SEED HEALTH: AN IMPORTANT QUALITY FACTOR

D. C. McGee [1]

When the American farmer plants seed, he usually expects that almost all of it will emerge at about the same time to produce a uniform stand of healthy seedlings. For the most part, his expectations are realized. A complex technology is required to maintain this standard of quality in an industry that must provide sufficient seed to plant more than 350 million acres of crops annually in the U.S.A. The product is the end result of a procedure involving growing, harvesting, conditioning, storing and planting the seed. Throughout this process, the seed must be handled carefully to avoid mechanical damage, it must be protected from adverse environmental conditions and protected from insect pests and diseases.

No one of these factors is necessarily more important than the others. There are few seed crops, however, in which some measure of disease control is not necessary during production. Some well-known examples of such control include fungicide treatment of corn seed, testing bean seeds for bacterial blights, and the location of seed production of cruciferous crops in the Pacific-Northwest. These control practices were developed because diseases severely limited seed production. They have been used successfully for many years. As agricultural technology changes, however, with the introduction of new varieties, changes in cultural practices, development of new crops, and increased movement of germplasm across geographical boundaries, the seed disease situation may alter significantly, either because of changes in the importance of known pathogens or because of the appearance of new ones. It also is generally recognized that, with many of the major crops in the world, plant breeding is unlikely to continue to make the dramatic increases in yield achieved in the past. Greater emphasis, therefore, will be placed on improving other aspects of crop production to optimize yield potential. An increasing demand for high quality seed is therefore likely. Seed pathology, because of its important role in seed quality, must continued to develop to meet these future needs of the seed industry.

---

[1] Seed Pathologist, Department of Plant Pathology, Seed and Weed Sciences, Iowa State University, Ames, IA

Scope of Seed Disease Problems

The annotated list of seed-borne diseases published in 1979 records almost 1500 seed-borne microorganisms on about 600 genera of agricultural, horticultural, and tree crops. From the plant quarantine standpoint, these statistics do not exaggerate the magnitude of the problems involved in controlling the movement of seed-borne microorganisms into areas where they have not previously been recorded. The figures are misleading, however, in estimating the extent of seed-borne microorganisms as problems when seed is produced for established crop production areas where the microorganisms are known to be present.

To obtain a perspective of this aspect of seed-borne disease, seed-borne microorganisms can be considered under four classes. One consists of pathogens for which the seed is the main source of inoculum and, when seed infection is controlled, the disease is effectively controlled. An example would be lettuce mosaic virus. For many of these pathogens, the importance of seed-borne inoculum has been long recognized, and control practices have been developed. Another class consists of important pathogens that are seed-borne, but in which the seed-borne phase of the disease is of minor significance as a source of inoculum. An example is Lepthosphaeria maculans, the cause of blackleg of oilseed rape. In Victoria, Australia, where this pathogen is a limiting factor in oilseed rape production, seed-borne inoculum does occur. However, in fields in which rape was grown in the previous year, large amounts of rape residue, covered with perithecia of L. maculans were found at the beginning of the following season. When seedlots with different amounts of seed infection were planted in a field which had not previously grown rape but was located near fields in which rape had been grown in the previous year, blackleg severity was the same across plots from all seedlots throughout the growing season, suggesting that crop residues in neighboring fields were the major source of inoculum and that seed-borne inoculum was of minor importance. The third and largest group of seed-borne organisms are those that have never been shown to cause disease as a result of their presence on seeds. An example would be Chaetomium spp. on soybeans. Studies of nine fungal genera commonly found on soybean seeds showed that only Phomopsis and Fusarium spp. were associated with reduced viability of seeds. Rather than having detrimental effects on seeds, some of the microorganisms in this class may in fact be beneficial. Interactions between fungi on soybean seeds could possibly be manipulated to control pathogenic fungi. The presence of nonpathogenic fungi in seedlots can cause considerable confusion in routine laboratory germination tests. The environmental conditions during these tests usually involve high humidity and high temperatures, allowing rapid growth of fungi such as Rhizopus and Aspergillus on the seed that tends to exaggerate the amount of the contamination of the seedlot by these fungi. Perfectly healthy seedlots sometimes are considered by inexperienced seed analysts to be "diseased" because of the growth of such fungi, despite high germination counts. Finally there is a group of microorganisms that can infect seed either in the field or in storage causing reduction in yield and seed quality. Examples of field infecting fungi include Diplodia, Gibberella, and Fusarium spp. on corn, and Fusarium, Cladosporium, or Alternaria spp. on cereals. The storage fungi, Aspergillus and Penicillium spp., can invade most types of seeds under high-moisture storage conditions.

At present, only a small proportion of the 1500 microorganisms listed as being seed-borne realistically can be assigned to any of the four classes just defined. Other than the fact that they have been shown to be associated with seeds, there usually is little information to indicate the significance of the seed-borne nature of many of these microorganisms.

Options in Seed Disease Control

Although many of the strategies used in controlling diseases in grain crops also can be applied for seed crops, special considerations regarding the quality of the produce make disease control in seed crops a more complicated matter. There also are options available in controlling seed diseases that cannot be used for grain crops.

