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Effect of different pre-sowing seed treatments on germination and seedling growth of Kachnar (*Bauhinia variegata*): A review

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Abstract

Bauhinia variegata, commonly known as Kachnar or Mountain Ebony, is a multipurpose tree species belonging to the family Fabaceae. The species is widely distributed in tropical and subtropical regions of India and possesses significant ornamental, medicinal, nutritional, and agroforestry importance. The present review compiles comprehensive information regarding taxonomy, botanical description, seed characteristics, dormancy behavior, nursery management, and various pre-sowing seed treatments employed to enhance germination and seedling growth in *Bauhinia variegata*. Different seed dormancy mechanisms, including physical, physiological, and morphophysiological dormancy, have been discussed along with methods used for dormancy breaking such as mechanical scarification, hot water treatment, acid scarification, hormonal priming, Osmo priming, and bioprimer. The review also summarizes germination parameters including germination percentage, mean germination time, germination rate index, and seed vigor characteristics. In addition, the nutritional and medicinal significance of Kachnar flowers, bark, buds, and seeds has been highlighted due to their rich phytochemical composition and therapeutic properties. The review concludes that appropriate pre-sowing treatments significantly improve germination, seedling vigor, and plantation success of *Bauhinia variegata*, thereby enhancing its utilization in agroforestry, forestry, and medicinal plant cultivation programs.

Keywords: *Bauhinia variegata*, seed dormancy, seed germination, scarification, seedling, vigor, medicinal tree species

Introduction

Bauhinia variegata, commonly known as Kachnar, belongs to the family Leguminosae mostly found in the regions of South India (Sahu *et al.*, 2012; Gamble *et al.*, 1915). It is also known by various names like Kachanara (Hindi), Raktakanchan (Marathi), Mountain ebony or orchid tree (English) and kachnar means "A beautiful glowing lady" in Sanskrit (Patil, J. K., *et al.*, 2012). Agroforestry is a comprehensive term encompassing land-use systems where woody perennials like trees, shrubs, and bamboos are cultivated alongside herbaceous plants such as crops, pasture, and/or livestock. These elements are organized spatially or temporally, facilitating ecological and economic interactions between the tree and non-tree components. The principal constituents of agroforestry systems include trees, shrubs, crops, pastures, and livestock, along with factors like climate, soil, and the surrounding environment (Bargah *et al.*, 2024; Yadu *et al.*, 2026)). Seed germination is a complex process that leads to the resumption of active growth in the embryonic axis, rupture of the seed cover and emergence of the young plants. For physiologists and biochemists, germination is complete when the radicle ruptures and the cover becomes visible. For seed technologists, foresters, nurserygrowers, etc. however, germination is a complex process that leads to the resumption of active embryonic growth and continued growth and development until a potentially independent seedling is formed (Bargah *et al.*, 2025; Tirkey *et al.*, 2026). Nurseries provide the means to control moisture, light physical and chemical soil constituents in such a way as to produce healthy and uniform seedlings for planting. Several factors can influence seedling growth in the nursery [65, 22, 58, 9, 4]

(Nishad *et al.*, 2025; Rajwade *et al.*, 2025). Plants are propagated and grown to a size that can be planted in a nursery. A quality nursery stock is necessary to create a good plantation.

The necessity of forest nurseries in order to properly nurture seedlings before planting them on land that needs to be replanted (Verma *et al.*, 2024; Singh *et al.*, 2026) Seedlings are small plants with enough potential to grow into mature trees. These seedlings grow naturally, but they can also be propagated by seeding and germinating, which helps them to sprout quicker and boost their chances of survival. The factors must be optimal to produce a healthy and vigorous seedlings, and among them, the genes and the nursery environment determine to a large degree how a tree can survive (Minj *et al.*, 2024; Patil *et al.*, 2018). Kachnar is closely related to peacock flower and Kachnar tree is considered as a beautiful tree in the world when it blooms. Orchid tree, camel's foot tree, mountain ebony, butterfly ash, poor man's orchid, the ebony tree are all common names of Kachnar. It is an ornamental tree with beautiful and scented flowers. This tree is used to attract hummingbirds in parks and gardens. Leaves, flower buds of Kachnar tree are eaten as vegetable (Verma *et al.*, 2012; Patil *et al.*, 2012). *B. variegata* is used traditionally as a medicine for the treatment various diseases like infections, diabetes, pain and inflammation edema, leprosy, wounds etc. due to presence of many phytochemicals. As per Ayurveda *B. variegata* contains saponins and glycosides and it is cold in potency, astringent in taste, light, dry. In India, about 15 species of this genus are found. *Bauhinias* are mostly propagated from seeds. Tannins, fibre, gum and oil are procured from *Bauhinia* species which are useful in industries. The plants bear fragrant and beautiful flowers. *Bauhinia variegata* L. is one of the important fodder species on which farmers rely during the winter lean period when the grasses are dry, less digestible and unpalatable. It has lush green foliage and excels to other tree fodder in a comprehensive nutritive value and collates with cultivated green leguminous fodder (Negi, 1986) [53, 60, 45, 56, 71, 58, 49].

