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Insects and Pests That Affect Seed Quality

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INSECTS AND PESTS THAT AFFECT SEED QUALITY

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Insects and other pests can have an adverse effect on seed quality after it has been harvested and while it is being stored and/or conditioned. The primary emphasis here is on insects and how they can affect seeds both directly and indirectly. Less emphasis will be placed on how rodents, birds, and microorganisms can affect seed quality. It has been said that the more you know about your enemy, the better you are able to combat him. It is with that approach that this subject is addressed.

Insects

General

Of over a million different species of insects that are present in our world, only a relatively small number have adapted themselves to living in the rather dry environment that we call seeds. The insects that we have to be concerned with in seeds, are the same as those in market grain storage. Some of these insects are internal-infesting insects that spend their developmental period inside individual seeds and others are external-infesting insects that develop totally on the outside of seeds. each of these kinds of insect can result in a different type of damage as far as seed quality is concerned.

Insects belong to a group of generally small animals called Arthropods. The insects, with a few exceptions, are smaller than the seeds they infest. They have an exoskeleton which give them certain characteristics that allows us to differentiate between these insects. The exoskeleton also gives them a certain amount of protection against the rather dry environment in which they live.

Insects don't arise by spontaneous generation, although it may seem that way sometimes. However, we must have a male and female insect that mate and then the female lays eggs. The insects that infest seeds generally lay a large number of eggs, in the range from 100 to over 400, with an average of about 200 eggs per female. The eggs are laid either into grain kernels or loosely among the kernels and hatch within a matter of a few days into a small form that is called a larva. The larva goes through a series of growth stages where it increases in size.

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It is in this stage that most of the direct damage occurs as a result of larval feeding. Generally, the larva goes through a series of four growth stages called instars that usually take about 20 to 24 days. Then the larva transforms in a pupa where the insect completely changes it appearance from that of a worm to that of the adult insect. It generally remains in this stage for about four to five days and then transforms into an adult. Within a matter of two to three days the adult is able to start mating and laying eggs again. This is a relatively short life cycle, approximately 30 days depending upon the conditions under which the insect develops.

The conditions needed are a favorable temperature, a favorable moisture content, and a suitable food material. Below 60°F we find that the temperature tends to restrict the multiplication of insects. Temperatures of 70 and 80°F seem to be the optimum and when we get to higher temperatures, 90°F and above, the numbers tend to drop off. Most of the lower temperature control is probably due to reduction in egg laying, whereas at the higher temperatures, probably due to the inability of insects to maintain their water balance in a relatively dry environment. In cereal grain seeds with less than 12 percent moisture content there is a rather dramatic reduction in the number of insects that will be produced. At 12, 13, and 14 percent moisture content, conditions are the most favorable as far as insect development. Above 14 percent there is less concern about insects and more about the microorganisms or molds that may attack cereal grain seeds.

Hypothetically, it has been calculated that starting out with just one pair of insects within a matter of about five months you could have well over a million insects just from that one pair. This, assuming that the female will lay 200 eggs, approximately 80 percent of the eggs will survive, and that it takes approximately a month to complete a life cycle. This should provide an idea of how rapidly a population of insects can multiply if something is not done about controlling it.

Internal Infesting Species

Weevils, borers, and the Angoumois grain moth comprise the internal infesting species. There are three very closely-related weevils that infest seeds, the rice weevil (*Sitophilus oryzae*), the maize weevil (*S. zeamais*), and the granary weevil (*S. granarius*). The grain weevils are characterized by having a long slender snout. There are other characteristics that are used to separate the various weevils but they will not be discussed here.

The weevils use the long snout to chew holes into seeds. After the female weevil has chewed a hole into the seed it turns around and inserts its ovipositor and lays an egg right inside the seed. The egg is covered with a small gelatinous plug to protect it and makes it virtually invisible to the naked eye. The egg hatches within a matter of a few days into a larva and the larva, as indicated, goes through a series of growth stages, all on the inside of the seed. At each growth stage the larva forms a new exoskeleton and then casts off the old one, increasing in size at each stage. The weevils go through four of these growth stages, or larval instars. The larva is the stage that does all the feedling inside the seed. Still on the inside of the seed the larva transforms into a pupa, and takes on the characteristics of the adult. It emerges from the kernal by chewing its way out. It then goes on to set up this same cycle again. Under proper conditions for development, the rice weevil egg will hatch within 3-4 days. The larval period requires about 20-22 days; the pupa 3-4 days; and the adult before emerging about 3-4 days.