Cultural practices may be appropriate when inoculum persists in the soil or on crop residues. Burning grass seed production fields in Oregon destroys inoculum of Gloeotinia temulenta (blind seed) and Claviceps (ergot) than can survive on unharvested seed. Soybean seed infection by Phomopsis spp. can be reduced by rotating soybean seed fields with corn rather than using a continuous soybean rotation. Other cultural practices such as varying planting time are sometimes effective. Winter wheat sown early in autumn may escape infection from bunt (Tilletia foetida, T. caries) because plants are past the susceptible growth stage before spores germinate, while later-sown crops may become infected.

Breeding for resistance to seed diseases specifically to improve seed quality is usually not economically feasible in temperate regions of the world unless the disease also is an important problem in grain production fields. This approach, however, may be of more importance in underdeveloped countries where the major source of seed is that which the farmer saves from his grain crops.

Disease control has been a major consideration in locating seed production in particular geographical areas. Much seed production, therefore, is concentrated in California, Oregon, and Washington where warm, dry conditions are unfavorable for disease development. On a smaller scale, the isolation of seed fields from other fields of the same crop within the same growing region also will be of value in disease control. While this practice is primarily used to maintain varietal purity, it also serves to isolate the fields from inoculum of airborne pathogens.

Storage conditions are a major consideration in maintaining seed quality. Most seedsmen appreciate the importance of correct storage conditions, but few probably realize that prevention of invasion by storage fungi (*Aspergillus* and *Penicillium* spp.) is one of the main reasons for maintaining seed moisture content below certain levels. In many tropical countries, where controlled environment storage facilities may not be available, maintenance of seed viability under conditions of high relative humidity and temperature is one of the most important limiting factors of seed production.

The importance of seed conditioning in controlling seed diseases is often overlooked. The process of cleaning and sizing seedlots automatically eliminates diseased seeds where their physical characteristics have been altered and structures of pathogens such as galls or sclerotia are present. Seed conditioning equipment has considerable potential as a means of reducing the amount of a pathogen in a seedlot to tolerable levels. There are few examples in the literature, however, of research in this direction. The results of gravity table separation of "scabby" wheat seed presented in Figure 1 are illustrative of what can be done.

Perhaps the most widely used seed disease control practice is treatment of seed with fungicides. For some crops, (e.g., corn and peanuts) the use of fungicides with broad spectra of activity against soil and seed-borne pathogens has been tried and tested over many years and the benefits are well established. Treatment of cereal seeds with fungicides specifically active against smuts also have proved beneficial in some circumstances. However, with other crops such as soybeans, the value of fungicide seed treatment has not been clearly demonstrated. This is in part due to a lack of knowledge of the factors that influence the efficacy of seed treatment.

Physical seed treatments using hot water or aerated steam also are used to control seed diseases. The benefits of these treatments, however, often have to be balanced against the damage done to seed viability. The use of hot water to control blackleg (*Phoma lingam*) and blackrot (*Xanthomonas campestris*) in high-value hybrid cabbage seed exemplifies this problem.

There has been considerable interest in recent years in treating seed with fungi and bacteria that are antagonistic to seed or soil-borne pathogens. So far, however, the results have been inconsistent. As Kommedahl and Windels suggest, one of the major problems with this apprach is a lack of understanding of the ecology of the microorganisms involved. Biological seed treatment certainly has potential, but will not be widely accepted by the seed industry until these problems are resolved.

Fungicides also are used as foliar sprays to control disease on the seed. This method is not used as widely as seed treatment, primarily because of costs. In the U.S.A., foliar application of benomyl on soybeans has been used to control Phomopsis spp. seed infection. The value of this treatment has been questioned, however, in production areas such as Iowa where the severity of the diesease does not justify the use of the fungicide in some years. The recommendations for the use of this fungicide were based on little knowledge of the disease epidemiology. Using earlier information obtained in Iowa, considerable progress has been made on developing a predictive method for the use of foliar fungicides on soybean seed crops based on measurements of Phomopsis pod infection. This could lead to much more efficient use of this control practice.

Seed diseases can also be controlled by seed health inspection programs. These are carried out either by field inspection of seed crops or by laboratory tests on harvested seeds. These methods are used for seedlots that have to be certified for plant quarantine purposes and for pathogens for which tolerances of seed-borne inoculum have been established.

Seed Health Testing

Seed health testing is one aspect of seed pathology that has been well investigated. Diseased seeds can sometimes be detected by visual examination of dry seed, but this method of assessment of seed-borne inoculum rarely is sensitive enough to be of practical value. Most tests involve either plating seeds on culture media, incubating them on blotters, or growing them in sand or soil/sand mixtures. Certain special tests are possible for particular pathogens, such as the embryo test for loose smut of cereals or the water droplet test for Gloeotinia temulenta in ryegrass. Serological tests for detection of seed-borne bacteria and viruses also have been developed. For many pathogens, the values obtained in laboratory tests cannot be related to the risk of disease development once the seed is planted. The test that provides the highest count for a pathogen may not be the most useful in predicting field disease. In tests for seed-borne Fusarium avenaceum on subterranean clover in Australia, seed infection averaged 67% on culture plates and 5% on blotters. A selective medium was used in the plate test thus eliminating competition from other seed-borne organisms that might restrict the growth of F. avenaceum from the seed onto the medium. In the blotter test, however, the pathogen was detected only after it had grown on the seed and caused a rotting of the emerged radicle. It is possible that the latter test gave a better measure of the seed-borne inoculum that had the potential to cause root rot in the field. Unless epidemiological studies are made to relate laboratory seed health tests to the risk of subsequent field disease, these tests are of little practical value.