

Recalcitrant versus Orthodox seeds; OR, they die as they dry!

Revised January 7th, 2013.

Seeds are divided into two main types based on storage requirements. Everyone is familiar with common lawn, garden, and agricultural seeds, which mature dry, are picked, re-dried, and stored at relatively normal temperatures. Seeds that are tolerant of dry storage are orthodox seeds. Orthodox seeds have low moisture content (15-20%) at maturity and can tolerate drying to less than 5% moisture content without a loss of viability. Other seeds contain a significant amount of moisture when ripe, cannot be dried, and require special handling. Species which do not tolerate dry storage are recalcitrant, or hydrophilic, and include many spring woodland wildflowers, some emergent species, some willows, poplars, elms, maples, oaks, hazels, walnuts, chestnuts, hickories, and many tropical economic species, such as coffee, cola, rubber, and chocolate. Recalcitrant seeds may contain 30-70% moisture content at maturity, with loss of viability beginning at 30-65% nearly complete at 25-20%.

Recalcitrant seeds, when available, are best planted as soon as possible after ripening and dispersal. It is best to follow the practices of William Cullina, plant fresh or plant properly and briefly stored seed in the fall. Ripe seed must be briefly dried (\pm 7 days), cleaned while still moist, placed in ziplocks and refrigerated until planted. Their long-term storage is not practical. (Deno various years). With luck, you might pre-book some woodland wildflower seeds at a native nursery specializing in rare species or find a seed company maintaining limited stock in proper cold storage. A very limited amount of this seed is available and it needs to be installed in the appropriate season, not the following spring.

Several Midwestern nurseries work hard to harvest and clean some of these rare natives. Few of those nurseries know or tell the complete story of these species' seeds. Some know more than they say and properly store the seeds. Because of the seed ecology of these species, we only include a few in a select group of our standard mixes. Except for the *Peltandra*, *Spartina*, and *Zizania* (which require special consideration), we do not recommend the following species in commercial restoration, but in stewardship projects only. Several species should be used on a seasonal basis only.

SOME RECALCITRANT AND SEMI-RECALCITRANT* SEEDS

Aconitum (Cullina 2004a)

Actaea pachypoda and *rubra* (Cullina 2004b)

Aesculus pavia (Cullina 2004a)

Allium tricoccum (Cullina 2004a)

Anemone canadensis, *caroliniana*, *patens*, and *quinquefolia* (Cullina 2004b)

Anemonella thalictroides (Cullina 2004b, Deno 1993)

Arisaema triphyllum (Shultz 2005, Genesis seed tests)

Asarum canadense, *caudatum*, and *lemmonii* (Cullina 2004b)

Calla (Cullina 2004a)

Caltha palustris (Cullina 2004b, Deno 1993, Genesis seed tests)

Carex flava (Cullina 2008)

Carex laxiflora group (Cullina 2008)

Carex pensylvanica (Cullina 2008)

Carex plantaginea and *platyphylla* (Cullina 2004b)

Caulophyllum thalictroides (Cullina 2004b)

Chamaelirium (Cullina 2004a)

