

Utilization of Seed Dormancy in Plant Breeding

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A seed is not simply a sleeping baby plant it is a survival strategy honed over millions of years of evolution. Seed dormancy, the seed's ability to delay germination even under favourable conditions, allows a species to spread its risk across time instead of germinating all at once and risking total loss to a bad season. This adaptive trait helped wild plants disperse their seed, avoid germinating in unfavourable conditions and survive across variable environments. Somewhere along the road of domestication, however, humans began selecting the opposite trait rapid, uniform germination because that is what early farmers needed from a crop and as a result dormancy has been weakened or lost in most modern cultivated crops. That loss created a new problem and today plant breeders find themselves doing something curious: reintroducing, fine-tuning or deliberately manipulating dormancy rather than simply breeding it away. This is the story of how a trait once discarded by domestication has become a precision tool in the breeder's hands.

How Seeds “Decide” Not to Germinate

Seed scientists classify dormancy using a system that traces back to the Russian physiologist Marianna Nikolaeva and was later refined by Jerry and Carol Baskin. Their internationally accepted scheme recognises five classes of dormancy — physiological, morphological, morphophysiological, physical and combinational — and distinguishes dormancy located inside the seed and related to the embryo (endogenous) from dormancy located in the seed coat or surrounding tissue (exogenous).

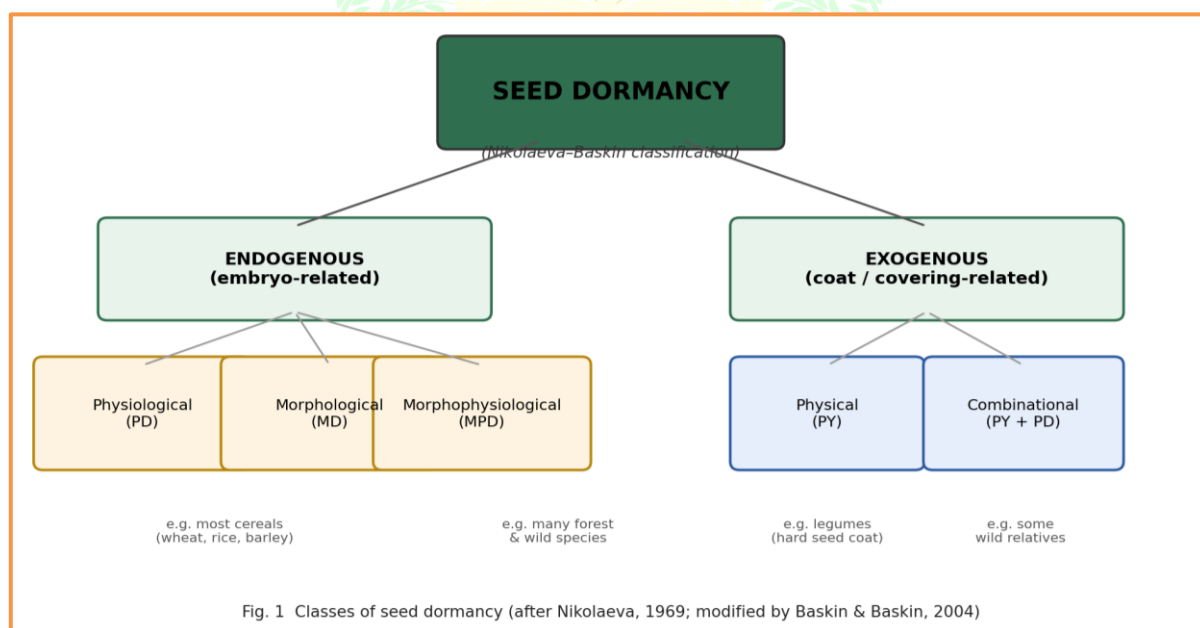


Fig. 1 — Classes of seed dormancy, after Nikolaeva (1969) and modified by Baskin & Baskin (2004). Original diagram prepared for this article from the published classification scheme

- **Physiological dormancy** — the embryo is fully formed but internal biochemical signals (hormones, inhibitors) prevent germination; this is the commonest kind in crop plants.
- **Morphological dormancy** — the embryo itself is underdeveloped at the time of seed shedding and needs more time to mature.
- **Physical dormancy** — a hard, water-impermeable seed coat physically blocks water and gas exchange (common in legumes).
- **Morphophysiological and combinational dormancy** — combinations of the above, requiring multi-step treatments to break.

The Breeder's Balancing Act

Here is the central paradox that makes seed dormancy such an interesting breeding target: neither zero dormancy nor excessive dormancy is desirable. A cultivar needs “just enough.”

