Introduction

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Planted seeds are the end product of a series of steps that include growing, harvesting, conditioning, storing, and planting. During these steps, seeds are subject to deterioration. Before harvest in the production field, abortion of flowers or other fruiting structures or development of small, shrivelled, moldy, or insect-damaged seeds may occur. During harvesting and conditioning, mechanical damage may result in shattered seeds and broken seed coats. In storage, seeds may decline in germinability and vigor and show visible signs of invasion by fungi or insects. After planting, seedling emergence may be poor, and transmission of pathogens to the new crop may occur. Management of seed production to minimize deterioration requires an understanding of the mechanisms of seed deterioration.

The basic causes of seed deterioration fall into two broad categories. First, seed tissues may deteriorate due to aging. Plant physiologists have paid considerable attention to this problem. Second, seed deterioration also may be caused by invasion of and damage to tissues by microorganisms, insects, or rodents. These problems have been addressed by plant pathologists and entomologists.

Plant physiologists have developed three groups of theories to explain physiological and biochemical causes of deterioration. These are covered in detail by Anderson (1). The first group of theories relates to accumulation of deleterious products of metabolism. This includes theories involving cross-linkage of macromolecules that could render enzymes and nucleic acids inactive and membranes nonfunctional and could cause accumulation of metabolically inert material and mutagenic substances. The second group includes wear-and-tear theories, which assume that organelles, cells, and organs become inefficient with increasing use. The final group consists of somatic mutation theories, which suggest that mutation rates increase as tissues age and that a corresponding increase in undesirable mutations may lead to metabolic malfunctions.

Plant physiologists also have defined environmental conditions favorable for the production and maintenance of high-quality seed. Preharvest factors include moisture, temperature, photoperiod, and nutrition. During storage, seeds generally maintain viability best under conditions of low moisture content, cool temperature, and low oxygen tension. In the postplanting phase, the effects of soil temperature, moisture, and type have been considered, as well as agronomic factors such as planting depth, seeding rate, etc.

Plant pathologists have contributed to the understanding of seed deterioration in the studies of storage fungi by Christensen et al (3). Their work, and associated studies on the formation of mycotoxins, has been directed primarily at controlling the invasion of grain by fungi. It also has been valuable in defining safe conditions for seed and grain storage. Extensive efforts have been made to identify seedborne microorganisms. The annotated list of seedborne pathogens (7), published in 1979, records more than 1,500 microorganisms that are associated with over 600 genera of plants. For the majority of these, however, very little is known about the significance of the association. For those seedborne pathogens that have been studied, the emphasis usually has been on the importance of seed transmission of the pathogen rather than the effect of the pathogen on seed viability. Plant pathologists also have been interested in improving seedling emergence, but this work has tended toward controlling the pathogens, whether they be seedborne or soilborne, rather than understanding relationships among the seed, the pathogen, and the soil environment.

The approaches of physiologists and pathologists to studying seed deterioration have been quite different. Physiologists have tended to address the problem of seed deterioration directly, whereas pathologists have considered this as a secondary objective. Physiologists usually have studied the problem under conditions in which no obvious physical changes occur in the seed. The deteriorative processes that take place under these conditions usually are subtle physiological and biochemcial changes that lend themselves to basic studies. The assumption often is made that microorganisms are not important factors in deterioration under these conditions. The approach of plant pathologists has been to examine the pathogen and to pay little attention to physiological changes in the seed.

A major objective of this symposium is to review previous studies of mechanisms of seed deterioration in which both physiological and pathological factors have been considered and also to indicate benefits from integrating the physiological and pathological approaches to this subject. Cherry (2) and St. Angelo and Ory (8) have shown that many seed enzymes, with activities similar to those of pathogenic fungi, actively contribute to seed deterioration. They also found that changes in biochemical mechanisms that occur in saprophyte-seed interactions efficiently and systematically enhance the growth of the fungus at the expense of the seed. Anderson (1) discussed ultrastructural changes that take place in seeds invaded by fungi. Harman (5) has shown the effect of toxin production on germination of pea seeds invaded by *Aspergillus ruber*. These types of studies bridge the gap between physiologist's and pathologist's approaches to seed deterioration. As Anderson (1) points out, some physiological work may be in error because of the neglect of possible involvement of seedborne microorganisms. There is no such thing as an uncontaminated lot of seed produced under natural conditions, and it cannot be assumed that the contaminating microorganisms are inactive when seed appears to be visually uncontaminated. The paper of Halloin (4) clearly signals plant pathologists to become aware of the possible benefits in understanding physiological and biochemical changes that take place in seeds invaded by microorganisms. He lists a series of potential resistance mechanisms about which very little is known, including physical barriers in the seed coat, factors within the seeds such as enzyme inhibitors, lectins, and lipids, and active resistance systems such as those involving phytoalexins.

Another major objective of this symposium is to examine pathological aspects of seed deterioration caused by factors other than storage fungi and mycotoxins, which have been well reviewed by others. Harman (5) discusses the involvement of viruses, bacteria, and fungi in seed deterioration from the production field, through storage to post-planting. His review reinforces the point made earlier in this paper that most previous work has been on transmission of pathogens. Apart from storage fungi, there is only limited information on the effects of pathogens on seed quality before planting. Mills (6) has provided a much needed review of interactions between insects and fungi in seed deterioration.

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Previous reviews have tended to deal with insects and fungi separately. By taking an ecological holistic approach to the problem, Mills has made a valuable contribution by emphasizing the complexity of the interacting factors involved in seed deterioration.

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