It is widely cultivated throughout the country for its leaf fodder and for its beautiful flowers. It is a multipurpose agroforestry tree species producing fodder, fiber, fuel and small timber (Netam *et al.*, 2025; Gupta *et al.*, 2025). With the increase in demand for fodder, there is a need to strengthen the tree improvement programme in the species with a view to develop new varieties/ hybrids suiting to different agro-climatic zones with improved yield, fodder value and growth characters which may also meet the present day need of tree breeders for developing superior genotypes. About 600 species of *Bauhinia* grow in the tropical regions of the world (Larson, 1974). The genus includes trees, vines, and shrubs that are frequently planted for their showy flowers and ornamental foliage (Bailey 1941; Neal, 1965). *Bauhinia variegata* is native to southeastern Asia and grows from India to China. It is one of the most commonly cultivated small trees in India and is a reliable greenhouse species (Bailey 1941) [51, 24, 34, 5].

Bauhinia variegata is a small to medium-sized evergreen or deciduous tree (Little and others 1974) that reaches 1.8 to 7.6 m height and up to 20.3 cm in diameter. The leaves are variable in size, ranging from 5.1 to 12.7 cm in diameter. They are somewhat broader than they are long and are divided one-fourth to one-third in length (Bailey 1941, 1949; Little and others 1974). The resulting lobes are rounded and dissected by 9 to 13 main veins that radiate from the heart-

shaped base (Markam *et al.*, 2025; Manhare *et al.*, 2025). The species grows well in soils of medium fertility that are either droughty or moist; it is not tolerant of nutrient-poor sites. Although reproduction is abundant, *B. variegata* spreads slowly and is confined to a limited habitat. *Bauhinia* spp. bloom within 3 to 4 years (Bailey 1941). *B. variegata* flowers occur from autumn to spring (Little and others 1974). The five-petaled, showy flowers appear on short racemes, about seven to each shoot. They are 7.6 to 10.2 cm across and range in color from white (in the variety candida Buch. Ham.) to rose or lavender-purple (Bailey 1941, Little and others 1974). Bailey (1941) and Neal (1965) report that the petals are variegated with red and yellow, and that the lowest petal is larger and marked with crimson. Bailey (1949) notes that the petal lips are often attractively marked or mottled with purple. Little and others (1974) Buds of Kachnars are used on commercial scale in local markets later on which can be used for curry preparation or various dish preparation such as pakoras (Bargah *et al.*, 2024). The flowers of *Bauhinia variegata* contains digestible carbohydrates, significant amount of protein content, fat content, etc. and also has high energy value (Dhruw *et al.*, 2025; Singh *et al.*, 2026). Besides its traditional uses and known health benefits, the crop is still underutilized. Regular consumption of plant parts dried or raw (buds, stem, flower, bark, seeds etc.) in diet to claims us to have beneficial effects on human health and helps in protecting the body from chronic diseases like cancer, arthritis, ulcer and diabetes. Still wide ranges of plants are unexplored for the human consumption and are known in only particular area. These plants can be used for various medicinal properties (Nag *et al.*, 2025; Navrang *et al.*, 2026). The flower of *Bauhinia variegata* contains carbohydrates and significant amount of protein and fat content and also have high energy value and are used in dried and raw form. Flower is used for chutney, pickle, curry and for juice (Ready to serve beverages, squash, appetizers, wine, vinegar). Whereas dried flowers are used for pharmaceutical industry, instant food products mix (chutney, pakora mix) flavouring agents [36, 5, 6, 37, 38, 48, 9, 17, 67, 44, 47].