Chrysogonum virginianum (Cullina 2004b)
Cimicifuga americana, *racemosa*, and *rubifolia* (Cullina 2004b)
Claytonia virginica (Cullina 2004b, Deno 1993)
Clematis albicoma, *crispa*, and *ochroleuca* (Cullina 2004b)
Clintonia borealis, *umbellata*, and *uniflora* (Cullina 2004b)
Coptis trifolia (Cullina 2004b)
Corydalis sempervirens (Cullina 2004b)
Cymophyllus fraseri (Cullina 2004b)
Delphinium carolinianum and *exaltatum* (Cullina 2004b)
Delphinium tricorne (Deno 1993)
Dentaria (Cardamine) diphylla and *maxima* (Cullina 2004b)
Dentaria laciniata (Cullina 2004b, Deno 1993)
Dicentra cucullaria and *spectabilis* (Deno 1993)
Dicentra canadensis, *cucullaria*, *eximia*, and *formosa* (Cullina 2004b)
Diphylleia cymosa (Cullina 2004b)
Diplazium pycnocarpon (Cullina 2004b)
Disporum (Prosartes) hookeri, *lanuginosum*, and *maculatum* (Cullina 2004b)
Disporum smithii (Cullina 2004b)
Dryas octopetala (Cullina 2004b)
Epigaea (Cullina 2004a)
Erythronium species (Deno 1993)
Erythronium albidum and *americanum* (Cullina 2004b)
Fothergilla gardenii and *major* (Cullina 2004b)
Galax urceolata (Cullina 2004b)
Geranium maculatum (Cullina 2004b, Deno 1993)
Hamamelis virginiana (Cullina 2004b)
Heionas bullata (Cullina 2004b)
Hepatica acutiloba and *americana* (Cullina 2004b, Deno 1993)
Hydrastis canadensis (Cullina 2004b)
Hydrophyllum canadense and *virginianum* (Cullina 2004b)
Iris cristata and *I. verna smalliana* (Cullina 2004b)
Isopyrum (Enemion) biternatum (Cullina 2004b)
Jeffersonia diphylla (Deno 1993) (Cullina 2004b)
Lindera bezoin (Cullina 2004b)
Lysichiton americanum (Cullina 2004b)
Maianthemum canadense and *kamtschaticum* (Cullina 2004b)
Matteuccia struthiopteris (Cullina 2004b)
Medeola virginiana (Cullina 2004b)
Melanthium hybridum and *virginicum* (Cullina 2004b)
Mertensia virginica (Cullina 2004b, Deno 1993, Genesis seed tests)
Mitchella (Cullina 2004b)
Oplopanax horridus (Cullina 2004b)
Orontium aquaticum (Cullina 2004b)
Osmunda cinnamomea, *claytonia*, and *regalis* (Cullina 2004b)
Pachysandra procumbens (Cullina 2004b)
Panax quinquefolius (Cullina 2004b)
Peltandra virginica (Richard Agnew personal communication, Genesis seed tests)
Phlox (some) (Cullina 2004b)

Phlox divaricata (Cullina 2004b, Deno 1993)
Phlox bifida (Deno 1993)
Phlox pilosa (Genesis seed tests)
Phlox glaberrima (Deno 1996)
Podophyllum peltatum (Cullina 2004b)
Polemonium reptans (Deno 1993)
Polygala paucifolia (some) (Cullina 2004b)
Polygonatum biflorum, commutatum, and pubescens (Cullina 2004b)
Pyrola (Cullina 2004a)
Pyxidantha (Cullina 2004a)
Quercus (Cullina 2004a)
Rosa (Cullina 2004a)
Sanguinaria canadensis (Cullina 2004b, Deno 1993)
Scirpus cyperinus and longii (Cullina 2004b)
Scrophularia lanceolata (Cullina 2004b)
Senecio aureus (Deno 1996, Genesis seed tests)
Shortia (Cullina 2004a)
Smilacina racemosa and stellata (Cullina 2004b)
Spartina most species (Cullina 2008)
Spartina pectinata (Genesis Nursery)
Spartina species (Cullina 2008)
Spigelia marilandica (Cullina 2004b)
Streptopus roseus (Cullina 2004b)
Stylophorum diphyllum (Cullina 2004b, Deno 1993)
Tiarella cordifolia (Deno 1993)
Trillium cuneatum, erectum, grandiflorum, recurvatum, and undulatum (Cullina 2004b)
Trillium grandiflorum (Deno 1993)
Trollus laxus (Cullina 2004b)
Uvularia grandiflora (Deno 1993)
Uvularia grandiflora, perfoliata, and sessilifolia (Cullina 2004b)
Viola (Cullina 2004a)
Xerophyllum (Cullina 2004a)
Zizania aquatica (Baskin & Baskin 1998)

This list is by no means complete. Our experience with seed testing confirms many of these species as having Highly Perishable Seed. *Caveat emptor.*

The native seed industry has been stumbling over hydrophilic seeds for decades. Species were often noted as double dormant or needing soaking under water hocus-pocus bullshit. Indeed, some emergents are best stored in water, and they are horribly misused in seed mixes. Through our observations and experience, we have just (2009) added *Spartina* to the list. Cullina (2008) notes all *Spartina* species but *S. pectinata* are hydrophilic. In older references, it was noted that *S. pectinata* was double dormant and needed warm moist stratification followed by cold moist. A standard recommendation was to place the moist seed in a ziplock and place the bag on top of (not in) a refrigerator. Germination typically occurred during warm moist stratification. Some sources suggested that the seed should be soaked in water and stored cold, indication drying was harmful. Our experience with Illinois seed and seed from other Midwestern states indicates *Spartina* seed is non-dormant, but it has a short shelf-life when dry

stored in woven poly bags at room temperature, in a refrigerator, or in an unheated barn. For almost twenty years, the industry has been dancing around the fact that *S. pectinata* seed is hydrophilic and needs stored in sealed plastic containers under refrigeration until planting. *Sporobolus heterolepis* may need this treatment also. Both species are at least semi-recalcitrant.

