A REVIEW ON SEED PRE-SOWING TREATMENTS IN FORESTRY APPLICATIONS

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Abstract: Seed dormancy is one of the major hurdles in germination which can be conquered by following some treatments which are termed as pre-sowing treatments. The dormancy of the seeds can be broken by following different pre-sowing treatments like scarification (mechanical, acid), water soaking (hot/cold), using chemicals and plant growth regulators or by alternate wetting and drying prior to sowing. The type of treatment chosen depends on the type of dormancy exhibited by seed. The technological advancement laid forth a road map for improving traditional seed treatment technologies and developing new ones, such as priming, irradiation using gamma rays, magnetic exposure of seeds for enhancing germination. Another advanced technology which has found applications in all most all existing fields of science is nanotechnology which is now showing promising effect in seed germination. Lack of awareness in identifying suitable pre-sowing seed treatments for various tree species is an important concern for mass production and conservation of many species. In order to tackle this issue, some efforts are made to discuss selected seed treatments with their advancement and significance in this review.

Keywords: Dormancy, Scarification, Irradiation, Plant growth regulators, Nanotechnology

INTRODUCTION

Seed is defined as fertilized mature ovule, which possesses an embryonic plant enclosed inside a protective covering packed with storage food material (R. Umarani and K. Vannangamudi, 2004). Seeds protect and sustain life. They are highly organized fortresses, well stocked with special supplies of food against long siege. Seeds are vehicles for the spread of new life from place to place by the elements and by animals and people. (Boswell, V. R, 1961). Seeds in the soil seed bank are ready to germinate provided they encounter the appropriate environmental cue enabling seeds to maximise the likelihood of survival in patchy and unpredictable environments (Copeland, & McDonald, 2012).

Though propagation through seed is easier, we may not get abundant seeds every year (Hussain et al., 2018) second most constrain for seed germination is its viability which denotes the degree to which a seed is alive, metabolically active and possess enzymes capable of catalysing metabolic reactions needed for germination, seed viability is probably highest at the time of physiological maturity, which gradually declines (Copeland, & McDonald, 2012) and some seeds exhibit seed dormancy which is one of the important hurdles for germination of seeds. Seed dormancy is defined as a physiological state in which a viable seed does not germinate even in the presence of favourable conditions (R. Umarani and K. Vannangamudi, 2004, Willan 1985, Kumar 2015, Baskin & Baskin, 2005). It is a block to the completion of germination of an intact viable seed under favourable conditions (Hilhorst, 1995; Bewley, 1997a; Li & Foley, 1997). This block to germination has evolved differently across species through adaptation to the prevailing environment, so that germination occurs when conditions for establishing a new plant genera are likely to be suitable (Hilhorst, 1995; Vleeshouwers et al., 1995; Bewley, 1997a; Li & Foley, 1997; Baskin & Baskin, 2004; Fenner & Thompson, 2005). Therefore, a diverse range of blocks (dormancy mechanisms) have evolved, in keeping with the diversity of climates and habitats in which they operate.

Dormancy is most commonly found in species which occur in areas of seasonally harsh climates and enables the organism to survive as a seed when it might perish as a seedling, even in moist tropical forest dormancy occurs in pioneer, light demanding genera such as Macaranga, Trena etc (R. Umarani and K. Vannangamudi, 2004). Baskin & Baskin (1998, 2004) have proposed a comprehensive classification system which includes five classes of seed dormancy: physiological, morphological, morphophysiological, physical and combinational (Baskin & Baskin, 2005).

Types of Dormancies:

Physiological dormancy:
The majority of seeds exhibit ‘physiological dormancy’ — a quiescence program initiated by either the embryo or the surrounding endosperm tissues. Physiological dormancy uses germination-inhibiting hormones to prevent germination in the absence of the specific environmental triggers that promote germination (Steven Penfield, 2017). Physiological Dormancy can be divided into three
levels: deep, intermediate and nondeep (Baskin & Baskin, 2004, Baskin & Baskin, 2005, Finch & Leubner 2006). Freshly matured seeds with non-deep physiological dormancy either cannot germinate at any temperature or they only germinate over very narrow range of temperatures. Species like Fagus, Pinus and eucalyptus shows this type of dormancy. Whereas species exhibiting deep Physiological dormancy, Embryos excised from these seeds either do not grow or will produce abnormal seedlings (Baskin & Baskin, 2004; Baskin et al., 2005). And in intermediate physiological dormancy embryos isolated from seeds will grow resulting normal seedlings (R. Umarani and K. Vannangamudi, 2004). Physiological dormancy decreased from evergreen to deciduous forests but increased slightly in savanna and montane forests, while physical dormancy increased from evergreen to savanna forests but decreased in the montane (Baskin & Baskin, 2005). Physiological dormancy occurred in 282 species in 57 families in evergreen forest, 147 species in 47 families in semi-evergreen forests, 37 species in 15 families in deciduous forests, 63 species in 35 families in savannas, and 32 species in 15 families in montane forests (Baskin & Baskin, 2005).

