Morphological Characteristics of Seeds With Physical Dormancy©

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INTRODUCTION

Seed dormancy is a condition where seeds will not germinate even when the environmental conditions (water, temperature, light, and aeration) are permissive for germination (Hartmann et al., 2011). Not only does seed dormancy prevents immediate germination, it also regulates the time, conditions, and location where germination will occur. In nature, different kinds of dormancy have evolved to aid the survival of a species by programming germination for particularly favorable times in the annual seasonal cycles (Baskin et al., 1998).

The major seed dormancy categories include:

- Primary dormancy
    - exogenous dormancy (physical)
    - endogenous dormancy (physiological and morphological)
    - combination dormancy (physical plus physiological)
- Secondary dormancy

The focus of this paper will be to describe the morphological characteristics associated with physical dormancy and indicate how specialized structures on the seed called water gaps function to coordinate dormancy release.

PHYSICAL DORMANCY

Exogenous physical dormancy is imposed upon the seed from factors external to the embryo including the outer seed coat or parts of the fruit coverings (Hartmann et al., 2011). Seeds with physical dormancy fail to germinate because the seed is impermeable to water. Physical dormancy is found in at least 15 plant families, including horticulturally important families like the Fabaceae, Malvaceae, Cannaceae, Geraniaceae, and Convolvulaceae (Baskin et al., 2000). For horticultural crop production, seeds are scarified to mechanically abrade the seed coverings or seeds are treated with concentrated sulfuric acid to alleviate physical dormancy. In nature, exposure to high temperature or fluctuating temperatures is the most likely cause of dormancy release (Geneve, 2003).

Two features characterize seeds with physical dormancy. Physically dormant seeds have an outer seed or fruit cell layer comprised of macrosclereid cells and there is also a surface feature within the outer seed layers that functions as a water gap to allow water imbibition.

MACROSCLEREID CELL LAYER

Macrosclereid cells form the outer cell layer in the seed coat or fruit wall in physically dormant seeds and are responsible for preventing water uptake (Fig. 1). These cells belong to a plant cell type called sclereids. Sclereids are characterized by extensive secondary wall formation and are usually non-living at maturity. This cell layer is also referred to as the Malpighian or palisade cell layer. Malpighian cells

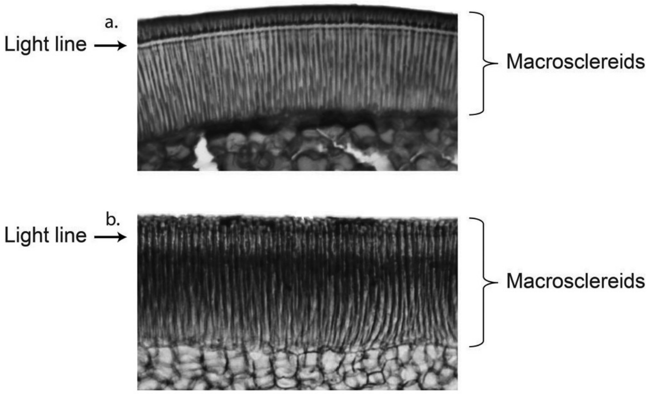

Figure 1. Macrosclereid layer and light line in (a.) eastern redbud (*Cercis canadensis*) and (b.) canna (*Canna indica*).

is an older term no longer in common use and refers to the early 17th-century Italian plant anatomist Marcello Malpighi. During the later stages of seed development, cells of the outer integument coalesce and deposit water-repellant materials within and on the surface of the macrosclereid cells. This seals the seed and makes it impervious to water. These materials include lignin, suberin, cutin, and waxes (Rolston, 1978).

Most macrosclereid cells have a single light line that appears to form a continuous layer across cells (Fig. 1). The light line does not actually extend between cells but occurs at nearly the same location in adjacent macrosclereid cells giving the appearance of a continuous layer. This layer is apparently at the location in the macrosclereid cell where there is a change in the cell's chemical composition that refracts light in a way that appears to form a line in the cell. The light line has been implicated in helping to maintain physical dormancy, but it appears to be secondary to the water repellant materials in the cuticle and sub-cuticle outer layers of the macrosclereid cells.