One thing that's important from the standpoint of seed quality is the fact that from one-third to more than one-half of the seed may be consumed in the development of weevils on the inside of a seed of wheat. The rice weevil is a relatively small insect and there are cases where we can actually find two individuals developing on the inside of a given seed, and in that case virtually all you have left is the pericarp and the embryo. Studies have been conducted indicating that where one insect develops in a wheat seed, 10 percent of those seeds will germinate. In other cases, none of the seeds germinated.

The maize weevil looks virtually the same as the rice weevil but is generally slightly larger in size. The names do not necessarily mean or indicate where the insect feeds exclusively. The weevils will cross-feed on a variety of types of seeds. The maize weevil has actually been found in acorns. It goes through the same kind of life cycle as the rice weevil. The third species, the granary weevil, is uniform in color and is not capable of flight. This is in contrast to the rice and maize weevils, that have four light spots on the wing covers and do have functional flight wings. The maize and granary weevil take slightly longer to complete their life cycles.

Another insect that develops inside the grain kernel and creates the same kind of damage by consuming the endosperm or the carbohydrate storage reserve is called the lesser grain borer (<u>Rhyzopertha dominica</u>). It's microscopic in size and about the same size as the rice weevil but it is cylindrical in shape, like a piece of pencil lead and does not have a long snout. The lesser grain borer goes through the same kind of life cycle as just described, however, the eggs are laid outside the seeds and the newly-hatched larva must chew its way into the seed. From that point, development occurs within the seed until the adult emerges. The adults also feed on seeds and are capable of penetrating various types of packaging material. Production of a large quantity of dust is another characteristic of the lesser grain borer. It produces a very distinctive odor which is probably carried through the dust that it generates; most of this is excrement. It's a very voracious feeder. As the larva develops, it feeds and consumes a large amount of carbohydrate material and then also as the adults feed they continue to consume seeds and cause quite extensive damage. Another pest that is very closely associated with the lesser grain borer is the larger grain borer (Prostephanus truncatus). This has become a serious pest in some of the African countries and was said to have been imported from the United States. This is an insect that primarily attacks seeds that may be stored on the ear starting at one end of the cob and going right down through the embryo and then exiting at various points.

Indirect damage due to internal infesting insects. Development on the inside of the seed consumes a part of the seed so that it makes it a less valuable commodity as far as planting for production. But some of the indirect damage can be equally detrimental. The weevil can be used as an example. As the larva develops it feeds; as it feeds it is producing waste products. The cast skins that are left behind are food contaminants and from the standpoint of seeds are not important. More important from the standpoint of seeds is the fact that there is heat generated by the insects as they metabolize the carbohydrate material. As they feed, insects generate a certain amount of heat, a certain amount of moisture, and some carbon dioxide. That heat can accumulate in bulks of seeds because seeds are generally good insulators and a large enough population of insects developing in a quantity of seeds can create what is called a "hot spot" or a portion within that quantity of grain where the temperature increases. As the temperature increases, the insects don't like it, and tend to move out or migrate. That tends to spread an infestation and not only will this quantity of seed be damaged but will also spread the insects to other parts of the seed storage whether in sacks or bulk. Also, this "hot spot" by increasing the moisture content in this localized area can promote the development of microorganisms. They're very devastating as far as the embryos are concerned and can destroy the viability of the seed very rapidly. In addition, the hot air that is produced here tends to move upward and tends to carry warm moisture with it to the surface where we may have condensation of moisture onto the seeds at the surface or absorption in the seeds below the surface. This in turn will promote conditions that are favorable for the development of microorganisms.

