4-1-1984

Seed Coverings - An Appreciation

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SEED COVERINGS - AN APPRECIATION[1]

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Coverings are one of the three general structural components of a seed and contribute in crucial ways to its propagative function. The origins and basic designs of the coverings on seed are limited, but they - the coverings - are almost infinitely variable in detail. Some coverings are smooth as polished wood, while others are intricately - even exquisitely - ornamented; some are drab, others flamboyantly colorful; some are delicate like fine tissue, others are hard as stone and tougher than leather; some are affixed with various projections and appendages, others are essentially featureless; most are aesthetically pleasing, but some are exasperating, especially to seed producers and conditioners. The old adage, "you can tell a book by its cover" applies. Seeds are mostly recognized and/or identified by their characteristic coverings.

The Source

The origins of seed coverings are few. The basic covering is the seed coat which develops from structures called integuments that enclose or surround the ovule in seed plants. The ovule, of course, is the sexual structure that, after fertilization, develops into the seed. (A seed is a mature ovule!). Gymnosperm (e.g., conifer) seed are covered only by the seed coat because they are "naked" and not borne in a fruit as is the case of the Angiosperms - the plant group to which most of our crop species belong.

Diversity in Form

Seed coverings are most diverse and complex in the Angiosperms because in addition to the "true" seed coat, they - the coverings - can include all or part of the fruit covering and various structures surrounding the fruit. The extent to which structures exterior to the seed coat, i.e., the "true" seed, are part of the seed coverings is determined by the nature of the "unit of dispersal." The unit of dispersal ranges from the true seed to multiple seeded fruits surrounded by bracts and appendages. The unit of dispersal for soybeans is the seed which is

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released at pod (fruit) dehiscence and covered only by a rather thin seed coat. The dispersal unit for cocklebur, on the other hand, is a formidable structure that contains two one-seeded fruits. In both cases - soybean and cocklebur - the structures exterior to the reserve storage tissue and embryo/embryonic "axis" are coverings and influence the functioning of the "seed" as the propagative unit.

Adaptative Value

There are many examples of adaptations of seed coverings to facilitate seed dispersal: the fibers of the cotton seed; the pappus or parachute of dandelions; the barbs of the cocklebur. Since seed dispersal is important for the survival of the species, the appendages and other projections from the seed coverings that aid dispersal play an important role in natural propagation. These accessories and appendages, however, are a nuisance in crop propagation and, as mentioned above, exasperating to seed producers and conditioners.

Problems in Conditioning

Appendages of seed coverings such as spines, awns, long hairs and fibers, coarse pubescence, wings and persistent "extra" coverings, such as hulls, add useless bulk to and reduce the flowability of seeds - to about zero in some cases. Seed that have poor flowability are difficult to impossible to handle, clean and package efficiently. Special and additional operations are required to "precondition" them so that they can be adequately conditioned. Consider some of the operations that are involved in changing the physical properties of seed coverings to reduce useless bulk, improve flowability, singulate the seed, and facilitate mechanical planting.

Defuzzing - reduction of the pubescence of tomato seed to singulate them and improve flowability.

Defringing - removal of the "fringes" along the "seams" of carrot seed to singulate and improve flowability.

Dewinging - removal of the "wings" of pine seed and other kinds of tree seed to reduce bulk and increase flowability.

Debearding - (also deawning) removal of awns and other projections from seed to increase bulk density, flowability and plantability.

Delinting - primarily applied to cotton; removal of the residual short linters from cotton seed mechanically or chemically to increase bulk density and improve flowability and plantability.

Clipping - removal or "clipping" of the loose ends of the hulls of oats to improve bulk density, flowability and plantability.

Hulling - removal of the hulls or pod from seed for a variety of purposes: to increase density, flowability and plantability; to improve germinability (bermudagrass); to change physical properties of the seed so that weed seeds can be separated (lespedeza).

Breaking-up - break-up of unthreshed pods (flax bolls), spikelets, and so on, to facilitate cleaning and reduce seed loss.

The processes mentioned are done purposely with special equipment such as huller-scarifiers, modified hammer-mills, popcorn polishers, and debearders for the various reasons mentioned, e.g., to increase density. Sometimes similar modifications in seed coverings that are effected more or less incidently to other operations such as harvesting contribute to rather than relieve conditioning problems. Cocklebururs, for example, are harvested and ginned along with the seed cotton. The burs are altered during ginning which makes them similar in size to cotton seed and difficult to remove. Johnsongrass seed hulled during harvesting and handling are much more difficult to separate from certain kinds of crop seed than unhulled Johnsongrass seed.

Coverings and appendages of seed reach their zenith as exasperating nuisances in some of the range and tropical grass species. The threshed seed can have a consistency more nearly like hay than seed and useless bulk might constitute 90% or more of the volume and 50% or more of the weight of the mass. But, range and tropical grass seed producers are ingenuous and persistent and do quite remarkable work producing and supplying seed of some of the really monster species.