Morphological dormancy: MD is evident in seeds with embryos that are underdeveloped (in terms of size), but differentiated (e.g., into cotyledons and hypocotyl-radical). These embryos are not (physiologically) dormant, but simply need time to grow and germinate (R. Umarani and K. Vannangamudi, 2004, Finch & Leubner 2006). It is due to the presence of a small or underdeveloped embryo that must grow to a species-specific critical length before radicle emergence is possible. Depending on the species, embryos in freshly matured seeds begin to grow within a period of a few days to 1-2 week, and seeds germinate within 1 to about 4 week (Baskin & Baskin, 2005). Example: celery (Jacobsen & Pressman, 1979), fraxinus spp, Ginkgo biloba (R. Umarani and K. Vannangamudi, 2004).

Morphological dormancy was not very important in any of the five forest types, but it decreased from evergreen to savanna forests and then increased in montane forests (Baskin & Baskin, 2005). This type of dormancy is found in seven families (Annonaceae, Araileae, Arecaeae, Magnoliaceae, Myristicaceae, Olacaceae, and Podocarpaceae) in the evergreen forests and in eight species in seven families (Annonaceae, Araliaceae, Icacinaceae, Myristicaceae, Olacaceae, Podocarpaceae, and Winteraceae) in the semi-evergreen forests (Baskin & Baskin, 2005).

Morphophysiological dormancy: MPD is also evident in seeds with underdeveloped embryos, but in addition they have a physiological component to their dormancy (Baskin & Baskin, 2004, Finch & Leubner 2006). Germination does not occur until physiological dormancy has been broken and embryos have grown (Baskin & Baskin, 2005) morphophysiological dormancy decreased from evergreen to deciduous forests, it increased in savanna and montane forests (Baskin & Baskin, 2005). Morphophysiological dormancy was recorded in 80 species in eight families (Annonaceae, Araliaceae, Arecaeae, Magnoliaceae, Myristicaceae, Olacaceae, Pittosporaceae, and Podocarpaceae) in evergreen forests, and it was found in 28 species in 10 families (Annonaceae, Aquifoliaceae, Arecaeae, Canellaceae, Dilleniaceae, Icacinaceae, Magnoliaceae, Myristicaceae, and Olacaceae) in semi-evergreen forests (Baskin & Baskin, 2005, Jacobsen & Pressman, 1979).

Physical dormancy: This is caused due to seed coats impermeable to water which is due to a layer of thick walled, cutinised palisade like macroscleroid cells. The actual cause of hardseedness has been attributed to both physical and chemical attributes of the seed coat (Tran and Cavagh 1984, Egley 1989, Finch & Leubner 2006). In some seeds the impermeability of water may be related to structure of the hilum (Gittelman, 1993) Example: Acacia nilotica, Albizia lebbeck (R. Umarani and K. Vannangamudi, 2004). Some members of Anacardiaceae, Bixaceae, Bombacaceae, Cannaceae, Cistaceae, Cochlospermeae, Convolulaceae, Cucurbitaceae, Cusutaceae, Dipterocarpaceae (subfamilies Monotoiaeae and Pakaraimoideae but not subfamily Dipterocarpoideae), Fabaceae, Geraniaceae, Malvaceae, Nelumbonaceae, Rhamnaceae, Sarcocalaenacea, Sapindaceae, Sterculiaceae, and Tiliaceae have seeds (or fruits) that are impermeable to water, and consequently the dispersal unit has physical dormancy (Baskin et al., 2000).

