Managing Seed Dormancy in Forage Legumes and Grasses: An Update

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Abstract. Seed dormancy is a common feature of the majority of forage species. It usually causes problems both to the grower and the seed analyst. Many methods have been developed to break dormant seed over the time, and efficacy of a method usually varies with species and cultivars. The objective of this paper is to review and summarise important methods used for seed dormancy breaking in forage legume and grass species, and the mechanisms involved.

Keywords: Seed dormancy breaking, seed scarification, seed stratification.

Introduction

Legumes and grasses are the most important families among forage species. However, one of the major constraints associated with forage species is seed dormancy which results in problems to both the grower and the seed analyst, when the seeds fail to germinate even under optimal conditions (Tomer and Kumari 1991). It is important to break seed dormancy before planting, as a high content of dormant seed often leads to poor stand establishment, less competitive with weeds (Dittus and Muir 2010). Seed dormancy is one of the most extensively research areas in plant biology, however, mechanisms on how seeds remain in a dormant state, particularly in grasses, are less understood (Simpson 1990; Adkins *et al*. 2002). Many dormancy breaking techniques have been developed and modified over the time, but it seems that no single method can be recommended for all forage species in general (Kimura and Islam 2012). The objective of this paper is to review and summarise the important and popular methods used for seed dormancy breaking in forage legume and grass species and the mechanisms underlying these methods. The information generated is aimed to provide useful information not only for researchers and growers, but also for seed analysts.

Forage legumes

Hard seed, also classified as physical dormancy, is very common in forage legumes (Baskin and Baskin 2004). Generally, this kind of dormancy is caused by an impermeable seed coat which restricts water into the seed and thus inhibits seed germination. Many methods, based on scarifying the seed coat have been developed such as mechanical scarification, chemical scarification, percussion, high atmosphere pressures, heat, radiation, dry storage, ultrasound and low temperatures (Baskin and Baskin 1998). Among these, the most important and popular used methods in forage legumes are sulphuric acid, mechanical and heat scarification.

Concentrated sulphuric acid is one of the most widely applied methods to remove hard-seededness in forage legumes (Argel and Paton 1999; Martin and De La Cuadra 2004; Wang *et al*. 2007). This treatment causes degradation of the seed coat, thus allowing water entry into the seed in almost all legume species (Nagaveni and Srimathi 1980). It is also effective in controlling seed borne fungi at the same time as breaking hard seed dormancy in seeds of several *Stylosanthes* species (Nan *et al*. 1998). The times used for pretreatment with sulphuric acid vary from a few seconds to several hours, in most cases between 1 and 20 minutes (Ellis *et al*. 1985). Concentrated sulphuric acid for breaking hard seed of some forage legumes is also recommended by the International Seed Testing Rules (ISTA 2012). Generally, the effectiveness of concentrated sulphuric acid scarification depends on the duration of treatment and species and cultivars (Kimura and Islam 2012; Wang *et al*. 2007), and even accessions and seed lots used (Wang *et al*. 2007). In addition, particular care should be taken to avoid potential harm of this chemical to the human body and environment (Wang *et al*. 2007).

Mechanical scarification is a technique to physically create scars on the seed surface to increase water imbibitions of the seed. Various types of tools including sand paper, file, knife, razor blade, scalpel and needle have been used in breaking hard seed of forage legumes particularly for seed testing and research. These treatments are very effective and can make all individual hard seed permeable to water. However, the treatment can be a very labor intensive and time-consuming especially if a large number of scarified seeds are required (Baskin and Baskin 1998; Wang *et al*. 2011). Thus machines that roll or blow seeds against an abrasive surface such as glass splinters or sand paper in some kind of containers have been built (Carleton *et al*. 1971; Townsend and Mcginnies 1972). Such machines have the capability to scarify a large volume of seeds. However, it has been reported that these machines work fine for small, thin-coated seeds like those of *Trifolium subterraneum*, but they may not work well for thick-coated seeds like those of *Acacia* species (Kimura

and Islam 2012).

Heat scarification is a method that uses high temperatures to break or crack the seed coat and has advantages of being simple, clean, cheap and easy to use. Two main heating devices widely used are ovens and hot water. This technique has been reported effective for a number of forage legume species (Wang *et al*. 2007; Hu *et al*. 2009a), but it does not work in all of them (Nie 2011). Efficacy of treatment for a given species depends on heat devices, treatment times and temperatures used. Generally, a few minutes of exposure to oven temperature of ≥100ºC (Baskin and Baskin 1998) and immersing seeds into hot water with temperature ranged from 70 to 80°C are required to break hard seeds of most forage legume species (Wang *et al.* 2011; Nie, 2011; Hu *et al.* 2009a).