Nutritional value of Kachnar

Nutrition Values: Kachnar is rich in vital essential nutrients of vitamin C, B vitamins, key minerals of calcium, phosphorous, magnesium, iron, zinc, besides requisite macronutrients of reducing-sugar carbohydrates, dietary fibres, proteins and healthy unsaturated fats (Naeem and Ugur, 2019). In many regions of India, curries and pickles are prepared, by cooking, frying kachnar buds, seasoned with onions and spices, as a customary food, which is then eaten as vegetables or side dishes as part of the regular diet (Sharma *et al.*, 2021) [43, 66].

Products made from *Bauhinia variegata*

Kanchanar Guggulu is an effective Ayurvedic remedy for treating hypothyroidism, hormonal imbalance, PCOS and joint pains. The word Guggul originated from the Sanskrit word Guggulumeans 'protection from the disease'. It also promotes the functioning of the lymphatic system and in getting rid of toxins (Ramadan *et al.*, 2006).

Key Ingredients Kanchanar Guggulu comprises Kanchanar (*Bauhinia variegata*) bark, ginger, black pepper, long pepper, Haritaki, bibhitaki, amlaki (the combination of triphala), Varuna (crataevanurvala bark), cardamom, cinnamon, and Guggulu resin in equal amounts. Kanchanar bark is brewed

into a decoction and gets mixed with guggulu and other items to make it into a tablet (Naeem and Ugur, 2019) [61, 43].

Table 1: Plant profile

Taxonomic Rank	Classification
Kingdom	Plantae - Plants
Subkingdom	Tracheobionta - Vascular plants
Superdivision	Spermatophyta - Seed plants
Division	Magnoliophyta - Flowering plants
Class	Magnoliopsida - Dicotyledons
Subclass	Rosidae
Order	Fabales
Family	Fabaceae - Pea family
Genus	<i>Bauhinia</i> L. - Bauhinia
Species	<i>Bauhinia variegata</i> L.

(RaghuvierIrchhaiya *et al.* 2014)

Seed Characteristics of *Bauhinia variegata*

Although published reports on the handling of *B. variegata* pods and seeds are not available, in most hard-seeded temperate Fabaceae, pod ripeness is determined by a color

change from green to light or dark brown (U.S. Department of Agriculture 1974). Ripe pods are picked by hand or shaken/flailed from the trees and then spread to air-dry. Seeds are threshed or mascerated from the dry pods and separated from the chaff by screening, fanning, or water flotation. Relatively large at 1.3 cm in diameter, the seeds average 4,950 per kg in Puerto Rico (Francis and Rodriguez 1993). Once dried (moisture content less than 12 percent; Roberts 1973), seeds are placed in sealed containers and stored between 2 and 4 °C. Athaya (1985) reports that *B. variegata* seeds have a higher germination percent when stored after cleaning; however, viability is lost within 3 years. This viability loss may be attributable to high moisture content or mechanical damage, because hard-seeded Leguminosae should store well for longer periods of time. Germination studies of *B. variegata* using excised embryos produced results comparable to experiments using intact seeds (Babeley and Kandya 1986). Francis and Rodriguez (1993) report excellent germination of *Bauhinia* spp. without scarification, and they record a 77 percent germination for *B. variegata* seeds placed on moist blotting paper [70, 21, 62, 2, 4].

Table 2: Kachnar is Known by Various Names in Different Languages

Language	Common Name(s)
English	Mountain ebony
Bengali	Raktakanchan
Hindi	Barial, Gurial, Gwiar, Kachnar, Kandan, Kaniar, Khairwal, Khawairaal, Koliar, Padrian
Malayalam	Kovidaram, Suvannamandaram, Unna
Marathi	Kanchan, Raktakanchan, Thaur
Sanskrit	Ashmantaka, Asphota, Chamari, Chamarika, Champavidala, Gandari, Girija, Kanakaprabha, Kanchanala, Kanchana, Kanchanara, Kantar, Karaka, Karbudara, Kovidara, Kuddala, Raktapushpa, Shonapushpaka, Suvannara, Svalpakkesara, Tamrapushpa, Uddalaka, Yamalachada, Yugapatraka, Yugmapatra
Tamil	Mandarai, Segappumandarai, Semmandarai, Vellaippuvatti
Telugu	Bodanta, Devakanjanamu, Kanjanamu, Mandara, Mandari
Urdu	Kachnal
Odia (Oriya)	Boroda, Kosonaro, Kanjoni

(Irchhaiya *et al.*, IJP, 2014)

Botanical description

Bark

The bark is light brownish grey, smooth to slightly fissured and scaly. Inner bark is pinkish, fibrous and bitter. The twigs are slender, zigzag; when young, light green, slightly hairy, and angled, becoming brownish grey.

