.) Raker uses a highly automated greenhouse production system to schedule and track production.

Attention to Detail (ATD) is an important key to consistent success with propagation, and a foundation to the Raker system. By ensuring consistency in medium composition, tray filling, and compaction levels, media covering (when used), watering practices, and environment, Raker is able to produce over 4,000 different seed and vegetative items to order, year-round.

Seed lot tracking is an important component of the Raker sytem, as well. Every seed package, by law, must include a germination percentage, based on a formal germination test. Unfortunately, a high germination rate on a package label is no guarantee of good performance. More and more seed suppliers are doing plug tests, in addition to the formal lab test required by law, but it is still very difficult to predict the performance of a given seed lot without actually trialing it. By keeping track of what seed lot is sown in every tray, which supplier provided the lot, and when it was purchased, Raker is able to identify problem seed lots quickly.

One technique for improving plant stands used at Raker is sowing multiple seeds per plug cell to help ensure that at least one plant germinates in every cell. Typically, two to six seeds per cell (SPC) are sown for perennials, and the SPC rate can be set for every cultivar we offer. Raker also starts extra trays ("overstart" trays), used in patching to ensure we ship trays at our guaranteed count. As with SPC, we can adjust overstart by taxon. Typical overstart rates range from 5% to 100%.

When forced to use poorly performing seed lots, we have the option of increasing SPC and/or overstart. Depending on how poor a seed lot germinates, overstart rates can be as high as 200% – 300%.

As an example of how many seed Raker sows to produce a single saleable perennial tray, consider *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm', our top-selling seed perennial. We use enhanced seed for all 'Goldsturm' sowings. Even so, in a 128-cell plug tray, we sow three SPC, with a 40% overstart to ensure that we can consistently meet orders. This works out to about 538 seeds sown to produce 125 saleable plugs.

Table 1. Perennial germination recommendations. This table indicates recommended production practices for 128-cell seed perennials.

Genus	Germination temperature (°F)	Cover	Weeks to finish (no.)
Achillea	70–75	No	8
Alcea (*Althea*)*	70–75	Yes	4
Alchemilla	70–75	No	10
Anaphalis	70–75	No	9
Anchusa	70–75	Yes	7
*Anemone**	60–65	Yes	12
Anthemis	70–75	No	9
Aquilegia	70–75	Yes	9
Arabis	70–75	Yes	8
Arenaria	60–65	Yes †	8
Armeria	60–65	Yes †	10
Asclepias	70–75	No	9
Aster	70–75	No	8
*Astilbe**	70–75	No	10–11
Aubrieta	70–75	Yes	8
Aurinia (*Alyssum*)	70–75	No	8
*Baptisia**	60–65	Yes †	9
Bellis	70–75	No	7
Bergenia	70–75	No	10
Buddleia	70–75	No	10
*Campanula**	70–75	No	9–11
Catananche	70–75	No	9
*Centaurea**	70–75	Yes	8
Centranthus	60–65	No	8
Cerastium	70–75	No	8
Cheiranthus	70–75	No	7
*Coreopsis**	80–85	No	9
Coronilla	60–65	Yes	7
Cymbalaria	70–75	No	8
*Delphinium**	60–65	Yes	8
Dianthus	70–75	No	8
*Digitalis**	70–75	No	8
Doronicum	80–85	Yes	8

Echinacea	70–75	Yes	8
Echinops	70–75	Yes	8
*Euphorbia**	70–75	Yes	8
Gaillardia	70–75	Yes	8
Geum	70–75	No	10
Gypsophila	70–75	No	8
Helenium	70–75	No	8–11
Helianthemum	70–75	No	9
Heliopsis	70–75	No	9
Heuchera	70–75	Yes	11
Hibiscus	70–75	Yes	5
*Hypericum**	80–85	No	11
Iberis	60–65	Yes †	8
Kniphofia	70–75	Yes	10
Lathyrus	70–75	Yes	8
Lavandula	60–65	Yes †	11
Leotopodium	70–75	Yes	10
Leucanthemum	70–75	No	8
*Liatris**	70–75	No	10
Limonium	70–75	No	10
Linaria	70–75	No	9
Linum	70–75	No	8
Lobelia	70–75	Yes	10
Lunaria	70–75	Yes	9
Lupinus	70–75	Yes	5
Lychnis	70–75	No	8
Monarda	70–75	No	8
Myosotis	70–75	No	7
Nepeta	70–75	No	7
Oenothera	60–65	Yes †	9
Papaver nudicaule, P. alpinum	60–65	Yes †	10
Papaver orientale	70–75	Yes †	10
Penstemon	70–75	No	7–8
Physalis	70–75	No	7
Physostegia	70–75	No	9