Functional Roles of Coverings

The role of seed coverings in seed dispersal is one of their most evident functions. Another related and, perhaps, even more evident role or function of the seed coverings is containment.

Containment

The embryonic axis and nutritive tissue - the essential elements of the seed - are enclosed and contained by the seed coverings, thus, maintaining the spatial relationships of the two elements during the events that culminate in germination and even later.

The containment role of seed coverings cannot really be separated from the protective and regulatory roles or functions, which are most crucial in terms of germinative success. The seed coverings not only contain the embryonic axis and nutritive tissue, they also protect these vital, often fragile, elements.

Protection

The protective role of the seed coverings has two aspects: mechanical protection against physical forces; and barrier protection against the entry of microorganisms. The mechanical aspect of the protective role has become increasingly important - and appreciated - with increasing levels of mechanization of harvesting, handling and conditioning operations. In the natural order of things, that is, before the intervention of man in the life cycle of plants, the mechanical properties of the seed coverings were undoubtedly of lesser importance than they are now. Properties of the coverings that resisted digestive processes and permitted the seed to pass through animals functionally unimpaired were of greater importance than their sheer mechanical strength.

Effects of Man's Intervention: Since the intervention of man, however, the requirements of the human food grinding and digestive systems have caused conscious and unconscious selection of food grain types with more digestible, less mechanically strong seed coverings, or at least with more easily removed coverings. These preferences continue. Just a few years ago a breeder pointed out that the soybean seed coat didn't really contribute anything of value to the "product", and that if it could be reduced to one half of the portion of the seed it presently constitutes, the "difference" in terms of base chemicals and energy might show up in usable products - oil or protein. Little thought was apparently given to the problems that would arise in maintenance of soybean seed quality if the varieties were developed with thinner, even more fragile seed coverings.

Mechanical Damage: Mechanization of harvest, handling, and conditioning operations subjects seeds to physical forces that can and do exceed the mechanical resistance of the seed coverings and the seed as a whole to slowly applied static loading (crushing), impacts, abrasions, and various types of cutting and shearing actions. The failure of the seed coverings to protect the embryonic axis and nutritive tissue from physical damage affects the germination capacity of the seed. The degree to which germinative capacity is affected is determined by the severity and location of the damage. Gross damage manifested as splits, cross broken, decoated, and crushed seed immediately and irrevocably destroys the germinative capacity of seed. Lesser degrees of damage generally have lesser consequences, although rather slight damage to a critical site of the embryonic axis can destroy the germinative capacity of the seed as completely and irrevocably as fragmentation into many pieces.

Physical damage that does not immediately destroy the seed's germinative capacity can result in various sorts of structural defects in the seedlings produced. Some of these defects cause the seedling to be classified as abnormal or "non-germinable", but in other cases the seedlings are considered normal although they might be stunted, or have drastically altered and less efficient root systems, and so on. It should also be recognized that while the declaration by an analyst that the seedling from a damaged seed is abnormal eliminates it from the "germination percentage" it does not eliminate it from the lot. Abnormal seeds germinate and produce plants that take up space and utilize light, water and nutrients without contributing much to yield - just like weeds.

Rupture, gouging or fracture of the seed coverings can have an effect on germination and emergence even though the embryonic axis and nutritive tissue are unaffected. Usually the effects are indirect. Cuts in cotton seed coats permit direct contact of embryonic tissue and sulfuric acid during acid delinting which produces necrotic lesions on the cotyledons and may destroy the root tip. Certain chemical seed treatments, especially some systemic insecticides, are more phytotoxic to damaged than non-damaged seed.

Rupture or fracturing of the seed coat also destroys the "barrier" protection of the seed coverings. One reason for the use of seed fungicides is to overlay a "chemical" barrier over gaps in the physical barrier of the coverings caused by cuts, ruptures, and fractures. Disruption of the physical barrier allows entry of soil borne microorganisms which can destroy the seed unless a chemical barrier is overlaid. A substantial portion of the fungicide treatments applied to seed, therefore, is to "cover up" mechanical damage.

Benefits of Mechanical Damage: It is somewhat ironic that as well as the damaging effects of mechanical abuse are understood, controlled mechanical damage is the center piece of several operations routinely done during conditioning of some seed kinds. Mechanical scarification of clover, alfalfa and vetch seed is done to increase germination by reducing hardseededness. Mechanical scarification, however, is nothing more or less than controlled mechanical damage which produces more good effects (permeable, germinable seed) than bad effects (severely damaged, non-germinable seed). While the short term benefits of mechanical scarification outweigh the adverse effects, the situation can reverse in the long term. Scarified seed do not store well. Acid scarification has somewhat the same effects as mechanical scarification and is used for the same purposes. Hulling of seed results in incidental damage, which again, can have an adverse effect on storability of the seed.