Another insect that develops inside the grain kernels is the Angoumois grain moth (Sitotroga cerealella). Where seeds are stored in bulk its infestation is confined to the surface area. Because it is a moth and is very delicate it can't penetrate down into large bulks of seeds. This insect scatters its eggs over the surface of the seeds. The eggs hatch and the larvae chew their way into the seeds. From that point on their developmental cycle is within the seed. After the larva has gone through all the growth stages it transforms into a pupa, still on the inside of the seed. The adult moths don't have mouthparts with which to chew so it may be a mystery as to how they get out of the seed. Before it transforms into the pupa, the larva goes to the surface of the seed and makes a "window" for an escape hatch. It then transforms into the pupa and when the adult is ready to emerge all it has to do is push open the "window" and work its way out. It is then free and ready to start mating and laying eggs again. The adult moths die within a matter of a few days. All the damage done by this insect is by the larva. Another thing that is important about the Angoumois grain moth is that in its diet it seems to have a need for the types of materials that are in the embryo. Whenever it feeds on a seed it consumes a certain amount of the embryo. The size of the seed pretty much determines the size of the adult insect. It's interesting too, that even though we have a small moth from a seed of millet, the size of the egg it lays is about the same size as the eggs layed by moths from maize. The moth from millet may produce just one egg but it's a good sized one. The Angoumois grain moth is one of the few insects that has the ability to penetrate paddy rice or rough rice. The outer hull of the rice kernel provides protection from many of the other insects. The Angoumois grain moth and other moths are probably more damaging to seeds where the seeds are stored for periods of time on the head because it exposes all of the kernels.

Beans are subject to infestation by insects known as bean or pea weevils belonging to the family Bruchidae. Some of these insects lay their eggs directly on the seeds and some infestation occurs in the field and is brought into storage. Bruchids develop on the inside of seeds and emerge in much the same way as the Angoumois grain moth, creating an escape hatch. The adult doesn't feed and most of the damage again is done by the larva as it develops. The bean seed, being a little bit larger, can tolerate a certain amount of insect damage. Where uninfested beans showed a 75 percent germination when only one insect developed, that percentage dropped to about 44 percent and as the number of insects increased to four, the germination of seeds went to 0. It's not uncommon to have more than one insect develop in bean seeds.

External infesting insects develop outside the seeds. The Indian meal moth (Plodia interpunctella) is another moth that many of you have probably seen. Again, the adult moth doesn't feed and dies in a relatively short period of time. It does lay eggs over the surface of bulk stored seeds or along seams of bags. When the eggs hatch, the larvae feed on the seeds. Their primary point of feeding is at the embryo. The larvae feed on the embryo first, and then they'll continue back into the endosperm portion of the seed. They do a very clean job of scalping out the embryo and leaving behind a seed which still has most of the endosperm present but can't be grown into a new plant. The Indian meal moth probably consumes 40 embryos per larvae as it develops and if you have a heavy infestation quite a few embryos can be destroyed in a relatively short period of time. When the larva is ready to transform into the adult, it migrates and comes out of the bulk or bagged seeds and looks for a place to pupate. Cracks and crevices along the doors or on the insides of storage facilities are good places for them to pupate; or along the areas where sacks may be stitched together. In addition to laying eggs over the surface of bulk stored seeds, a favorite place for laying eggs is along the folds in sacks. When the larva hatches it has direct access into the packaging material.

If a lot of dead moths are observed lying on the floor it doesn't necessarily mean that your control program has worked. It may mean that you have a pretty good-sized infestation and that these adults have just died and are lying there on the floor for you to sweep up. Remember that adult moths live only a matter of a few days to a few weeks and their only function is to mate and lay eggs.

Another of the external infesting insects that we find in cereal seeds are flour beetles, the Tribolium species. They prefer a diet of ground or cracked seeds rather than whole seeds but when forced they will live on whole seeds. On sound seeds, larvae and adults scalp off the embryo first and then feed back on other parts of the seed itself. But the more broken seeds you have the greater opportunity for this type of insect to develop. Again, its prime target as far as food materials it's feeding and developing in these seeds is the embryo and it doesn't take long for them to destroy quite a few seeds.

