ESSAY

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Protector of the Seeds: Seminal Reflections from Southern Africa

Patricia Berjak

Despite their marked geographical and cultural diversity, the peoples of Africa are bound together by concerns about food security and the vagaries of rainfall across the continent's extensive terrain, much of which is arid or semi-arid. This makes the scientific study of seeds and their storage an imperative. I became convinced of this scientific mandate even as a graduate student at the University of Natal in Durban in the late 1960s where, under the guidance of Trevor Villiers, I metamorphosed from an animal-oriented biochemist into a seed-focused cell biologist.

To most people, a seed is a dry structure that can be maintained in a desiccated condition in a state of suspended animation until provided with water and other conditions that will promote germination. These traits define "orthodox" seed behavior. Maize (corn), which produces orthodox seeds, is the staple crop of much of Africa, yet it is ill-suited to the drought-prone conditions that prevail in many regions, where it is cultivated in preference to the native cereal, sorghum.

Annual production of maize is important not only for food security, but also in providing seeds for planting in following seasons. Unfortunately, the crop is frequently jeopardized by droughts. The threat to the crop is exacerbated by seed storage under warm, high relative humidity conditions that can drain seeds of their vigor and viability, while encouraging fungal growth in the seeds. My doctoral work on maize seeds aimed to characterize the course of rapid deterioration that inevitably occurs under these poor seed-storage conditions. I concentrated on the root cap of the seed embryo. After germination, the integrity of this structure is essential to protect the tip of the root as it grows through the sharp, abrasive soil.

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Radical Fungi

There were several exciting outcomes from those investigations. The first was the original microscopical characterization in plant cells of lysosomal vacuoles—fluid-filled vesicles collectively containing enzymes capable of breaking down all other intracellular constituents. A second discovery was that cells that form the root cap self-destruct by autolysis in the final phase of their developmental program (a process called apoptosis, or programmed cell death) and are sloughed at the cap surface. The work also showed that the events involved in apoptosis are accelerated when seeds are poorly stored and that intracellular membranes are the primary loci of degeneration.

Membranes are pivotal for compartmentalizing intracellular functions. They also provide the selective barrier between the cell and its surroundings. Membrane breakdown is a key factor in cell debilitation and death. For seeds, that translates into a loss of viability. Then, as now, the generation of free radicals within the cells of dry seeds in storage is considered to be a major cause of deterioration of membranes and other cellular structures.

On the premise that membrane damage is caused by free-radical activity, Norman Pammenter, my husband and major research collaborator, and I had an inspiring discussion with a Hungarian animal physiologist, K. Molnár, about his work on the efficacy of cathodic protection in extending the lifespan of mice.

Consequently, we stored maize seeds under deteriorative conditions, but in a static electric field. The results, published 30 years ago in this journal, showed that the application of cathodic protection had a dramatic effect in extending seed lifespan. That outcome could be attributable to quenching of free radicals. With hindsight, however, another interpretation is also possible: The efficacy of the treatment resulted from its adverse effects on fungi within the seeds.

With the help of two graduate students, David Mycock and Michelle McLean, my laboratory became active in seed fungus research. The fungi in question are xerotolerant—they survive the dry conditions within stored orthodox seeds. They also produce mycotoxins, which include some

CREDIT: DENISE BERJAK

Patricia Berjak
South Africa

Patricia Berjak, a professor at the University of KwaZulu-Natal in Durban, South Africa, has studied seeds and seed storage for over 30 years. A biochemist initially, she metamorphosed early in her career into a cell biologist with a passionate focus on seeds. She works with her husband and scientific colleague, Norman Pammenter, and many of her graduate students have moved on to distinguished careers of their own. She is a recipient of the 2004 Distinguished Woman Scientist Award, administered by the South African Department of Science and Technology, and the Silver Medal of the South African Association of Botanists. She was recently inducted as a Fellow of the Third World Academy of Sciences. In addition to her scientific pursuits, she enjoys high-performance cars, light-aircraft aviation, and ballroom dancing.

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