The protective role of the seed coverings is very important in our modern, mechanized agriculture. Adjustments in the various mechanical operations to take advantage of seed conditions that maximize resistance of the seed to mechanical forces (moisture contents of 13-16%) and/or to minimize the magnitude of the forces applied are critical features in quality assurance programs.

The containment and protective roles of the coverings of seed are well established and rather obvious. The failure of seed coverings to contain and/or protect as in a split bean seed is highly visible. The equally, or even more important regulator role of the seed coverings, however, is neither well known nor obvious.

Regulation

Seed coverings regulate the rate of water absorption and gaseous exchange by seed, and as a consequence of these regulatory aspects and others, the germination process is regulated. Most seedsmen are familiar with the "hard seeds" that occur in the legume family, okra and other kinds. A hard seed is a seed in which water absorption is regulated by the seed coverings to the degree that no water is absorbed, i.e,. the seed coverings are impermeable to water. Regulation of water absorption ranges even within the same seed kind from the impermeable level to a level where the entry of water is scarcely impeded by the coverings. Regulation of water absorption by the coverings regulates germination because absorption of water or rehydration is the crucial step for germination. A seed with a water impermeable seed covering, i.e., a hard seed, does not germinate - it is dormant, while the germination of seeds with a covering slowly permeable to water is delayed. These are rather straight forward, "expected" types of responses. An unexpected response is germination dysfunction and/or seedling damage as a result of insufficient regulation of the rate of water absorption by the seed coverings, i.e., too rapid absorption. Considerable evidence has been accumulating which implicates damage from too rapid water absorption in germination failure under wet and cool conditions. Key evidence in this area was reported by Tully, Musgrave and Leopold (Cornell U.) a few years ago. They demonstrated in most convincing ways that imbibitional chilling injury in soybean and pea seed was controlled by the rate of water absorption, hence, permeability of the seed coverings. The pea seed covering, for example, retarded water absorption enough to minimize chilling injury, while the non-pigmented seed coat of soybean did not. Nicking the pea seed coat negated its regulatory role and chilling injury was not prevented. Much earlier (1966) Pollock and others had shown that mechanically damaged lima bean seed are more susceptible to cool, wet conditions.

Considering the rather high percentages of mechanically damaged seed that can occur in cotton, soybean and peanut seed lots, and the frequency of cool, wet conditions at planting time, e.g., planting interrupted by a cool rain, we can speculate that too rapid absorption of water might be a major cause of poor stands. Seed treatment protects the imbibitionally injured seed from microorganisms but the damage is already done. Perhaps, water absorption retardant seed coverings are needed in such situations.

Seed coverings through their control of water absorption (liquid and vapor forms) can regulate the life span of seed. Seed of soybean lines with even a moderate degree of hardseededness (say, 50%) retain their germination better under weathering pressure prior to harvest and during storage under warm, humid conditions.

The water absorption aspect of the regulatory role or function of seed coverings is deliberately modified or negated by scarification with highly beneficial results. Treatments that tighten-up rather than eliminate the regulation on water absorption imposed by the seed coverings might be equally beneficial under certain circumstances or situations, which need to be more clearly defined and characterized.

Gaseous exchange is regulated by seed coverings: more specifically, the absorption of oxygen. As in the case of regulation of water absorption, oxygen absorption can be regulated to the extent that insufficient oxygen is available at the crucial sites for germination and, thus, dormancy is imposed. It is very likely that even in non-dormant seed, oxygen absorption is restricted by the seed covering until it is ruptured by the emerging radicle. Enhancement of oxygen absorption prior to rupture of the covering could accelerate germination and, possibly, increase germination percentage. The products of anaeobic respiration are very damaging to low vigor, damaged seed.

Seed coverings act in several additional ways to regulate germination. There is substantial evidence that germination is prevented in some kinds of seed, i.e., dormancy imposed, by mechanical restriction of the seed coverings. The processes that lead to a release of dormancy, however, are not at all clear. For dormancy to be released, the mechanical strength of the coverings must be diminished in some way and/or the emergence force of the seedling must be increased. The seed coat can also regulate germination by acting as a light filter. Thick or pigmented seed coverings that exclude light or the effective wave lengths of light could hold light sensitive seed in a dormant condition. Finally, seed coverings regulate germination by serving as a respository or reservoir for inhibitors that migrate into the seed on wetting and block metabolic events critical for germination.

Summation

The coverings of seed are truly marvels of form and function but we shouldn't be content to just gaze on them with awe. Efforts to minimize damage to the coverings - except when needed to overcome dormancy - must be continued. And, careful thought needs to be given to the suitability of the coverings of major crop species in modern agriculture. Perhaps, better, or at least amended, seed coverings are needed.