Leaves

Leaves have minute stipules 1-2 mm, early caducous; petiole puberulous to glabrous, 3-4 cm; lamina broadly ovate to circular, often broader than long, 6-16 cm diameter; 11-13 nerved; tips of lobes broadly rounded, base cordate; upper surface glabrous, lower glaucous but glabrous when fully grown.

Flower

Flower clusters (racemes) are unbranched at ends of twigs. The few flowers have short, stout stalks and a stalk-like, green, narrow basal tube (hypanthium). The light green, fairly hairy calyx forms a pointed 5- angled bud and splits open on 1 side, remaining attached; petals 5, slightly unequal, wavy margined and narrowed to the base; 5 curved stamens; very slender, stalked, curved pistil, with narrow, green, 1-celled ovary, style and dot like stigma., *B. variegata* flowers occur from autumn to spring (Little and others 1974). The five-petaled, showy flowers appear on short racemes, about seven to each shoot. They are 7.6 to 10.2 cm across and range in

color from white (in the variety candida Buch. Ham.) to rose or lavender-purple (Bailey 1941, Little and others 1974). Petals are 5.1 to 6.4 cm long and 2.5 to 3.2 cm wide. The calyx splits along one side when opening and remains attached. There are five to six fertile stamens per flower. Little and others (1974) [5, 36, 16, 6, 63].

Seeds

Pods dehiscent, strap-shaped, obliquely striate, 20-30 cm; long, hard, flat with 10-15 seeds in each; seeds brown, flat, nearly circular with coriaceous testa (Deswal *et al.*, 2015). Little and others (1974) note that pods reach lengths of 12.7 to 22.9 cm. Bailey (1941) reports pod lengths of 30.5 to 61 cm, but, in 1949, reduces pod length to "1 ft. or less." Fruits mature in late spring or early summer. Stomata are present on both the seeds and the pods (Rugenstein and Lersten 1981); the seeds are light brown, rounded, and flat.

Seed dormancy

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).

Baskin & Baskin (1998, 2004) have proposed a comprehensive classification system which includes five classes of seed dormancy: physiological, morphological, morphophysiological, physical and combinational (Baskin, 2005) [71, 73, 33, 12, 25, 13, 35, 11, 12].

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. Hereas 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).

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.

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)

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 Cavanagh 1984, Egley 1989, Finch & Leubner 2006).

Combinational dormancy: It is evident in seeds with water-impermeable coats (as in PY) combined with physiological embryo dormancy (Baskin & Baskin, 2004, Finch & Leubner 2006).

Pre- sowing seed treatment methodologies

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) [53, 11, 12, 20, 65, 19, 49, 18].

Physical scarification

Mechanical treatment: Mechanical treatment refers to the mechanical cutting or filling 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). 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) [30, 18, 71].

Knuckling and sandpaper scarification (mechanical)

Mechanical methods are essential in breaking the tough, impermeable seed coats of species like *Acacia catechu*, *A. nilotica*, *Albizia spp.*, and *Cassia fistula*. Studies have shown that knuckling the distal ends of *Gliricidia sepium* seeds improves germination without harming the embryo Sandpaper scarification of seeds from *Melia azedarach* and *Acacia auriculiformis* resulted in impressive germination rates of 80% and 78%, respectively.

Hot Treatment

This affordable and farmer-friendly method has been recognized for improving seed germination. It is particularly effective for most medium-sized dry seeds, as it allows them to absorb sufficient water and soften their seed coats. Heat treatment also proves moderately successful in overcoming seed dormancy. Research recommends a combination of 1-30 minutes of acid scarification followed by a one-hour heat treatment at temperatures between 55-77°C to optimize germination, depending on the species (Koutouan Kontchoiet *al.*, 2020) [32].

