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Managing Seed Quality during Storage: Challenges and Strategies

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INTRODUCTION

The purpose of seed storage is to uphold the seeds in a favourable physical and physiological state, ensuring their quality remain intact from the moment of harvesting to the moment of planting. Pests that infest stored grains constitute a major biotic factor responsible for substantial losses during storage. On average, insect-related losses in storage typically range from 10 to 20 per cent, but they can occasionally escalate to as much as 30 per cent. Insect-induced losses include more than just the direct consumption of grain kernels; they also involve the buildup of insect-related waste materials such as frass, exuviae, webbing, and insect carcasses. High levels of these insect residues can render food grains unsuitable for human consumption. Additionally, insects can alter the storage conditions, leading to the formation of warm, moist "hotspots," which create ideal environments for the growth of storage fungi, resulting in additional losses.

List of important stored grain insects is given in Table:

Insect pest	Scientific Name	Family	Order	Preferred host
Primary pests				
Rice weevil	*Sitophilus oryzae* (L.)	Curculionidae	Coleoptera	Rice, wheat, maize
Lesser grain borer	*Rhyzopertha dominica* (F.)	Bostrichidae	Coleoptera	Wheat, rice
Angoumois grain moth	*Sitotroga cerealella* (Olivier)	Gelechiidae	Coleoptera	Paddy, maize and wheat
Pulse beetle	*Callosobruchus maculatus* (F.)	Bruchidae	Coleoptera	All pulses
Secondary pests				
Khapra beetle	*Trogoderma granarium* (Everts)	Dermestidae	Coleoptera	Wheat, rice, maize
Red rust flour beetle	*Tribolium castaneum* (Herbst)	Tenebrionidae	Coleoptera	Wheat flour

Insect pests in seed stores:

Stored grains offer a range of habitats for numerous insect species, but only a select few have successfully adapted to thrive in stored grain environments and are primarily responsible for the majority of damage. These insect pests are mainly found within the Coleoptera and Lepidoptera orders, accounting for approximately 60% and 10% of the pests, respectively (FAO, 2009).

These insects can be classified into two main categories:

- Primary pests: Primary pests target whole grains and have the ability to breach an intact seed coat and pod to consume the embryo, endosperm, or cotyledons.
- Secondary pests: Secondary pests feed on grain products or grains that have already been compromised by the primary pests, or as a consequence of activities such as harvesting, handling, and transportation.

Source of Infestation in Seed:

- Field infestation
- Infestation by migration
- Infestation though storage bags
- Infestation through transport carriers
- Infestation through storage structures
- Infestation through bird nests and rodent burrows

Conditions conducive to insect infestation during storage

1. **Temperature:** Abiotic and biotic elements associated with stored grains are affected by the temperature of the grains and the air within the grain mass. Stored grain insects can only operate within a specific temperature range due to their inability to regulate their body temperature. The minimum temperature required for insect development falls within the range of 15-22°C, while mites have an even lower threshold, typically ranging between 5 and 12°C. Fungi require temperatures as low as 2-5°C, and microbes function at temperatures around 5-6°C.
2. **Moisture content:** The most critical factor influencing the storability of seeds is their moisture content. A moisture content level, typically between 8 to 9%, within grains or seeds is insufficient to sustain insect activity. Conversely, even with high moisture content in grains, insect activity cannot occur if the temperature is not within the optimal range. Generally, warm grain temperatures at harvest and during storage, coupled with a grain moisture content of approximately 12-13%, create favorable conditions for the proliferation of insect populations.
3. **Initial physical quality of seed:** The presence of inert materials or broken grains in stored seeds can create favorable conditions for insect infestation, especially the formation of hotspots. Cracked kernels and foreign substances serve as a food source for insects and occupy the spaces between kernels, impeding the natural airflow through the grain. As kernels continually release heat and moisture through respiration, reduced airflow within the grain mass tends to result in the development of hotspots and clumping of grains. Broken grains also become breeding grounds for a larger number of mold spores and storage fungi. This type of grain tends to saturate the inter-granular air with humidity, increasing the availability of moisture content for both insects and storage fungi.
4. **Duration of storage:** Infestation is also contingent on the length of time the storage persists, and as the storage duration extends, the likelihood of infestation also rises.

Storage Losses

Quantitative losses: Insect pests are recognized for their potential to inflict damage to stored grains and grain products, with damage percentages typically ranging from 5.0-10.0 per cent in temperate regions and escalating to 20.0-30.0 per cent in tropical zones (Talukder, 2006). Experts from the Food and Agricultural Organization (FAO) have estimated that biological attacks during storage

result in a 10% loss of harvested crops. Their earlier studies have indicated an annual loss of 5% due to insect infestation in all harvested cereals, pulses, and oilseeds.

Qualitative losses: Insects do not just contribute to postharvest losses in terms of quantity; they also diminish grain quality by depleting specific nutrients, contaminating grains with their shed skins, excrement, fragments of immature insects, and other by-products. This can negatively impact germination capacity and, in turn, affect the economic value of the grain (Ozkaya *et al.*, 2009).

Effect on carbohydrates, proteins and lipids of seed: Cereals contain carbohydrates in their endosperm, while proteins and lipids are found in the germ portion. Since many storage insects feed on both of these sections, they can significantly alter the nutrient composition of the entire grain. The rise in crude protein levels in infested grains can be attributed to the production of non-beneficial, even harmful proteins, including shed skins, exuviae, deceased insects, wings, legs, and other insect body parts that accompany the infested grain samples. This increase may also result from a significant reduction in the carbohydrate content.

Effect on seed germination and viability: Both internal and external feeding insects impact seed germination through their direct consumption of the endosperm and embryo of the seed and indirectly through the biochemical alterations that take place within it. Internal borers that develop inside the seed have a significant influence on seed health, rendering it a less desirable choice for use as planting material. The germination rate of stored seeds typically decreases as the level of insect infestation increases.

Insect pest management within the ecosystem of stored seeds:

- Regular monitoring or sampling is a crucial component of integrated pest management. It offers insights into the extent of insect infestation, the dynamics of insect populations, and ultimately equips decision-makers with the capability to implement protective measures at the appropriate moment.
- Sanitizing stored commodities and storage structures, as well as implementing effective measures to keep stored grain insects out, are the fundamental elements of preventive management.
- The threshing floor or yard should be maintained in a clean and insect-free condition, situated away from villages or granaries.
- Harvesting equipment, transportation containers, loading areas, and storage bins should be thoroughly cleaned before storing commodities.
- In some cases, it's advisable to apply insecticide to the interior surfaces of walls, floors, and ceilings within these structures and machinery to prevent any pre-existing infestation.
- Temperature manipulation, Chemical control, Manipulation of moisture, Use of desiccants these all can also be adopted.

Conclusion: The escalating issue of post-harvest losses attributed to insects in various storage structures, whether at a small-scale or commercial level, has prompted a pressing demand for the exploration of alternative management strategies. This necessity acts as a significant catalyst for research in the field of insect management within stored grain systems. The quantitative and qualitative losses inflicted by these insects have a substantial effect on the economic worth of the produce. However, there is a significant need for the strategic incorporation of various methods to deliver optimal results while minimizing potential health and environmental hazards.

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