Combinational dormancy: It is evident in seeds with water-impermeable coats (as in PY combined with physiological embryo dormany) (Baskin & Baskin, 2004, Finch & Leubner 2006). Examples: Geranium and Trifolium. The dormancy is due to combined effect of embryo, Testa and pericarp which is common in many trees and shrubs due to which they become difficult to propagate and more than one treatment may be necessary to break this dormancy (Kumar 2015). In order to overcome the problem of seed dormancy, seeds need to be subjected to pre-sowing treatments which helps in enhancing germination. Pre-sowing treatments or pre-treatment is defined as various treatments applied to seed prior to sowing in order to increase the rapidity or completeness of germination (L S Khanna 2021). Similarly, (Umarani R and Vanangamudi K, 2004) defined Seed treatment as application of any treatment by chemical, physical or biological means to alter the germination of seeds.

Scope of pre-sowing treatment: Pre sowing treatments have wide scope in breaking dormancy (Okunlola A L et al., 2011). The treatments are given based on the view that it helps
in terminating dormancy of seeds and speeding up germination, giving protection against pests, diseases or adverse conditions and improving the uniformity of seeds or to render them more visible (Dwivedi, 2006). Helps to facilitate precision planning, delays the process of senescence and improves storability, augments seed germination per cent, rate and uniformity of seed germination (Umarani R and Vanangamudi K, 2004).

**Types of pre-sowing treatments:**

The following treatments are preferred in prior to seed sowing to hasten germination, which include:

**Mechanical treatment:**

Mechanical treatment refers to the mechanical cutting or filing of hard impervious coat of seed so that moisture may reach inside (L S Khanna 2021). Seed coat may be cut, drilled or rubbed before sowing which will make seed coat permeable to water and scarification can also be successfully used to break seed dormancy (Dwivedi, 2006). Mechanical scarification treatment was carried out by spinning the handle of the instrument, till the hard endocarps became thin and shiny, but not pierced, after the Seeds Soaked in fresh water for 10 hours and then treated with 10% Cloroxy for 15 minutes as surface sterilization. Later the seeds treated with chemicals like potassium nitrate, Thiourea, Ethylene, Chlorohydrine to make the seed coats soft and weak then they are sown in beds (Jetti et al., 2017) and scarification can also be done using concrete mixture with sharp gravel or sand; special drum lined with abrasive material such as sand paper, cement with abrasive disks may be made (Umarani R and Vanangamudi K, 2004).

Soaking in cold water for 24 to 48 hours before sowing: Most of the species germinate easily if their seeds are soaked in water for 24 hours where germination is improved when seed absorbs adequate water and softens seed coat (Kumar 2015). This treatment is applied to most medium sized dry seeds. Hussain et al (2005) stated that Terminalia chebula seed showed highest germination percentage (66.7%) with treatment of cold water for 48 hours whereas germination percentage increased to 73% when they are depulped before cold water treatment. Similar work was conducted by Viswanath S C et al., 2021 on Terminalia paniculate concluded that maximum germination was observed in seeds soaked in water for 24 hours.

**Soaking in boiling hot water:**

The water is heated in a container and when it starts boiling, the container is removed from fire and the seed is dropped in it and then allowed to cool. This treatment is used for hard costed seeds. Subabul seeds soaked in hot water for 12 hours and planted at 1cm depth have given significantly increasing germination percentage (42.22%) (Hamad S O & Anwer L S 2021) similarly, stated that Sapindus mukorossi seed soaking in hot water for 10 seconds recorded the highest germination (72%). The treatment of seeds with hot water to improve germination is a better, safe and cost-effective alternative to sulfuric acid and sandpaper methods, which are recommended by the Brazilian Ministry of Agriculture, Livestock and Supply (Ministry of agriculture and livestock supply, 2017). Immersion of seeds in hot water at 80° for 5 minutes improved the germination od Acacia mearnsii effectively helped in germination (São José, J. F. B.2019). Acacia auriculaformis recorded highest germination percent (83%) when treated with hot water (Azad S et al., 2011).