There are other insects such as the saw-toothed grain beetle (Oryzaephilus surinamensis) which gets its name from the six saw-tooth structures on each side of its body. Larvae and adults feed on the embryos and look for seeds where there may be cracks in the pericarp over the embryo. The flat grain beetles (Cryptolestes spp.) actually can complete their development living right under the embryo. A crack in the pericarp or any kind of break allows the egg to be laid there, or a small larvae to penetrate, and then it stays right inside the seed and its prime food is the embryo of the seed.

The Dermestids, primarily the genus Trogoderma, feed on seeds and it's the larvae again that do the most damage feeding on the embryos. The adults are relatively short lived, but the larvae are particularly hazardous because when food is not available they can remain dormant for long periods of time. When fresh seeds are available the larvae again become active and it's the embryo they intend to go for.

Some of you may see a cadelle (Tenebroides mauritanicus) occasionally, especially if you have wooden types of storage. The larva of this insect feeds on the embryo but it also has the ability to feed on the storage structures. It will tunnel into wood and at times infestations can become so heavy that they weaken the structure itself. In addition to providing a place where the larvae can develop, tunnelling in wood provides a place where dust can accumulate, mold spores can develop, other insects can receive a certain amount of protection from pest control measures that might be applied such as treatment with insecticides or fumigants. the cadelle is an insect that has the capability of living through a winter and some pretty cold temperatures.

Another type of damaging organism that is even smaller than the insects is mites. They are more closely related to spiders and ticks. They also have as their prime target in feedling, the embryos of seeds.

In general, the external infesting insects--the grain beetles, the flour beetles, the Indian meal moth--are probably more damaging on seeds which have an exposed or a relatively exposed embryo in contrast to those seeds such as barley and oats which have more protection.

Rodents

General

Rodents can cause a direct reduction in seed quality and can also be a source of concern to seedsmen in a variety of other ways. Like many of the insects, rodents seem to have a preference for the embryo of cereal grain seeds. This is particularly true of corn where the embryo with part of the endosperm is consumed first. With the smaller grains such as wheat and sorghum often the entire seed is consumed.

In addition to actual destruction of seeds, rodents can be damaging from the standpoint of container and facility damage. Sacks (jute, paper, and polyethylene) can be chewed by rodents with subsequent spillage and loss. There is also the problem of appearance of packaging on customer acceptance of the product. A rodent chewed or contaminated package is aesthetically less acceptable than a sound package. Rodent chewed bags which resulted in spillage from the bottom bags of a stack caused a stack collapse with resultant structure damage to the warehouse wall and door.

Because of a "need" to keep incisor teeth worn, rodents chew on solid objects such as wood, mortar, and other construction materials. The damage created can provide access for additional rodents; inaccessible harborages for both rodents and insects; and in some instances fires have been attributed to rodent chewing of electrical wiring.

Rodents are carriers of diseases which can be spread directly in excreta and urine or indirectly through ectoparasites. Although the diseases carried by rodents will not affect seed quality, if rodents are allowed to exist in seed conditioning and warehousing situations the potential for employee health problems exists.

The Rodents

There are three species of rodents which have adapted themselves to living in close association with human populations--the Norway rat (*Rattus norvegicus*), the roof or black rat (*Rattus rattus*), and the house mouse (*Mus musculus*). There are field rodents which may on occasion enter structures but they are considered incidental pests when compared to the three commensal rodents indicated above.

The rats can be distinguished from one another by certain body characteristics and behavior. The Norway rat is an aggressive robust animal. It may weigh as much as one pound when full grown and may measure about 18 inches from nose to tip of tail. A blunt nose and small eyes and ears in relation to head size together with a relatively stout, short tail (shorter than head and body length) characterize Rattus norvegicus. The roof or black rat is smaller (about 3/4 pound) and has a pointed nose and large eyes and ears in relation to head size. The tail is longer than the head and body combined. As the name implies, the roof rat prefers an elevated location, crawling in overhead areas of structures whereas the Norway rat is a burrowing rodent that tunnels and lives in the ground, moving into structures to feed. In the U.S., the potential to encounter the Norway rat exists across the entire country especially in urban areas; the roof rat is a more tropical type of rodent and more likely to be found along the west coast and Gulf and Southeast Atlantic coastal areas.