THE WATER GAP

There is usually a single area of the seed coat that acts as a water gap to relieve physical dormancy and initiate imbibition. It is thought that water gap structures act as environmental sensors to detect appropriate times for germination based primarily on temperature (Baskin et al., 2000). Water gap structures are usually associated with areas of the seed coat where there were natural openings in the ovule during seed development such as the hilum, micropyle, and chalaza. The morphological characteristics of water gaps can vary significantly between physically dormant seeds, but is reasonably similar within a plant family. A list of the known water gap structures are listed in Table 1.

For many seeds, temperature is the environmental signal that relieves physical dormancy (Hartmann et al., 2011). High temperature or temperature fluctuations

Table 1. Water gap structures and associated plant families.

Bulge gap	Convolvulaceae
Chalazal blister gap	Malvaceae, Malveae
Chalazal opening	Malvaceae, Gossypieae
Endocarp slit	Anacardiaceae
Hilar slit	Convolvulaceae, Fabaceae
Hilum associated gap	Sapindaceae
Hinged valve gap	Geraniaceae
Imbibition lid	Cannaceae
Lens gap	Fabaceae

physically alters the water gap, which opens to permits water uptake (Baskin et al*.,* 2000). For example, treating mimosa (*Albizia julibrissin*) seeds with moist heat [50 °C (122 °F)] for 24 h causes the eruption of a plug located in the lens region of the seed (Fig. 2). As the plug separates from the seed, it provides a gap in the otherwise impermeable macrosclereid layer permitting imbibition. Another example of a temperature-sensitive water gap structure is the imbibitonal lid that forms in *Canna* seeds after being submerged in boiling water for 1 min (Fig. 2). The lid separates from the seed again allowing water to enter the seed.

CONCLUSION

Physical dormancy is thought to provide several ecological advantages to the seed. First, since the seeds remain dry until released from dormancy, seeds have the potential to remain viable for many years. Some of the longest-lived seeds have been those with physical dormancy including sacred lotus (*Nelumbo nucifera*) documented to be viable after 1000 years (Shen-Miller et al., 1995). Secondly, the water gap acts as an environmental sensor to fine-tune germination to coincide with an environment that provides the best chance for seedling survival and ecosystem colonization. Temperature is postulated to be a way for seeds to detect differences in the seasonal year or whether they are in an open or protected area. Therefore, a species such as *Ipomoea lacunosa* that has seeds that require moist temperatures above >30 °C (86 °F) for dormancy release would germinate in the summer in open areas when the soil temperature would be high (Jayasuriya et al., 2009).

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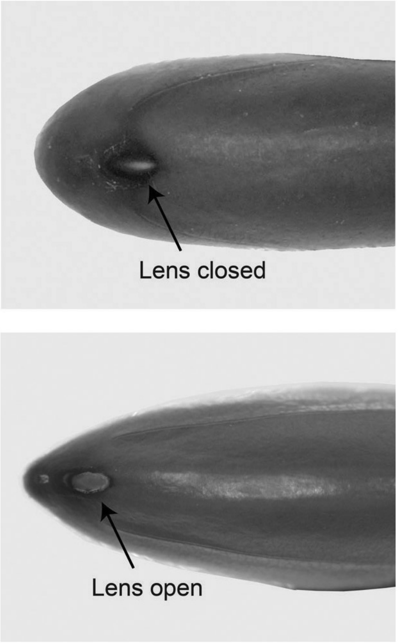

Figure 2. Dormancy release in mimosa (*Albizia julibrissin*) treated with moist heat at (50 °C; 122 °F) for 24 h showing the eruption of the lens plug to open the water gap.

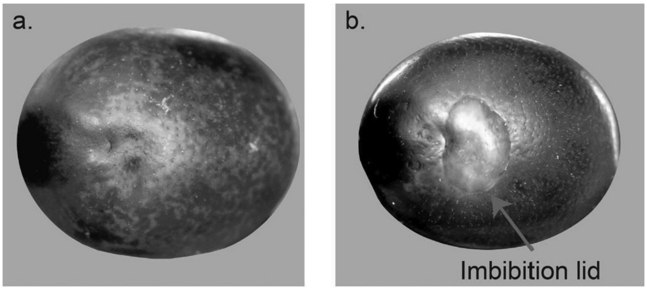

Figure 3. Dormancy release in canna (*Canna indica*) before (a.) and after (b.) treating the seed in boiling water for 1 minute.

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