**Alternate wetting and drying:**

In this method seeds are alternately wetted for some hours and then dry. This method is effective in seeds having thicker seed coat (Dwivedi A.P 2006). Gupta et. al., 1975 reported that seeds of teak from some locality require no treatment, some require alternate wetting and drying. Buchanania lanzan seeds showed highest germination of 86.7% when they are undergone alternate wetting (24 hrs) and drying (12 hrs) [Thounoajam and HL Dhaduk (2020)] similarly, Pamei et al. (2017) stated that the highest germination percentage, seedling height, root length of Tectona grandis was found when the seeds are subjected to a limate wetting (12hrs) and drying (12 hrs) for 8 days (43.3%, 16.48 cm, 14.09cm respectively

**Chemical treatment:**

Many seeds when treated with chemicals such as citric acid, hydrogen peroxide, sulphuric acid were found quite effective in breaking down the dormancy (Kumar 2015). This treatment refers to soaking of seeds in various chemical solutions to soften the hard coat of seeds and renders them permeable to water.

**Acid scarification:**

Soaking in concentrated sulphuric acid is the most common method to soften seeds or to render them more visible (Dwivedi, 2006). Helps to facilitate precision planning, delays the process of senescence and improves storability, augments seed germination per cent, rate and uniformity of seed germination (Umarani R and Vanangamudi K, 2004).

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the seed coat. Commercial grade sulphuric acid (96%, 36N) is preferred. To scarify the seeds, pour the undiluted acid until seeds get wetted. Stir them for few minutes to one hour depending on the species and immediately wash them thoroughly in cool running water for 5-10 minutes to remove all traces of acid. Shades dry the seeds unless wet sowing is preferred (L S Khanna 2021). Sulphuric acid is thought to disrupt the seed coat and expose the lumens of the macrosclereids cells, permitting inhibition of water (Nikoleave, 1977) seed treated with 98% conc.H2SO4 for 1 minute recorded the highest germination percent (74.67%) in Semicarpus anacardium.

Similarly, (Khazad gul zazai et al. 2018) reported that seeds treated with conc.H2SO4 soaking for 10 minutes and large fruit size had considerably higher germination (51.66%) and survival percentages (64.75%). Similarly, Olatunjii D et al 2012 reported that Acacia auriculiformis seeds treated with conc.H2SO4 for 5-10minutes has highest germination percentage of 92-96%. Similarly (Chiranjeevi M R et al 2017) stated that seed pre-soaking of Anola in GA3 200ppm solution recorded the highest germination percentage (88.88%).

**Hormonal treatment:**

**Plant growth regulators:** are the chemical substances which govern all the factors of development and growth within plants (B Desta and G Amare., 2021) and these growth hormones helps in Germination which has been found to be under strict regulation of plant hormones, including gibberellic acid (GA), abscisic acid (ABA), auxin and ethylene (Han and Yang, 2015). These PGRs also helps in Breaking dormancy and helps in speeding up the germination of dormant seed. The most important plant growth regulators are listed below as said by (Umurani R and Vanangamudi K, 2004) are:

- **Abscisic acid** inhibits germination of non-dormant seeds. It is the main chemical factor for induction of dormancy frequently accumulating in maturing seeds. It acts as stress hormone helping the plants to cope with the adverse environmental conditions (vangamudi et al., 2006). The expression of ABA biosynthesis genes is reported to show a direct impact on seed germination along with abiotic stresses (Vishal & Kumar, 2018) and ABA level at different developmental stages are responsible for the regulation of specific processes, such as seed maturation and seed germination, besides response to abiotic stresses (Lefebvre et al., 2006; Martínez-Andújar et al., 2011., Vishal & Kumar, 2018) and also regulates many processes during the plant life cycle, including key events during seed formation, such as deposition of storage reserves, prevention of precocious germination, acquisition of desiccation tolerance (Kermode,2005).

- **Gibberellin** stimulates seed germination of many species. Dormancies with chilling and light requirements are often overcome by treating with GA. The effect of GA3 treatments depends on species concentrations used and time of application (Mihaiela Corna-Cipcigan 2020). Gibberellic acid is considered as a medium to overcome seed dormancy of many species (Chen, Chang 1972). Gibberellins are the part of phytohormones which have multifunctional effects on the regulation of ontogenesis. They influence germination, flowering, are involved in sex determination and regulate seed and fruit development (Corna-Cipcigan, M et al., 2020). (Hemalatha M and chandari SB 2021) stated that Maximum germination percentage (34.66%) was recorded in the seeds treated with 300ppm GA3. Similarly revealed that high germination percentage was observed in Jatropha curcas seeds soaked in GA3 300 ppm for 8 hours followed by GA3 400ppm 10 hours. In parallel Khatana K J et al., 2013 revealed that KAGZILIME seeds treated with 500mg/l GA3 recorded maximum germination percentage (84.50%).