Chemical Scarification

The impermeability of seed coats, which hinders water absorption, can be addressed through chemical scarification. This is particularly challenging for seeds from tree species in dry and semi-arid regions, where seed coat impermeability affects germination (Kheloufiet *al.*, 2018). Dormancy can be broken by soaking seeds in various chemicals, such as acidic or basic solutions, organic solvents, alcohol, disinfectants, or boiling water. Common acids used for scarification include phosphoric acid (ranging from 25% to 75%, depending on the seed type), potassium nitrate, nitric acid, and concentrated sulphuric acid (96%). For potassium nitrate treatment, a 0.2% solution is prepared by dissolving 2 g of potassium nitrate (KNO₃) in 1 liter of water (Bargahet *al.*, 2025).

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 [31, 8, 33].

Sulphuric Acid

soaking in concentrated sulphuric acid is the most common method to soften 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^[30].

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 imbibition of water (Nikoleave, 1977) seed treated with 98% conc. H₂SO₄ for 1 minute.

Gibberellic acid

The effect of GA₃ treatments depends on species concentrations used and time of application (Mihaiela Cornea-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 (Cornea-Cipcigan, M *et al.*, 2020)^[14, 15].

Thermal treatment

Hot water

This affordable and farmer-friendly method has been recognized for improving seed germination. It is particularly effective for most medium-sized dry seeds, as it allows them to absorb sufficient water and soften their seed coats. Heat treatment also proves moderately successful in overcoming seed dormancy. Research recommends a combination of 1-30 minutes of acid scarification followed by a one-hour heat treatment at temperatures between 55-77°C to optimize germination, depending on the species (Koutouan Kontchoi *et al.*, 2020)^[32].

Warm Water

Stratification is a technique used to break the hard outershell of a seed to facilitate germination. This process involves exposing the seed to a moist environment, which helps soften the outer layer, allowing the seed to sprout more easily. There are two types of stratification: cold stratification and warm stratification.

Hormonal Priming

Hormone pretreatment is a commonly used priming approach to improve seed germination in stressful conditions (Atici *et al.* 2003; Gratao *et al.* 2005; Jisha *et al.* 2013; Masood *et al.* 2012; Hu *et al.* 2013). Hormonal priming in general consists of treatment of seeds with chemicals like growth regulators, sodium hypochlorite (NaOCl) or hydrochloric acid (HCl), natural substances and agrichemicals (e.g. fungicides, pesticides). It has reduced the severity of the effect of salinity, but the amelioration was found maximum due to the application of 50 ppm salicylic acid and 50 ppm ascorbic acid treatments and gives satisfied results on seedling growth, fresh and dry weights under non-saline and saline conditions, whereas hormonal priming with ABA was not effective in some of grass family crops (Afzal *et al.* 2006). In pepper (*Capsicum annum L.*), Khan *et al.* (2009) showed that pretreatment with acetylsalicylic acid and salicylic acid resulted in greater uniformity of germination and establishment of seedlings under high salinity. In addition to these chemicals, ethylene was used to minimise the effect of high temperatures on seed germination of lettuce (Nascimento 2004, Nascimento *et al.* 2005)^[3, 23, 27, 38, 26, 1, 28, 42].

Biopriming

Biopriming is a new technique of seed treatment that assimilates biological (inoculation of seed with beneficial organism to protect seed) and physiological aspects (seed hydration) of disease control. To respond to the negative effects of pathogens, biopriming uses beneficial microorganisms to protect against pathogens and enhance plant growth. Biological seed treatments for control of seed and seedling diseases offer the grower an alternative to chemical fungicides. Storage and application conditions are more critical than with chemical seed protectants and differential reaction to hosts, and environmental conditions may cause biological seed treatments to have a narrower spectrum of use than chemicals. Conversely, some biocontrol agents applied as seed dressers are capable of colonising the rhizosphere, potentially providing benefits to the plant beyond the seedling emergence stage (Nancy *et al.* 1997). Seed treatment with biocontrol agents along with priming agents may serve as an important means of managing many of the soil- and seedborne diseases, the process often known as 'biopriming'. It involves coating seed with a bacterial biocontrol agent such as *Pseudomonas aureofaciens* AB254 and hydrating for 20 h under warm (23 °C) conditions in moist vermiculite or on moist germination blotters in a self-sealing plastic bag. The seeds are removed before radical emergence. The bacterial biocontrol agent may multiply substantially on seed during biopriming (Callan *et al.* 1990). Biopriming seed treatments can 14 Seed Priming on Germination, Growth and Flowering in Flowers and Ornamental... 268 provide a high level of protection against root rot diseases of crop plants which was generally equal or superior to the control provided with fungicide seed treatment. So, it could be suggested that biopriming (combined treatments between seed priming and seed coating with biocontrol agents) may be safely used commercially as substitute for traditional fungicide seed treatments for controlling seed- and soilborne plant pathogens.