Platycodon	70–75	No	8
Polemonium	70–75	No	9
Potentilla	70–75	No	8
Primula	60–65	Yes †	10–12
*Pulsatilla**	60–65	Yes †	12
Rodgersia	70–75	No	10
Rudbeckia fulgida	80–85	No	9
Rudbeckia hirta	70–75	No	8
Rudbeckia triloba	70–75	No	9
Sagina	70–75	No	7
Salvia	70–75	No	9
Santolina	70–75	No	10
Saponaria	60–65	Yes †	8
Saxifraga ×*arendsii*	80–85	Yes	11
*Scabiosa**	70–75	Yes	6
Sedum	70–75	No	9
*Sempervivum**	80–85	Yes	13
Sidalcea	60–65	Yes †	8
Silene	70–75	No	8
Stachys	70–75	No	6
Stokesia	70–75	Yes	8
Tanacetum	70–75	No	8–9
Teucrium	70–75	Light	11
Thalictrum	70–75	Yes	10
Thymus	70–75	No	9
Trachelium	70–75	No	9
Veronica	70–75	No	7
Viola	60–65	Yes	7

† = a light media cover added after germination, to help prevent roots from spiraling.

= weeks to finish (WTF) for 128 cell plug.

* = some species or cultivars regularly have poor germination and/or vigor.

Table 2. Perennial "Frost Germinators." The following perennials germinate best when seed is provided with a warm germination environment (65–75 °F, 18–24 °C), followed by a cold germination environment (38–41 °F, 3–5 °C), and then back to warm conditions.

Aconitum spp.	*Hypericum* sp. (many)
Adenophora	*Iris* spp.
Aethionema cordifolium	*Lewisia* sp.
Alchemilla sp.	*Melittis melissophylum*
Allium sp.	*Mertensia virginica*
Anemone canadensis, A. nemorosa	*Panax ginseng*
Aruncus	*Penstemon* sp. (many)
Astrantia sp.	*Primula* sp. (many)
Bupleurum	*Pulsatilla* sp.
Campanula (some sp.)	*Ranunculus* sp.
Clematis sp.	*Saponaria* sp. (many)
Colchicum sp.	*Saxifraga* sp.
Dicentra sp.	*Scilla* sp.
Gentiana sp.	*Tiarella* sp.
Geranium sp. (many)	*Tricyrtis* sp.
Gillenia sp.	*Trollius* sp.
Gladiolus sp.	*Tulipa* sp.
Humulus lupulus	*Viola odorata, V. sororia*

Table 3. Perennial "Fresh Germinators." The following perennials germinate best when fresh seed (stored less than 6 months) is used. Species noted with * do not tolerate storage, and are best sown immediately after harvest. For some species, cold stratification may be helpful in germinating seed which has been stored.

*Aconitum**	*Chelidonium majus*
*Adonis vernalis**	*Chionodoxa luciliae*
Anemone biflora, A. blanda, A. caucasica, A. nemorosa, A. obtusiloba, A. polyanthes, A. ranunculoides, A. tetonensis	*Claytonia virginica*
	Clematis sp.
	Corydalis lutea
	Corydalis nobilis
Anemonella	*Dicentra spectabilis*
*Anemonopsis**	*Eryngium alpinum*
Asarum canadensis	*Helictotrichon sempervirens*
*Astrantia**	*Helleborus**
Aureolaria virginica	*Isopyrum thalictroides*
Bulbocodium vernum	*Paeonia*
Callianthemum	*Primula rosea*
Caltha palustris	*Thalictrum*
Campanula alliarifolia, C. altaica	*Tiarella*
Cardiocrinum giganteum	*Viola odorata*
Caryopteris incana	

RECOMMENDED REFERENCES

Jelitto Perennial Seeds Catalog. U.S.A. office: 125 Chenoweth Ln, Suite 301, Louisville, Kentucky 40207. U.S.A. <www.jelitto.com>

Deno, N.C. Seed germination theory and practice and supplements. 139 Lenor Drive, State College, Pennsylvania 16801. U.S.A. $20 postpaid in U.S.A. Two supplements at $15 each. Canadian shipping an additional $2 for the book (or both supplements), or $5 overseas.