- **Auxin** may be associated with the later stages of embryo expansion during seed germination. In recent days auxins like IAA, IBA, NAA and 2,4-D are widely used in seed soaking to enhance germination and to break dormancy. NAA and IBA are reported to stimulate germination. Thus, auxins at low concentrations promotes germination but these effects are subjected to variation depending upon form and species of plant (vangamudi et al 2006). It was previously thought that the sole function of auxins was to promote cell enlargement. But the work done in later years has proved them to be deeply associated with a variety of functions. In some cases, they act as a stimulating agent (Bisth et al., 2018) and they control basic processes such as division and cell elongation (George et al., 2008, vangamudi et al 2006). Seeds soaked in IBA resulted in high germination and also enhanced the root length (Venkatesh et al., 2000, virendra 1990, Kumar et al., 1991, Sharma 1994).

**Recent advances in pre-sowing seed treatment:**

Though traditional methods of treatments enhanced the germination of seed, some of the advance technologies have also been introduced for effective results which include seed priming, radiation treatment, magnetic field exposure, use of nanoparticles etc. Seed priming treatment is done before sowing seeds, which involves hydration of seeds plentiful enough to enable metabolic events before germination to take place, although preventing radicle emergence to occur (2004, Rehman et al., 2011). The priming treatments involve two steps: (a) seed hydration in water (hydropriming), osmotic solutions of NaCl (osmo priming), or other solutes; in a solid matrix as vermiculite (matrix priming); solutions of nanoparticles (nano priming) or it can occur naturally in the soil (natural priming; Benitez-Rodriguez et al., 2014; Gamboa de Buen et al., 2006; González-Zertuche et al., 2001; Lush, Kaye, &
endemic, endangered and globally threatened medicinal tree species. Use of magnetic field exposure to enhance germination is also increasing in recent years. Magnetic seed stimulation involves identifying the magnetic exposure dose to affect the germination, early seedling growth and subsequent yield of crop plants (Aladjadjiyan, 2010). The magnetic exposure dose is the product of the flux density of magnetic field and of the time to exposure. The flux density of magnetic field varies with static or alternating magnetic fields exposure to seeds. These not only increase the rate of germination, growth and yield (Balouchi, and Sanavy, 2009) but also reduce the attack of pathogenic diseases (Yinan et al. (2005), De Souza et al. (2006).

Future prospects:
Seed quality is vital for sustainability of a species. Seed treatments have a tremendous scope in breaking seed dormancy, enhancing the germination rate, uniformity of growth and reduce the time of emergence. Research into new seed technologies is one of the fastest growing sectors in global crop protection markets (Sharma, K. K. et al., 2015).

As pressure increases to make availability of endangered valuable forest species for their sustainable use and availability for any afforestation, reforestation or commercial plantation, the seeds need to be pre-treated to break dormancy and speedup germination process. Various pre-sowing treatments influence the rate of seed germination, enabling the period for germination to be reduced from several months to only a few weeks. A number of mechanisms have been proposed by which the seed coat can impose dormancy on a seed which include the mechanical restriction of germination of the embryo, prevention of the exit of inhibitors from the embryo, presence of chemical inhibitors of germination, restriction of water uptake and restriction of oxygen uptake (Bewley, J. D. 1994). A lot of research work have already been carried on effects of different pre-sowing treatments on seed germination and seedling growth in many forestry species. Furthermore, research needs to be conducted to standardise the treatments for different environmental conditions.

CONCLUSION

Seed dormancy is the major hindrance for a normal seed to germinate even under favourable conditions which becomes a bottleneck for the species sustainability as well as availability. So, in order to conserve the seed availability pre-sowing treatments are to be carried out. Thus, this review acts as a guideline for providing variable treatments for breaking different type of seed dormancies varying species. Recent advances provide a nutshell on the emerging seed treatments like Seed priming. Irradiation using Gamma rays, Magnetic exposure
and using Nano particles. Advances in seed treatment technologies will refine existing treatment strategies. Future research should focus on recent advances in a wide range to promote seed enhancement in different species.

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