Osmo priming

Also known as osmotic conditioning, is a widespread pre-sowing priming procedure which involves treatments of seeds with osmotic solutions at low water potential facilitating the control of water uptake into the seeds. The main goal of Osmo priming is to limit the reactive oxidative species, i.e. ROS-mediated oxidative injury through insufficient water absorption. Thus, the water potential of the osmotic agent used is a crucial parameter during the priming process (Heydecker and Coolbear 1977; Taylor *et al.* 1998). Priming with PEG provides beneficial conditions for bacterial growth due to poor aeration (Parera and Cantliffe 1994). It shows some disadvantage when used in bulk, due to high costs and extremely high viscosity which limits oxygen transfer within the solution. Hence, research has to be done for choosing the correct chemical and its optimum dose for a crop. It is difficult to manage huge quantities of wet primed seed especially under hot tropical climate condition, while in temperate areas, maintaining the priming temperature is crucial. Some of the osmotica (osmotic compounds used for Osmo priming) that can be used include potassium nitrate, potassium dihydrogen orthophosphate, dipotassium hydrogen orthophosphate, calcium chloride, zinc sulphate, borax, magnesium chloride, manganese sulphate, sodium chloride, sodium sulphate and organic compounds, viz. agrosan, cycocel, citric, furamic, succinic, malic acids,

purines, pyrimidines, caffeine, uracil, xanthine and uridine diphosphate (De Chandra 1999).

Effect on germination dynamics

Seed germination percent

Athaya (1985) reports that *B. variegata* seeds have a higher germination percent when stored after cleaning; however, viability is lost within 3 years. This viability loss may be attributable to high moisture content or mechanical damage, because hard-seeded Leguminosae should store well for longer periods of time. Germination studies of *B. variegata* using excised embryos produced results comparable to experiments using intact seeds (Babeley and Kandya 1986). Francis and Rodriguez (1993) report excellent germination of *Bauhinia spp.* without scarification, and they record a 77 percent germination for *B. variegata* seeds placed on moist blotting paper [2, 4, 21].

Formula

- GP (Germination percentage) = (Total number of seeds germinated/total number of seeds tested) × 100
- Final Germination Percentage (FGP%) = Final no. of seeds germinated in a seed lot × 100
- The higher the FGP value, the greater the germination of a seed population.

Mean germination time MGT

- (Mean germination time) = total (daily germination) × 1 days/total seed sowing
- Mean Germination Time (MGT day) = $\sum f \cdot x / \sum f$
- f = Seeds germinated on day x
- The lower the MGT, the faster a population of seeds has germinated.
- First Day of Germination FDG day = Day on which the first germination event occurred Lower FDG values indicate a faster initiation of germination.
- Last Day of Germination LDG day = Day on which the last germination event occurred Lower LDG values indicate a faster ending of germination [Kader (1998)]
- Germination Rate Index GRI (%/day) = $G1/1 + G2/2 + \dots + Gx/x$

G1 = Germination percentage × 100 on the first day after sowing, G2 = Germination percentage × 100 on the second day after sowing.

Conclusion

Bauhinia variegata (Kachnar) is a valuable multipurpose tree species with significant ornamental, medicinal, nutritional, and agroforestry importance. However, seed dormancy caused mainly by a hard and water-impermeable seed coat limits its rapid and uniform germination. Pre-sowing seed treatments are therefore essential for improving germination and seedling establishment. Among the various methods reviewed, mechanical scarification, hot water treatment, and sulphuric acid scarification were found to be the most effective dormancy-breaking treatments. Hormonal priming, particularly with GA₃ and salicylic acid, as well as osmo-priming and bioprimeing, also enhance germination, seedling vigor, and stress tolerance. Despite the species' importance, research on *B. variegata* seed dormancy and germination remains limited. Comparative studies on different treatments, optimization of treatment concentrations and durations, and investigations into physiological and biochemical

mechanisms are still needed. Future research should focus on developing standardized, cost-effective seed treatment protocols and evaluating their effectiveness under different agro-climatic conditions. Integrating scarification, hormonal priming, and biological treatments may further improve germination and seedling performance, supporting the wider use of *Bauhinia variegata* in forestry, agroforestry, and ecological restoration programs.

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