Mus musculus, the common house mouse, is found virtually everywhere in the world. It is a very small rodent somewhat deceiving in its appearance. the grey fur that covers the mouse makes it look much larger than actual. Small mice can enter openings slightly larger than 1/4 inch diameter. Mice generally weigh about an ounce when full grown and measure about 6 1/2 inches in length from nose to tip of tail.

The rodents are similar in that all are nocturnal, prefer hidden situations, have good senses of hearing and smell, have poor eyesight, can swim, can climb rough surfaces, and live, on the average, about one year. Rodents differ in their potential for reproduction with the rats producing about equal numbers per female with mice producing about twice as many per female per year. Rats also differ from mice in feeding and behavior. Whereas rats are very cautious in their movement and suspicious of new or a changed environment, mice are curious and readily explore new situations. feeding habits of rats reflect this also. Foods used in baiting programs may not be taken immediately but once accepted by rats, will be consumed in quantity. Mice are curious and will readily try new foods making use of a variety of baits (gum drops, peanut butter, bacon grease, etc.) in trapping quite effective. Liquid baits may work best for rats because of their need for a source of water; mice can metabolize the moisture they need from foods they consume.

Since rodents are nocturnal and prefer a concealed environment, they may not be seen physically. We rely heavily on seeing evidence of their activities to detect their presence. Droppings (excreta pellets) are easily seen and identified; and urine can be detected on packages using a "black light" (ultra-violet light). Chewing on packages and structures can also be identified easily. Since rats, especially, move over set pathways ("runs"), they can be detected by tracks, beaten paths, or body stains.

Birds

In seed storage, birds are more of a nuisance than a factor in the loss or reduction of seed quality. Cereal grains will be consumed when they are exposed as spillage around storage or conditioning facilities. But from the standpoint of quality, birds probably contaminate much more seed than they consume.

Birds roosting on the roof of a plant or storage facility or accumulations of bird droppings (excrement) on the exterior of facilities or on seed packages are an indication to customers of poor management.

An incidental but interesting association exists between bird nest and seed infesting insects. Certain species of Trogoderma have been found infesting bird nests, feeding on feathers and other nest materials and have subsequently infested cereal grains.

The two species of birds that are most likely to be pests at seed storage and conditioning plants are the English or House Sparrow (Passer domesticus) and the feral pigeon (Colombia livia).

When food and other conditions are favorable, sparrows can be expected to produce about 35 young per female where as pigeons will produce about 10 per female per year.

The sparrow is a particular nuisance in that it can enter very small openings and will readily nest in any small opening or space where a few pieces of grass or twigs can be forced. Once inside a warehouse, sparrows are quite difficult to remove and a considerable amount of product can be defaced with droppings within a relatively short time.

Pigeons prefer to roost in large numbers generally on the roofs or window ledges near areas where spillage occurs and accumulate. This is particularly true along rail and/or truck loading areas. Where pigeons may roost repeatedly in a confirmed area, the accumulation of excrement could provide a source of Histoplasma capsulatum, the causal organism of histoplasmosis.

Pest Control

An integrated approach is suggested for pest control in maintaining seed quality. Four basic groups of control methods are proposed: inspection, housekeeping, physical and mechanical, and chemical methods.

Inspections are used to detect potential or existing pest problems so that corrective action can be taken. Inspections can also be used to monitor an existing pest control program to see whether it is functioning according to expectations.

Housekeeping, simply stated, is cleanliness and orderliness and involves not only the interior of the storage and conditioning facility but also the plant perimeter and exterior. Orderliness in storage of bagged materials is an important adjunct to facilitating inspections, rodent control, and chemical control applications.

Physical and mechanical methods of control include temperature and moisture alteration of bulk seed stocks as well as particle size and density separations. Rodent and bird proofing of storage and conditioning facilities falls within this category of control as do traps and other mechanical pest control devices.

Chemical methods include contact insecticides, fumigants, rodenticides, and avicides. Only certain pesticides are approved for control of the pests discussed. Since by-products from seed conditioning plants may eventually be channeled to human or animal food uses, it is important that only those chemicals approved for food plant and storage facilities be used prior to treating and packaging cereal grains for seed purposes.

The integrated use of the methods mentioned with the emphasis on preventive pest control methods can reduce the potential for reduction in seed quality.

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