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Original article

Seed dormancy: Types, causes and its breakdown

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INTRODUCTION

Seeds of different plant species are genetic resources that is helpful in maintaining the biodiversity, ecosystem, conservation and restoration (Berjak and Pammenter, 2004). These are the major propagating material for majority of higher plants and ensure the dispersal of species in time and space. Most of the seed consists of embryo, endosperm and seed coat. Germination process commences with the imbibition of water followed by enzyme activation, hydrolysis and mobilisation of stored food reserves. After that embryo axis elongates leading to weakening and rupturing of the seed coat making way for radicle protrusion (Nautiyal et al., 2023). Seed germination occurs under favourable environmental conditions like water availability, appropriate temperature and in some cases light. Seed germination and its timing is a plant character that is most subject to environmental selection and during seed evolution give rise to a related second important character called seed dormancy (Hilhorst et al., 2010). Seed dormancy is a state of temporary inability of a viable seed to start germination even under favourable environmental conditions (Baskin and Baskin, 2004). Seed dormancy can be distinguished from quiescence, in which a non-hydrated seed does not germinate due to a lack of the necessary environmental factors, such as water, temperature and air. Plant species bearing the dormancy can adjust to diverse climates and precipitation patterns. Further, dormancy play a significant role in successful spread of existing species and the emergence of new ones (Baskin and Baskin, 1998). Seeds of many plants shows differences in in the degree of dormancy which exhibits sporadic release of dormancy causing uneven germination. The lowest proportion of dormant seed species were found in tropical rainforests and as we move from the equatorial line to both the poles, dormancy increases with decreasing temperature and precipitation (Baskin and Baskin, 2014; Chichaghare et al., 2021). Seasonal environmental variations, depth of burial in the soil, interventions of birds and animals and induction of dormancy at late-stage maturation are some factors determining the seed dormancy and germination processes (Nautiyal et al., 2023). Seed dormancy may be caused by surrounding tissue of embryo or present in embryo.

Classes of Seed Dormancy

Baskin and Baskin (2004) have proposed the five classes of seed dormancy 1. Physiological dormancy (PD), 2. Morphological dormancy (MD), 3. Morpho-physiological dormancy (MPD), 4. Physical dormancy (PY) and 5. Combinational dormancy (PY + PD).

1**. Physiological dormancy**

Seed with this kind of dormancy are water permeable but physiological inhibiting mechanism in the embryo prevents the radicle emergence. PD can be explained with respect to hormonal balance, in which ABA act as an inhibitor and GA act as a promoter. These hormones regulate the onset, maintenance and termination of dormancy. During seed development, the ABA produced by the embryo induces dormancy and GA promotes the germination of non-dormant seeds. Furthermore, ABA concentrations during seed development dictate the quantity of GA needed for mature seed germination. As a result, seeds that create less ABA during development exhibit low dormancy and need less GA to encourage germination, whereas seeds that produce more ABA during development exhibit deep dormancy and need more GA (Hilhorst et al., 2010). In addition, structures covering the embryo, such as endosperm, seed coats, indehiscent fruit walls and palea/lemma can also limit the radicle emergence especially in freshly matured seeds (Baskin and Baskin, 2014). Different treatments including chilling, GA, and ethylene in *Betula*, *Fagus*, *Prunus*, *Sorbus* can break physiological dormancy (Gendreau and Corbineau, 2009).

2**. Morphological dormancy**

Seeds with morphological dormancy (MD) is characterized by seeds having small and underdeveloped embryos, but are differentiated well into cotyledons and hypocotyl-radicle (Baskin and Baskin 1998). The Embryos are not physiologically dormant but simply requires time to complete the development of embryo to grow and then germinate. Under appropriate environments, embryos in freshly matured seeds begin to grow (elongate) within a period of 1–2 weeks and starts germination within about 30 days (Baskin and Baskin, 2004). Example, seeds of *Anemone coronaria* and *Delphinium carolinianum*, etc.

