

What a seed is

Structure, dormancy, germination and longevity as the basis of conservation

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Abstract

Every conservation decision rests on properties of the seed: whether it tolerates drying, how deeply it is dormant, what it needs to germinate and how long it lives. This paper describes the seed from the perspective of conservation — structure, maturation, dormancy, germination and ageing — and shows at each point what practical consequence follows for storage, testing and multiplication. It is the biological foundation paper of the strand and the basis for chapter 1 of the book.

1. Structure

A seed consists of three parts. In many dicotyledons, such as legumes, there is no separate storage tissue; the reserves are then held in the cotyledons of the embryo.

Part	Function	Significance for conservation
Embryo	the future plant: radicle, shoot axis, cotyledons	only the embryo has to survive; testing methods ask about it
Storage tissue (endosperm or cotyledons)	reserves for the first days: starch, oil, protein	determines how strongly moisture affects longevity
Seed coat	protection against drying, injury, attack	can block water uptake and thus prevent germination

The composition of the storage tissue is not incidental to storage. Oily seeds bind less water than starchy ones at the same air humidity. If both are dried to the same relative humidity, as the genebank standards provide, the oily seed reaches a lower moisture content by itself. Target values in per cent moisture content therefore only make sense per species. In the seed viability equation this shows in the moisture constant: around 6 for cereals, between 3.5 and 4 for oily species (paper P02).

2. Maturation and desiccation tolerance

At the end of their development, orthodox seeds undergo maturation drying. In this phase they form protective substances — sugars that form a glassy matrix as water is withdrawn, and protective proteins — which keep membranes and proteins stable in the dry state. Only this state makes them storable.

Recalcitrant seeds skip this phase. They are shed moist and metabolically active, often with the strategy of germinating immediately. Withdrawing water damages the cells before a resting state is reached. The boundary between behaviour types therefore cannot be shifted by more skilful drying (paper P07).

Practical consequence: Harvest timing matters. Orthodox seeds harvested prematurely have not completed maturation drying, are less desiccation-tolerant and shorter-lived. After-ripening in the fruit or on the inflorescence measurably improves storability.

3. Dormancy

A living seed that does not germinate under favourable conditions is dormant. Dormancy is not a defect but an adaptation: it spreads germination over time and prevents all seedlings from emerging at the wrong moment. Baskin and Baskin distinguish five classes:

Class	Cause	Typical release
Physiological	hormonal inhibition in the embryo	cold or warm treatment, after-ripening, gibberellin
Morphological	embryo still undeveloped when shed	time under germination conditions
Morphophysiological	both at once	sequence of warm and cold phases
Physical	water-impermeable seed coat	scarification, hot water, acid treatment
Combinational	physical and physiological	first open the coat, then species-appropriate stratification or after-ripening

Through breeding, crops are mostly only weakly dormant; wild species and crop wild relatives, in contrast, are often deeply dormant. This has a direct consequence for conservation.

Practical consequence: A germination test that counts a dormant seed as dead underestimates viability and triggers an unnecessary regeneration — or worse, makes a lot appear lost that is not. Dormant and dead seeds must therefore be recorded separately, for example by a cut test or a tetrazolium test on the ungerminated seeds (paper P09).

4. Germination

Germination begins with water uptake and ends when the radicle breaks through the seed coat. Three conditions must be met: water, a suitable temperature and oxygen. Many species additionally require light or darkness, alternating temperatures or the interplay of several cues.

For conservation, the distinction between germination in the botanical sense and a **normal seedling** in the sense of seed testing is important. The testing rules count only seedlings that carry all essential structures and can develop into a plant under favourable conditions. A seed that produces a root but no viable seedling does not count.

5. Ageing

Seeds age even in the resting state. Damage accumulates in membranes, proteins and DNA; repair is only possible on water uptake and succeeds the worse, the further the damage has progressed. The individual seeds of a lot do not die at the same time but at times that are normally distributed around a mean. Loss of viability therefore does not proceed linearly but along a sigmoid curve: nearly unchanged for a long time, then falling rapidly. The seed viability equation describes exactly this course (paper P02).

Loss of vigour comes before death. An ageing lot still germinates, but more slowly, less evenly and more sensitively to stress. Anyone who looks only at germination sees the end late.

Practical consequence: Record speed and uniformity of germination at every test. A falling germination speed at still-high germination is the earliest sign that a lot is reaching the steep phase of the sigmoid.

6. How old seeds can become

Two cases show the range.

The Beal experiment. In 1879, William J. Beal buried bottles of seeds of various wild herbs in Michigan to test how long they remain viable in the soil. The bottles were opened every five years at first, later every ten and since 1980 every twenty years. At the opening postponed to 2021 because of the pandemic, seeds of moth mullein and of a mullein hybrid still germinated after 142 years. It is the longest-running experiment of its kind.

The date palm from Masada. From a date stone about 2,000 years old, found in the fortress of Masada, a research group led by Sarah Sallon raised a living plant in 2005. Further plants from ancient stones followed.

Both cases are not the rule but extremes under particular conditions in each case: embedded in moist sand in the soil (Beal) and extremely dry in a desert climate (Masada). Masada shows that very dry storage permits longevity of the order the seed viability equation calculates for dry, cold storage. Beal demonstrates the role of the **soil seed bank**: seed resting in the soil is a form of conservation in its own right that appears in no genebank count.

7. What follows for conservation

Property	Consequence
Desiccation tolerance	decides the conservation route (P07)
Oil content	determines how far to dry (P02)
Maturity	harvest timing and after-ripening affect storability
Dormancy	separate dormant and dead seeds in testing (P09)
Germination requirements	species-appropriate test conditions, otherwise false results
Ageing	carry germination speed as an early warning sign

Limits of this paper

The paper treats the seed in outline, not as a textbook of seed physiology. The molecular biology of desiccation tolerance and dormancy is greatly abbreviated. The two long-term cases are individual cases under special conditions and cannot be generalised. For species-specific germination conditions and dormancy types, Kew's

Seed Information Database and the specialist literature should be consulted.

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10. Papers P02, P07 and P09 of this strand.