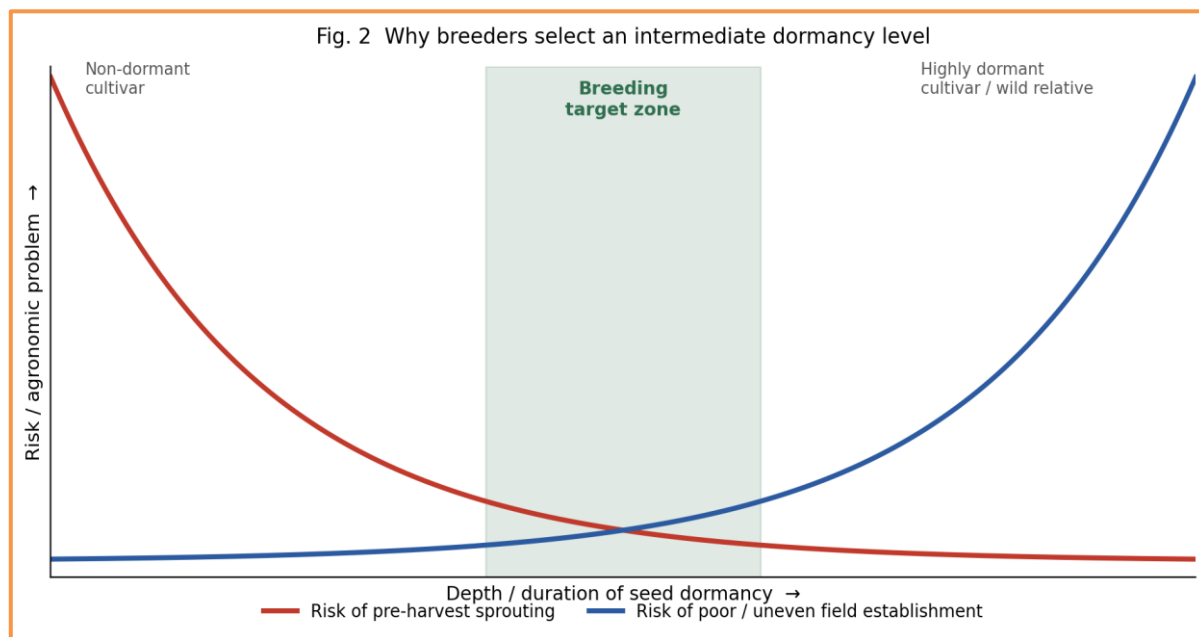


Fig. 2 — Conceptual illustration of why breeders target an intermediate dormancy level: too little dormancy invites pre-harvest sprouting, too much delays and uneven field establishment.
Original diagram prepared for this article

Breeding for dormancy preventing pre-harvest sprouting

Pre-harvest sprouting (PHS) is the germination of grain while it is still on the mother plant in the field, triggered by rain or high humidity just before harvest. It causes direct loss of grain yield and quality and is a growing problem in humid grain-growing regions as extreme weather events become more frequent. In wheat, PHS downgrades grain quality, limits end-use in baking and causes substantial financial losses, because sprouted grain accumulates the starch-degrading enzyme α -amylase. Because of this, dormancy breeding in cereals has flipped direction: instead of removing dormancy, breeders now deliberately select for an intermediate level of it. Breeding for seed dormancy is considered the most effective and environmentally sustainable strategy against PHS and plants with higher dormancy and stronger response to abscisic acid generally show greater sprouting resistance. But dormancy cannot simply be maximised excessively prolonged dormancy delays the crop cycle and causes uneven germination at the next sowing, so the real breeding target is an intermediate window: dormant enough to survive a wet harvest, but shallow enough to germinate promptly when the farmer sows the next crop.

Breeders have used several handles to hit this target:

- **Red grain colour** — long used as a visual marker linked to dormancy in wheat, though red-grained genotypes alone do not always guarantee resistance, so it is used alongside, not instead of, direct dormancy screening.

- **Hormone-sensitivity screening** — since abscisic acid (ABA) promotes dormancy and gibberellin (GA) promotes germination, their signalling pathways are primary research targets for solving the PHS problem.
- **Donor lines with naturally high dormancy** — highly dormant spring-wheat germplasm, whose seeds stay resistant to sprouting even after simulated rain and whose dormancy appears to be governed by several recessive genes, has been used as breeding parents to transfer the trait into elite backgrounds.
- **Rice breeding** — trials across rice cultivars found that higher seed-dormancy indices consistently correspond with greater resistance to sprouting on the panicle, making genetic diversity for this trait valuable for breeding sprouting-resistant varieties.

Breeding against dormancy for malting, seed production and rapid establishment

At the opposite extreme, some end-uses need dormancy switched off almost entirely. Malting barley must germinate quickly and evenly the moment it is malted residual dormancy delays the process and reduces malt quality. Seed companies producing hybrid seed for sale similarly need near-uniform germination so farmers get predictable field stands. In these programmes, breeders screen segregating populations and discard highly dormant genotypes the mirror image of PHS-resistance breeding and proof that “utilizing” dormancy in breeding really means controlling its level, not simply adding or removing it.

Practical Tools Breeders Use to Manipulate Dormancy

- Artificial after-ripening / accelerated ageing storing seed lots under controlled warm, dry conditions to hasten the natural loss of dormancy, speeding up generation turnover.
- Hormonal treatment soaking seeds in gibberellic acid (GA₃) to override physiological dormancy for germination tests, or applying ABA in bioassays to screen genotypes for dormancy strength.
- Mechanical and chemical scarification nicking, sanding or acid-treating hard seed coats to overcome physical dormancy in legumes and forage species.
- Cold / moist stratification mimicking winter chilling to break physiological dormancy in temperate species used in breeding programmes.
- Marker-assisted selection and QTL mapping molecular markers linked to dormancy QTLs let breeders track and combine the trait with yield and quality traits without waiting for full germination assays every generation.

Beyond the Field: Genebanks and Wild Relatives

Dormancy is also central to germplasm conservation. Seeds held in genebanks are often collected from wild relatives that retain strong natural dormancy — a survival trait breeders must first understand and break in order to regenerate and evaluate the accessions, before deciding whether the dormancy genes themselves are worth introgressing into cultivated lines, for instance to build climate resilience or pest/disease-escape mechanisms through staggered emergence.

The Bigger Picture

Seed dormancy research shows that plant breeding is rarely about simply “removing” or “adding” a trait — it is about calibration. What began as a wild survival mechanism, then a target for elimination during domestication, has come full circle to become a deliberately engineered trait, dialled up or down depending on whether the goal is a sprouting-resistant wheat variety standing safely in a wet field or a malting barley that germinates the instant it is needed. As climate variability increases and untimely rains during harvest become more common, seed dormancy is likely to remain one of the most actively researched — and most practically useful — traits in a plant breeder’s toolkit.

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