3**. Morpho-physiological dormancy**

MPD is characterized by underdeveloped embryo embryo with a physiological component of dormancy. Therefore, two things are very important before onset of germination one is that the embryo must grow in relative size and physiological dormancy requires a dormancy breaking treatment e.g. warm or cold stratification or GA application (Baskin and Baskin, 2014). Examples, *Manglietiastrum sinicum*, *Michelia yunnanensis*, *Magnolia grandis* (Iralu et al., 2019).

4. **Physical Dormancy**

PY is caused by water-impermeable seed coat that does not allow movement of water inside which is the primary requirement of germination. Physical dormancy is reported to be caused by one or more water-impermeable layers of palisade cells in the seed or fruit coat. Example, *Melilotus* and *Trigonella* (Baskin, 2003; Jayasuriya et al. 2009).

5. **Combinational Dormancy**

In this type of dormancy, seeds are with water-impermeable coats (PY) for water uptake in combination with physiologically dormant (PD) embryo (Baskin & Baskin, 2004). The germination of seed does not occur until both kinds of dormancy have been broken. Example, *Cercis* (Fabaceae) and *Ceanothus* (Rhamnaceae). In some species, PY is broken before PD (Pipinis et al., 2011) but in others PD is broken before PY (Chauhan et al., 2006a).

Ways to overcome dormancy

Scarification

In this method, a scar is created on the seed coat so that water gets enter the seed and hydrates the embryo. Three types of treatments namely hot water treatments, mechanical, chemical is generally used as scarification treatments. In hot water treatment, seed are soaked in hot water for 10-15 minutes to soften the seed coat. This method is commonly used in *Dalbergia*, *Cassia* and *Leucaena* etc. In chemical treatment, seeds may be treated with sulphuric acid (95%) or a strong alkali (NaOH) for 2 3 minutes followed by washing in running water to remove the traces of acid or alkali. Acid scarification is used in legumes, tamarind and Acacia spp., etc., while alkali treatment is employed in cashew drupes (Nautiyal et al., 2023). Mechanical scarification involving rubbing seeds on sand paper, using mechanical scarifier, knuckling of distal ends of seeds, making small incision by piercing a needle are employed to release hard seededness e.g. subabul, bitter gourd and rubber (Sinha et al., 2017).

Stratification

It involves exposing of seed to low temperatures of 3-5°C in stratified layers of wet sand or soil or sawdust for 2–3 days to several months, depending on the type of species. Cold stratification up to 150 days is the effective for breaking the dormancy and improving germination in *S. alnifolia* species with deep physiological dormancy (Tang et al., 2019; Nautiyal et al., 2023).

Growth hormones

Seed dormancy can be overcome by application of GA and kinetin. Both GA3 and kinetin had a positive effect on seed germination of *T. thianschanica* seed, while combination treatments of these hormones are more effective than those used sole (Lee et al., 2010). Seed treatments of *Cassia fistula* with GA3 significantly improved the germination percentage, germination value, root length, number of leaves, and plant height (Rout et al., 2017).

Magnetic field

In earlier studies with *Lens culinaris*, *Lathyrus sativus* and *Solanum tuberosum* it was reported that exposing seeds to magnetic field increase the seed germination and seedling growth by overcoming the dormancy. The seeds were sown in soil under different magnetic field strengths at 0, 75, 150 and 300 mT for different period of times 0, 24, 48, and 72 hours (Yildiz et al., 2017).

Advantages

1. It is a survival mechanism as it reduces the chance of species extinction, if adverse condition destroys the easily germinated seeds.

2. Helps to preserve seed quality by preventing in situ germination i.e., vivipary.

Disadvantages

1. Seed dormancy causes non-uniform and delayed germination.

2. It cause seeds of many species to remain undisturbed in to the soil for a longer time. These seeds appear as unwanted plants or weeds to subsequent crops.

3. Interferes in seed testing procedure (Sinha et al., 2017).

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