Many to most of these listed species are not retained on the stem for any length of time, but are dropped, fly away, or are forcefully expelled, foretelling a lack of tolerance for dry storage. An exception is *Zizia* that does not readily dehisce and would be thought to stand dry storage. Deno 1996 indicates *Z. aptera* germination decreases 75% with 6 months storage. *Tradescantia* also shows decline in storage.

Deno 1993 states *Erythronium* seeds stored for 6 months are severely damaged.

* Seeds which show significant decline of viability after 6 to 12 months of dry storage. “A category intermediate between orthodox and recalcitrant is now recognized (e.g. coffee) in which seeds survive desiccation but become damaged during dry storage at low temperatures.” (J. Derek Bewley and Michael Black, 1985, *Seeds: Physiology of Development and Germination*, Plenum Press New York 2nd Edition.)

After <http://data.kew.org/sid/storage.html>

Seed storage behavior in the main text is noted as:

Orthodox seeds can be dried, without damage, to low moisture contents, usually much lower than those they would normally achieve in nature. Over a wide range of storage environments, their longevity increases with reductions in both moisture content and temperature, in a quantifiable and predictable way. Includes Orthodox p (Orthodox probable)

Recalcitrant seeds do not survive drying to any large degree, and are thus not amenable to long term storage, although the critical moisture level for survival varies among species. In this database, this category includes those seeds, of some aquatic species in particular, described as viviparous. Includes Recalcitrant? (a greater than even chance).

Intermediate seeds are more tolerant of desiccation than recalcitrants are, though the tolerance is much more limited than is the case with orthodox seeds, and they generally lose viability more rapidly at low temperature. They do not conform to all the criteria defining orthodox seeds, especially in respect of the quantification and predictability of the relations between longevity and both drying and cooling.

Dot Wade, the *grand dame* of Midwest restoration once told us that seeds that ripen in spring and early summer should be planted soon after ripening, not stored. She was right.

Recalcitrant seeds must be planted within a few days of harvesting or they must be stored in a 1:1 ratio of damp sand, milled sphagnum, or a peat-perlite blend and stored in a refrigerator (not frozen).

Orthodox seeds generally have long shelf lives. Long-lived orthodox seeds remain viable for 15-25 years, while medium-lived orthodox seeds remain viable for 2-15 years (Luna & Wilkinson 2009). Warm season grasses have maintained high viability for 22-35 years in semi-controlled environments (Row & Wynia 2010). Low light levels, low humidity, and relatively low temperatures help extend the viable shelf life

Selected Sources

Bill Cullina 2004, Germination codes for species grown by the New England Wildflower Society Native Plant Nurseries, 2004 Georgia Native Plant Symposium Papers, <http://www.gnps.org/bc3.htm>, accessed 8/01/06.

Bill Cullina 2004b, Germination Requirements of Seeds, 2004 Georgia Native Plant Symposium Papers, <http://www.gnps.org/bc2.htm>, accessed 8/01/06.

Norman C. Deno, 1991, Seed Germination Theory and Practice, State College, Pennsylvania

Norman C. Deno, 1993, Seed Germination Theory and Practice Second Edition, State College, Pennsylvania

Tara Luna & Kim M. Wilkinson, 2009. 7: Collecting, processing, and storing seeds. In: R. Kasten Dumroese, Tara Luna, & Thomas D. Landis, editors. Nursery manual for Native Plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. p. 113-131.

John M. Row and Richard L. Wynia, 2010, Viability Of Native Warm-Season Grass Seed Stored Under Two Different Environments Following 35 Years Of Storage, USDA-Natural Resources Conservation Service, Plant Materials Center, Manhattan, KS 66502, USA

Jan Schultz, 2005, Propagation protocol for Jack-in-the-pulpit (*Arisaema triphyllum*) Native Plants vol. 6 no. 2 summer 2005, pp 109-110.

<http://www.wildflower.org/howto/show.php?id=8&frontpage=true>