Generally, dormancy breaking of hard seed occurs by the formation of an opening in the water-impermeable seed coat through a physical break in a specialized morphological anatomical area, while resealing of this opening seems to be not anatomically possible (Baskin *et al*. 2000). However, there are several claims for dormancy cycling in physically dormant seed (Rolston 1978; Norsworthy and Oliveria 2007; Taylor 2005; Wang *et al*. 2012). More recently, annual cycling of germinability was also observed in seeds of several legume species (Van Assche *et al*. 2003). This implies that physical dormancy release was not a simple process through coat breakdown, but a complicated phenomenon regulated both by environment and genetic background which needs further study. In many species, the lemma is believed to be responsible for seed dormancy release and acts as an environmental detector (Serrato Valenti *et al*. 1995; Baskin *et al*. 2000). However, other structures, such as the hilum, are also reported for dormancy release in some species (Hu *et al*. 2009b). The understanding of the role of water gap in controlling seed dormancy is expected to help develop effective methods to break seed dormancy, but the knowledge on their relationship is limited.

Forage grass

Contrasting with the forage legume species, the mechanism of dormancy in grass seed is more complicated which may involve mechanical restriction, chemical inhibition, plant growth regulator and/or embryo growth potential (Simpson 1990). Based on the causes of dormancy and the conditions required to break it, Nikolaeva (1977) proposed a concept of three groups of the seed dormancy types: coat-imposed, embryo-imposed and a combination of the two.

Coat-imposed dormancy is very common in forage grass seed. In this type of dormancy, the embryo has the capability to germinate, but dormancy is caused by the embryo covering structures such as lemma, palea, seed coats and endosperm (Simpson 1990). The mechanisms for seed maintaining dormancy may be due to either the imperme-ability of seed coat to gases, the mechanical prevention of radical extension, or to the seed covering structure prevent-ing inhibitory substances from leaving the embryo or by supplying inhibitors to the embryo (Bewley and Black 1994). Many techniques have been developed to overcome coat-imposed seed dormancy through scarifying the covering structure. The most popular methods used include soaking seeds in alkalis (Hou and Simpson 1994; Murray *et al*. 1980), acid (Tischler and Young 1983; Jones 1990; Voigt and Tischler 1997), water (He *et al*. 2010), and organic solvents (Taylorson and Hendricks 1979), and the manual removal of the covering structure (Ma *et al*. 2007;He *et al*. 2010). In addition, plant growth regulators (PGRs), such as gibberellins and cytokines, can have marked effects in breaking dormancy in some species, but they do not appear to influence all species of grasses (Simpson 1990; He *et al*. 2010; Ma *et al*. 2007). Inorganic substances, especially potassium nitrate, have been extensively used to break grass seed dormancy and are proposed as a pretreatment method in International Seed Testing Rules (ISTA 2012). However, the response of dormant grass seeds to nitrate treatment varies among and within species (Simpson 1990).

Embryo-imposed dormancy occurs in some wild grass species, which is caused by internal factors of the embryo that inhibits extension of growth. For this kind of dormancy, the expression of certain genes, levels of certain plant growth regulators, the activity of important respiratory pathways or the mobilization and utilization of food reserves may involve in this process. Generally, cold stratification (moist pre-chilling) is an effective technique in releasing embryo-imposed dormancy. This method involves mixing seeds with an equal volume of a moist medium (sand or peat, for example), or placing seeds on the moist paper in a closed container, and storing them in low temperature ranged from 0 to 10ºC. The temperature used and length of time it takes to break dormancy varies with particular species. However, understanding of how cold stratification releases seed dormancy is still limited (Simpson 1990; Baskin and Baskin 2004).

Conclusion

Seed dormancy breaking is important for successful stand establishment and seed quality evaluation in forage legume and grass species. The important methods used for forage legumes include acid, mechanical and heat scarifications; and those used for forage grass seed are alkalis, acid, water, organic solvents soaking, covering removal, and plant growth regulators application. Effectiveness of dormancy breaking method usually varies among species and even cultivars or accessions. It is necessary to understand the mechanisms involved in treated species to choose the optimal method.

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